32ND INDIAN ENGINEERING CONGRESS

Innovation in Engineering: Competitive Strategy Perspective

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Innovation in Engineering: Competitive Strategy Perspective

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Ph : (91) (33) 2223 1979 ● E-mail : president@ieindia.org ● Web Site : http://www.ieindia.org

N B Vasoya, FIE
PRESIDENT

"98 Years of Relentless Journey towards Engineering Advancement for Nation-building"

It is a pleasure for me to recognize the efforts of the organizers and all concerned who have meticulously planned and tailed hard to bring out this wonderful 'Technical Volume' on the occasion of the 32nd Indian Engineering Congress being hosted by Tamil Nadu State Centre at Chennai during 21 – 23 December, 2017 on the theme 'Innovation in Engineering: Competitive Strategy Perspective'.

The Indian Engineering Congress is the apex activity of the Institution enjoying a special status amongst the engineering fraternity. This is organized every year where professionals and engineers from all the disciplines of the engineering gather to debate and deliberate on the theme of the Congress and thereby it provides engineers with a forum for exchange of knowledge, updating information and developing a sense of responsibility in their professional functioning.

This volume comprises of the articles by engineering professionals with rich experience in their discipline. The content is equally fascinating which has discussed the use of technology and innovation to leverage strategic changes in human lifestyle as well as business perspective.

I am sanguine that the deliberations during this Congress will be in right perspective and the technical volume will benefit scientist, engineers, technologists, policy makers, academicians and all concerned.

Navinchandra B Vasoya
President

1 & 2, Shri Krishna Centre, First Floor. Near Mithakhali Six Roads. Navrangpura. Ahmedabad - 380 009
Phone : (079) 2646 3061. Fax : (079) 2646 0012. E-mail : navin@lvjprojects.com

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Sisir Kumar Banerjee, FIE
PRESIDENT- ELECT.

"98 Years of Relentless Journey towards Engineering Advancement for Nation-building"

India is a growing economy and science and technology plays a vital role in maintaining the balance between growth, protection of environment and employment generation. In a fast changing business environment constant innovation is essential to keep ahead of the competition. The dichotomy between competitiveness and creation can only be addressed through a well-planned approach of application of engineering and technology. Development of new and innovative businesses and products is critical for maintaining competitive position of the industries.

With this challenges in hand, The Institution of Engineers (India) can play the leading role in promoting innovative technologies which will cater to the need of the industries to ensure the nation's accelerated rate of economic growth. It is in this context that the theme of this year's Congress **"Innovation in Engineering: Competitive Strategy Perspective"** is very relevant and contemporary.

I congratulate the Technical Committee of the 32nd Indian Engineering Congress for successfully spreading the message of the Congress to a wide range of professionals and obtaining large number of papers from all over the country. I also understand that they have relentlessly worked on scrutiny of the papers and selected the best ones for presentation in the Technical Sessions of the Congress. I wish them all success.

Sisir Kumar Banerjee
President-Elect

1/4, Prem Chand Boral Street, Kolkata 700 012
Phone : (033)-22416240, Mobile : 9831073144, E-mail : mailpriyasisir@gmail.com

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"98 years of Relentless Journey towards Engineering Advancement for Nation-building"

Prof. R. Velraj
Chairman, Technical Committee

On behalf of the technical committee, I am honored and delighted to welcome you to the 32nd Indian Engineering Congress, in the wonderful city of Chennai. The major theme of this conference is towards innovation in engineering competitive strategy perspective with its main focus on Materials, Manufacturing, Energy and Environment, Cloud Computing, Big data analytics, Communication and networking etc. I am excited about the sessions in the emerging areas, and wide variety of ideas that speakers from industries and academic institutionswill bring into our fold.

This congresswill provide a wonderful forum to refresh the knowledge base and explore the innovations in major Engineering aspects and applications. In order to provide the latest technologies for the participants we have invited distinguished experts in several engineering discipline as keynote speakers.Further, this congress will strive to offer plenty of networking opportunities, along with the occasion to meet and interact with the leading scientists and researchersas well as friends and colleagues from various industries.

The success of the anyconference depends ultimately on the various resources who have worked in planning and organizing both the technical program and supporting social arrangements. In this connection I am extremely thankful to all the members of the technical committee for their wise advice and brilliant suggestionsand the reviewers for their thorough and timely reviewing of the papers. Recognition should go to the local organizing committee members who have all worked extremely hard for the details of important aspects of the conference programs and social activities.

We hope you will enjoy the technical sessions, make new contacts, get innovative ideas, and above all, have a pleasant& fruitful time. We believe you will join us for a symphony of outstanding engineering and technology, and take a little extra time to enjoy the spectacular and unique beauty of this region.

R. Velraj

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3D Printing Technique in Construction Industry

Vikrant Gupta[1], Sanjay Sehdev[2] and P. Parthasarathy[3]

Abstract In Today's world innovations in every industry are being driven primarily by cost, schedule and quality. Construction industry is no exception to this. Amalgamation of robotics and construction techniques has always being thought of as turning point in construction industry as it will not only eradicate the human errors but be advantageous in terms of cost and schedule. 3D printing in construction is one such process which is being researched and developed in which fusion of robotics and construction techniques have found to be successful in different parts around the world.

This paper discusses how 3D printing in construction had already revolutionized construction industry. It also focuses on challenges in fully implementing this method at construction sites across the world.

Until now application of 3D printing technologies in construction have resulted in fabrication of small housing units, small bridges and sculptures. But this technique can be further advanced to build bigger structures. Also designer's creativity can be easily turned into real structures with 3D printing which was earlier found to be impossible owing to limitations in present construction techniques.

This 3D printing technique shall remain underutilized if its use is limited to building/ construction on earth only. As now human dream is to perform construction/build habitats at inter planet or extraterrestrial regions like Moon or Mars. It is highly exciting to explore the options of using this technology for building infrastructure in extraterrestrial regions with the help of 3D printing.

Keywords: 3D Printing, Construction, Techniques

Introduction

History of human industry is a story of increasing mechanization, away from the use of manual labor. Not untouched modern construction industry today is the result of infusion of mechanical and advanced Information technology into the field though it still relies very heavily on manual labor. Primarily driven from economic considerations mechanization has helped improve construction quality, schedules, safety and living standards of the persons engaged in construction. It has helped by shifting site work to controlled & mechanized production yards away from the site allowing reduced human exposure to extreme site conditions–natural and manmade. Precasting, preassembly and modularization are some of the trending technologies supporting this cause. Interestingly but not irreverently, these are just scale ups of the micro modularization technology immemorially in use in the form of brick and rubble masonry construction.

Brick and Masonry construction is beautiful–our classical architecture bears witness to it but still discrete. But man has always yearned to actually imitate nature-building atom by atom blocks, which have a continuity, not just apparently whole but inherently whole-aesthetics with an increased advantage in strength. Towards this human quest one of the trending technologies is 3D printing which has made rapid strides in the automobile, aerospace and a myriad of other industries. In structures continuity is well served by concrete but the slightest shift from regular geometries requires a lot of investment in shape forming shuttering increasing cost and human involvement.

Could 3D technology free man from these constraints on his creative thoughts and yet be economical of labor and materials? Could it be versatile enough to be relevant both in the shop and the site?

3D printing in construction industry can prove to be a possible solution to these technology limitations which in recent times has gained a lot of popularity around the world and is currently being used in different industries like making sculptures, small housing units, automobile industry etc. The results of which are very promising and its use is being extended to new industries at a very rapid pace.

This had provided enough reason to architects and engineers across the world to make use of 3D printing

E-mail: [1]vikrant.gupta@fluor.com, [2]sanjay.sehdev@fluor.com, [2]p.parthasarathy@fluor.com

[1]Structural Engineer, Fluor New Delhi, India

[2]Senior Design Engineer, Fluor New Delhi, India

[3]Construction Engineering Manager, Fluor New Delhi, India

technology in construction and develop it further through research and development to use it in full scale in construction industry.

In addition to its benefit in Industry 3D printing can help change our lives. Affordable low cost housing and toilets to all is the dream by our country. But achieving this goal may become very difficult due to cost of implementation and low space availability. Improved design and Innovation in 3D printing technology and environment friendly materials can help us to achieve this goal by reduced cost and reduced carpet area and quick completion. Printing of the complete small scale houses in mass quantity at the desired location can improve the lives of humanity.

Also it's been always a dream of humans to explore extraterrestrial world and if possible construct habitats in life conducive environments in space. Huge amount of money is spent across the world to find ways which can make it a reality. This can be made possible only with the help of advanced construction methods like 3D printing techniques.

This paper widely discusses the advent of 3D printing techniques in construction industry across the world, units already fabricated, extent of use, advantages over traditional construction methods and its limitations as of now.

Understanding 3D Printing and Overview

3D printing is an additive manufacturing process that can create a 3dimensional physical/ solid object from a design file in a computer. A digital 3D model is required which is printed in space by addition of material layer by layer sequentially until the whole object gets created. It enables the creation of very complex shapes like curvilinear with saving in material and time and hence the associated cost. The popularity and use of technology is gaining ground around the globe at a rapid pace. In fact 3D printers which are very much placed inside the R&D laboratories are being moved out and finding a prominent place in live factories. Large amount of funds are being invested in research and development so as to enable it in converting the dreams of mankind into reality. Its use is being extended successively many big industries like automobile, medical applications, electronics, components and tool manufacture, aerospace engineering etc.

Construction Industry

Construction industry across the world always demands constant innovations, efficient methods so as to reduce the project costs at every stage. It is very often marred by technical and non-technical issues like skilled craft availability, delay in approvals and high demand for quick completion which increases the total installed cost of the project. So there is always a lookout for the design innovations that may eradicate such problems and provide a cost effective solution. 3D printing in construction industry is one such innovative solution which if properly researched, developed and applied can easily result in huge savings in material quantities (as it reduces waste by using the exact quantity of material.) and schedule.

Many times architects need to curtail their creativity owing to constraint in design aspects due to use of typical types of supporting elements that are more or less rectangular or straight in shape. For example any continuous curvilinear shape had to be adjusted and modified based upon the supporting structure profiles which limits the architect's creativity. Advent of 3D printing in construction opens up a plethora of new opportunities to architects and engineers.

A lot of experimenting is going on in the world to make effective and large scale implementation of 3D printing in construction. The 3D printing is performed with large 3D printers known as construction 3D printers with computer aided programming at the backend which may use special material like mix of special concrete and composite mixtures which is much thicker than regular concrete and has self-supporting ability as it sets. A wide variety of materials such as metal sheets, wax, plastics, powder etc. can be used depending upon the requirements. The materials are fused together to create the required object with the help of computer driven nozzles placing the material in sequential layers.

It is now evident construction industry has already opened its arms to welcome 3D printing technique to explore new possibilities and conquer past challenges. However it would be very interesting to take notice of some of the advantages and disadvantages which 3D printing directly throws upon related to construction industry.

Advantages of 3D Printing in Construction

Complex Designs

3D printing in construction may facilitate the possibility of making complex designs which were earlier thought impossible due to technology limitations. This may extend flexibility to Engineers and Architects to include any shape into their designs and hence into reality. Creativity which is often hampered or suppressed due to design restraints may find a medium in 3D printing through which no restriction shall be imposed and world may see imaginations getting build in the shape of structures and buildings.

Cost Effective Solution

This method being fully automated comes with huge saving in cost through saving in materials as there would be no or minimized waste. 3D printers shall use material as per the actual requirement and hence a lot of material can be saved as compared to traditional construction methods where a lot of material is wasted. Once installed it shall require very less labor cost which will further add to the cost savings especially in the bigger projects. This is also seen as game changer in affordable housing segment as it has been already experimented in china that cost per unit of small house constructed through 3D printing is way lesser than those constructed through traditional methods.

Error Free Environment

Since 3D printing shall start constructing on receiving digital signals transmitted through computer aided programming due to which designs from the computer shall directly translate into the actual structure with the help of machines without any exterior (human) interference so chances of errors while fabrication or casting of individual components or entire structure shall be next to zero. This will further add to the cost savings derived from minimized rework which is a regular phenomenon in traditional methods due to human interface errors.

Reducing CO_2 Footprint

3D printing can greatly help in maintaining greener society by using less material and hence reduce CO_2 emissions in the environment.

Schedule

As construction industry is always driven by delivering the project within schedule. This is often achieved due to external factors like weather conditions, lack of availability of skilled labor and labor unrest. 3D printing if used can eradicate these limitations very effectively as it would require far less manual labor efforts and can work in any weather conditions.

Creativity

Architects and Engineers around the globe can extend their imaginative designs into reality with full flexibility at their hands with the help of 3D printing techniques.

Harsh Climate Construction

There are sites across the globe which has extreme weather conditions and construction work can be performed for only at a fraction of a year. 3D printing in which very less manual effort is required can prove to be a boon to such scenarios as machines can even continue the construction under harsh conditions. Also there is a huge potential in extending this technology to make habitats in extraterrestrial planets like moon and mars. This technique also provides safe working conditions with minimized accidents.

Miniature Models

Construction team can print and review the construction methodology by printing miniature model of the unit which is under design. Any changes which may affect construction shall be reviewed and revised in the design phase of the project resulting in time and cost savings.

Repairs & Shortfalls

Printing out damaged components at site and carrying out repairs can be seen huge advantage. Also quick printing of items having a shortfall at site will definitely help in eradicating the delays.

Construction in Congested Areas

Using robotic 3D printing for carrying out construction work like repairs or modification in congested areas. For e.g. inside sewers, manholes, trenches etc.

Disadvantages of 3D Printing in Construction

Every technology has its share of some disadvantages along with the benefits which need to be properly addressed so as to make it useful in all aspects. Some disadvantages are mentioned below:

In situ Conditions–Requirement of Large Sized 3D Printer Machines

Large sized 3D printers need to be produced so as to help construction industry effectively which can be easily installed at site and are able to produce the entire structure irrespective of the size of the structure.

Quality

It is evident 3D printing shall be error free technique for casting or fabrication of structures but small errors can be committed even with the help of computers and machines. A small error if not identified and rectified can be easily reflected in the entire structure which can prove to be a blunder. Proper qualities check process need to be defined at every stage of printing so as to identify even a small error at early stage.

Regulation

Another big hurdle that 3D printing in construction may face is regulation. Prime requirement of any project is safety. So with the advancement of technology the safety and dependency of these autonomously built components or units need to be properly addressed to suffice the requirements of regulating agencies.

Materials

Non availability of low cost and environment friendly materials as of now is a hurdle but can be easily passed over with proper research and development targeting the new materials that can be used.

Investment

Initial cost of investment for 3D printing is very high. This will definitely tend to change in the future. However for mega projects this cost can easily be ignored as compared to the benefits it offers.

Practical Implementation

As this exciting technology is being researched and developed around the world, many examples of buildings, housing units build through 3D printing technique have come up in different countries. Some of them are discussed below:

1. 3D printed concrete houses in China with each costing far less than cost incurred if done by traditional construction and made within time span of 24 hours.
2. In Spain a 3D printed steel pedestrian bridge is constructed.
3. An office building (concrete) constructed through 3D printing technique in Dubai (UAE).
4. A large villa was constructed in China with durable 250mm thick concrete wall with 3D printing technique.

Many big projects like steel bridges, big housing units and multistory buildings like skyscrapers have been already conceptualized in different parts of the world and work already started to make these happen at the earliest.

Conclusion

3-D printing will turn out a revolutionary technology in the construction industry though a lot of research needs to be done on construction ready materials. Rapid strides need to be made to commence use of this technology for steel buildings.

Implementation of this new technology will demand codes and specifications addressing the new materials and techniques being utilized in this technology. The construction industry and the Government bodies need to take a proactive role towards this end so that these hurdles are overcome upfront.

Regulation is an issue because of the need to continuously monitor and inspect the materials as they are being produced.

To get the maximum benefit of the technology in the current stage of development it should be treated as an additional technology that can be innovatively integrated with the available technologies. Use of 3 D printing technology will see an integration of BIM with the 3-D printers without human intervention to make more effective use of the technology in the near future and built in functions to take care of other utilities–piping/ electrical as well.

Future 3-D printer robots would also be armed with artificial intelligence to take decisions based on the site conditions.

The construction engineers, software programmers, automation engineers need to join hands and come to a single platform to make it a success.

Also 3D printing can prove to be a highly effective technology in constructing extraterrestrial habitats like on moon, mars etc. which still remains a mega ambitious dream of mankind.

From here 3D printing in construction in bound to fly to new heights. We engineers need to fasten our seatbelts to embark on a very exciting journey ahead.

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Reference

1. https://en.wikipedia.org/wiki/Construction_3D_printing Wikipedia “Construction 3D printing”

A Comparative Study of Crack Width Estimation for Liquid Retaining Concrete Structures

Pankaj Goyal[1], Vikrant Gupta[2], Arnab K. Bhattacharya[3] and Sourabh Marakhwar[4]

Abstract Control of crack width under service loads is a key parameter in design of liquid retaining concrete structures and often holds precedence over other design criteria. The main purpose of limiting crack width within certain allowable limits is to avoid penetration of cracks in concrete, which if not controlled, may lead to leakage, corrosion of reinforcement and may also affect long term durability. Various guidelines have been put forward by different international codes to estimate the actual crack width occurring under serviceability design conditions.

However it is interesting to note that the difference in results across these guidelines can sometimes be quite significant for the same design condition. This essentially means that the same design condition may require different concrete thicknesses and reinforcement requirements, based on the guideline adopted. Consequently, this has a direct impact on the quantity as well as project cost.

The current industrial scenario is highly cost competitive. On one hand, we need to be continuously on the lookout for opportunities to reduce project installation costs. This can be achieved by applying innovative design methods and judicious application of engineering guidelines. At the same time, while providing proposal estimates; we need to be careful about potential underestimate of material quantities. This would require careful evaluation of the impact of guidelines applicable for a particular project vis-à-vis the standard database available from past projects.

This paper performs a comparative study of results across various international guidelines to emphasize on the importance of crack width estimation for projects involving large liquid retaining structures. Considerable variation in results were observed, which if factored in, would lead to a more accurate estimation of materials at the proposal stage. The paper also illustrates how a comprehensive analysis of all fallouts before adopting a particular codal provision as a project specification, may preclude cost buildup owing to unreasonably stringent design criteria.

Keywords: Serviceability, Crack Width, Liquid Retaining Structures, Material Estimation

Introduction

Control of crack width under service loads is a key parameter in design of liquid retaining concrete structures and often holds precedence over other design criteria.

There are three perceived reasons that were identified for limiting the crack widths in concrete. These are appearance, corrosion, and water tightness. Although appearance and corrosion are equally important aspects but this paper addresses mainly the water tightness criteria. Design of liquid retaining structures mainly involves ensuring liquid tightness or imperviousness of the structure which mostly governs the design among all other design conditions.

Cracking in a liquid retaining structure is a serviceability phenomenon, which if not controlled, may lead to leakage of the fluid and hence shall all together defeat the purpose of the structure even if structure is safe in strength aspect of the design.

Due diligence is to be observed in limiting the crack width to avoid the occurrence of leakage. Various international codes and standards advise the allowable crack width limits to be adopted which shall ensure the safe design.

However on careful investigation it was found that there is wide disparity among different international codes, which ranges from method of calculation to defining allowable limits.

Due to this, the design results for liquid retaining structures, i.e. concrete thickness estimation, reinforcement distribution may vary to great extent depending on code adopted, which can have direct impact on the overall cost and economic aspects of the project.

E-mail: [1]pankaj.goyal@fluor.com, [2]vikrant.gupta@fluor.com, [3]arnab.k.bhattacharya@fluor.com, [4]sourabh.marakhwar@fluor.com

[1,2,3,4]Structural Engineer, Fluor New Delhi, India

In this paper, a detailed comparative study is performed among different international codes pertaining to crack width estimation, by keeping similar design parameters like loading, reinforcement spacing, clear cover, grade of concrete, rebar grade etc. Allowable crack widths are limited to recommendations of respective codal provisions and the design requirements arrived based on formulation advised by the corresponding code.

A large scatter of results was observed which further reinforced the idea of extending the comparative study to perform a comparative cost analysis.

Assessment of Crack Width in Flexure

British Standards BS 8007-1987

It limits the strain in the tension reinforcement is to 0.8fy/Es and the stress in concrete to 0.45fcu with the design surface crack width will be calculated from below equation

$$w = \frac{3a_{cr}\,\epsilon_m}{1 + 2\left(\frac{a_{cr} - c_{min}}{h - x}\right)}$$

Permissible value recommended is 0.2mm for severe or very severe exposure.

Eurocode 2 1992-3 (2006) & Eurocode 2 1992-1-1 (2004)

Eurocode defines degree of protection against leakage for liquid retaining structures in terms of tightness class ranging from 0 to 3. In general liquid retaining structures tightness class 1 is adopted to prevent leakage which corresponds to allowable crack width of 0.05mm to 0.2mm depending upon the ratio of hydrostatic pressure to Section depth.

Eurocode recommends the following equation for calculating the crack width:

$$W_k = s_{r,max}\,(\varepsilon_{sm} - \varepsilon_{cm})$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \dfrac{f_{ct,eff}}{\rho_{p,eff}}\left(1 + \alpha_e \rho_{p,eff}\right)}{E_s} \geq 0,6\frac{\sigma_s}{E_s}$$

ACI 350R & ACI 318

The ACI 350R Requirements for crack width estimation are based the following equation:

$$z = f_s \sqrt[3]{d_c A}$$

Where, maximum value of z is limited to 20 MN/m for normal environmental exposure.

Above equation is intended to provide liquid tight environmental engineering concrete structures and based on stress limits derived from Gergely-Lutz equation:

$$w = 0.076\beta f_s \sqrt[3]{d_c A}$$

The numerical limitations of z = 20 MN/m for normal environmental exposure correspond to limiting crack widths of 0.25mm.

However ACI 318 was updated in the 2005 edition to reflect the higher service stresses that occur in flexural reinforcement with the use of the load combinations introduced in the 2002 Code. The maximum bar spacing is specified directly to control cracking. The spacing of reinforcement closest to the tension face, s, shall not exceed that given by

$$s = 15\left(\frac{40{,}000}{f_s}\right) - 2.5c_c$$

but not greater than 12(40,000/fs), where Cc is the least distance from surface of reinforcement or prestressing steel to the tension face.

Indian Standards IS3370 Part 2

Indian Code recommends that if the strain in the tension reinforcement is limited to 0.8 fy/Es and the stress in the concrete is limited to 0.45 fcu, the design surface crack width should not exceed 0.2mm and may be calculated from following equation

$$w = \frac{3a_{cr}\varepsilon_m}{1 + \dfrac{2(a_{cr} - C_{Min})}{D - x}}$$

It can be noted that provisions of IS code is very much similar to BS code.

Canadian Standards CSA A23.3-04

Bars in flexural tension zones shall be spaced so that the quantity z given by

$$z = f_s (d_c A)^{1/3}$$

The value of z is limited to 25000 N/mm for exterior exposure corresponds to limiting crack widths of 0.33mm.However for liquid retaining structures, permissible limits are not defined in above mentioned Canadian standard. Hence, results are not presented for this case.

Comparative Study

Structural Configuration

A comparative study for crack width estimation and wall design is performed for wall of a rectangular tank i.e. liquid retaining structures across different international codes with varying loading conditions. Other design parameters are as listed below.

Design Parameters

f_{ck}, cylinder	= 30 MPa
fy	= 365 MPa
Es	= 200000MPa
Cover	= 50 mm
Rebar Diameter	= 25mm
Rebar Spacing	= 200mm

International Codes Considered

1. British standards, BS 8110& 8007
2. Euro standards, EN 1992-1-1& EN1992-Part 3
3. American standards ACI 318 & ACI 350R
4. Indian standards, IS3370 Part 2
5. Canadian standards, CSA A23.3-04

Results

It is interesting to note that values of crack width predicted by the codal equations/provisions showed a large scatter. Microsoft excel was used as the tool to calculate crack widths and wall design.

Four types of results has been published:

1. Crack width estimation considering wall thickness of 800mm and design unfactored moment = 200 kN-m with other parameters as mentioned earlier. See Table 1 for results.
2. Wall thickness estimation by limiting the crack width upto allowable values in respective codes with other parameters as similar to case "a". See Table 2 for results.
3. Varying the design unfactored moments considering wall thickness of 500mm and keeping other parameters as similar to case "a". See Graph I for results.
4. Varying the design unfactored moments and keeping other parameters as similar to case "b". See Graph II for results.

Results clearly show there is large variation across different international codes. Eurocodes produce most stringent values amongst codes for achieving similar safe design which is clearly visible in Table I and Table II where largest crack width and wall thicknesses were reported if structure is designed as per Eurocodes.

However, it is interesting to note that worked out crack widths and hence the designed thicknesses for similar design parameters, at lower unfactored moment values shows less variations, while large scatter is observed at higher unfactored moment values.

See Graph-I & Graph-II.

As per Graph-II, for the considered highest unfactored moment, thicknesses arrived through Eurocodes exceeds by almost 20% as compared to ACI and 33% as compared to British as well as Indian Code. This shall obviously have a significant impact on the total installed cost.

Table 1

Crack Width Estimation

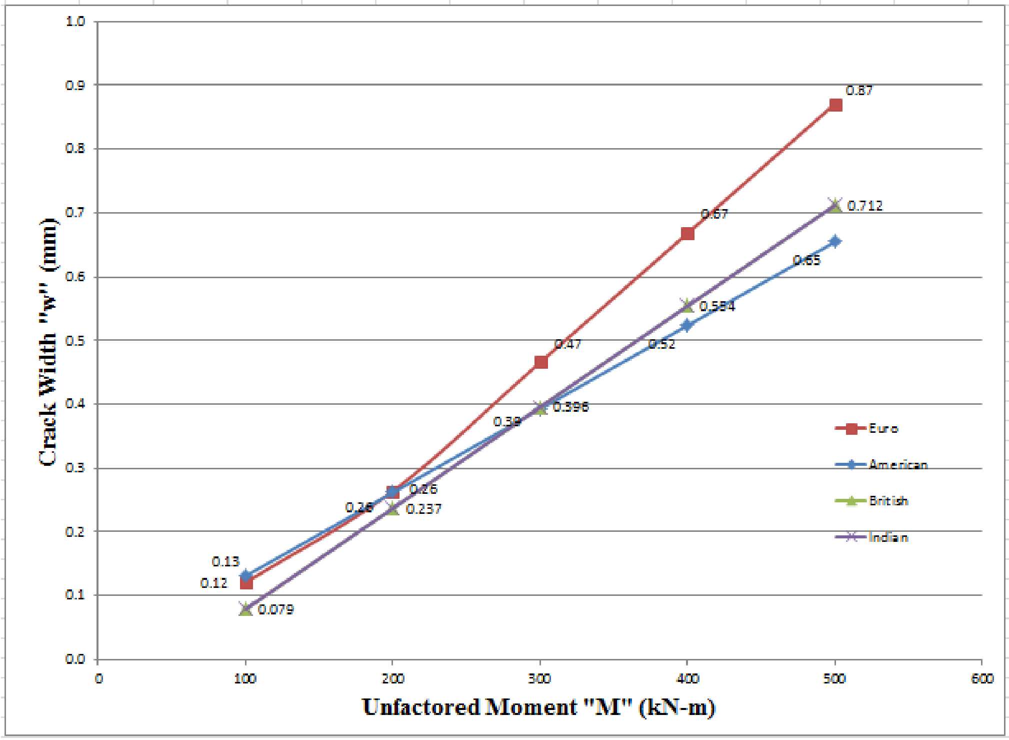
Sr. No.	**Code/ Standards**	**Crack Width (mm)**
1	British Standards	0.050
2	Euro Standards	0.156
3	American Standards	0.152
4	Indian Standards	0.050

Table 2

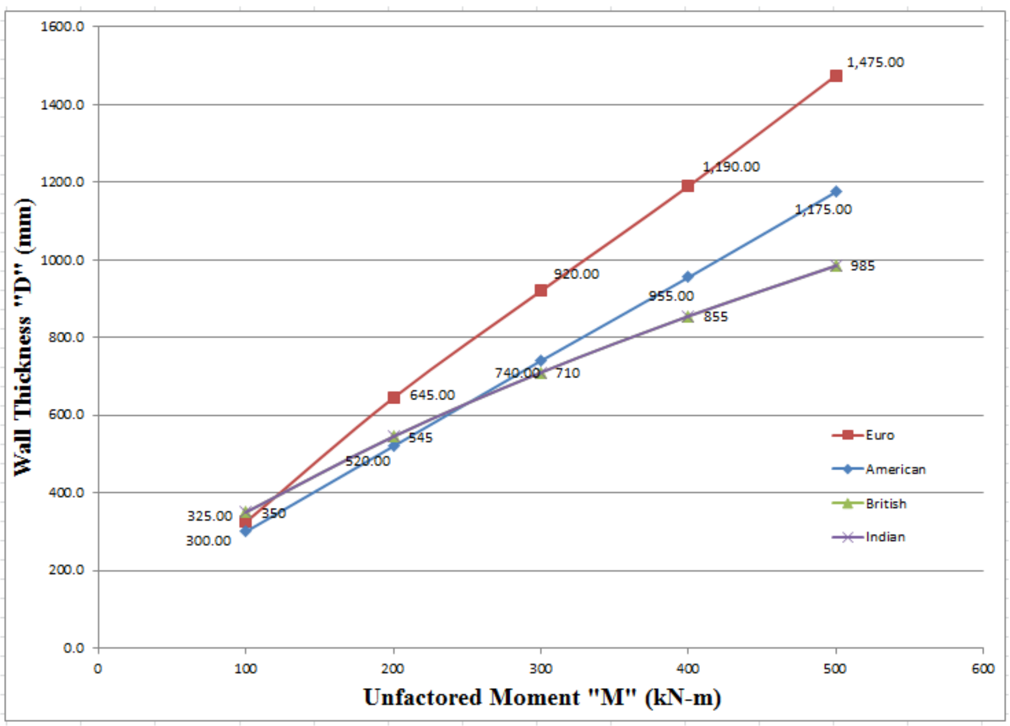
Wall Thickness Estimation

Sr. No.	**Code/ Standards**	**Wall Thickness (mm)**
1	British Standards	545
2	Euro Standards	645
3	American Standards	520
4	Indian Standards	545

Graphs



Graph 1



Graph 2

Conclusion

It is now understood that values of crack width predicted by different codal equations have a large scatter. This, in turn, will have a direct impact on the material and total installed cost of projects, which have large liquid retaining structures. Results shown in above section clearly indicate that selection of code may impact project material cost to the tune of about 35%.

As such, facility owners should carefully evaluate actual design requirements for their intended installations before prescribing a particular codal specification for the project. This will definitely add value to their project investments.

At the same time, parties bidding for these projects need to factor in these result variations while preparing their bid estimates based on their past projects.

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A Novel Approach Towards Energy Security and Environmental Cleanliness by Recycling MSW using Methenogenesis Process

Amar Kumar Das[1], Shovan Nandi[2] and Ritesh Mohanty[3]

Abstract Energy is a main cause for nation building and also plays a vital role in the development process as a domestic necessity and industrial progress. It mostly affects the price and services of other goods. Due to the scarcity of fossil fuels, itbecomes a great challenge for world's fuel demand. The decomposition of organic matters, both animals and vegetableswastes, a millions of cubic meter of methane in the form of biogas is produced in every year. Some alternative renewable sources like Methanol, Ethanol, Hydrogen, Natural Gas, LPG, CNG, LNG, Biogas and Biodiesel, etc. which may be produced at a reasonable cost from various wastes. Currently, much of our biodegradable wastes such as kitchen wastes, agricultural wastes & animal wastes are used to produce Biogas, a powerful greenhouse gas. Anaerobic digestion (AD) is a treatment that decomposes these wastes in the absence of oxygen, producing a biogas that can be used to generate heat and power. It resolves the social, economical, political and environmental issues to improve the quality of life. Biogas contains around (55–85)% of methane (CH_4), (30–40)% of carbon dioxide (CO_2), (0–0.005) % of Ammonia (NH_3), (0–2)% of Nitrogen (N_2), (0–2)% of Oxygen (O_2), (0–1)% of Hydrogen (H_2), a trace of hydrogen sulphide (H_2S) and moisture (H_2O). Methane has a calorific value of 10 KW/kg. The calorific value of biogas is around 4700 kcal or 20 MJ, Density is around 1.214 kg/m^3 and Critical temperature is around 82^0 C. The percentage of methane (CH_4) present in the biogas produced from the different wastes like Cattle dung around 60%, Green leaves& twigs around 65%, Food waste around 62%, Bamboo dust around 71.5%, Fruit waste around 49.2% and Dry leaves around 59.2%. The maximum volume of biogas produced from one cubic meters (1 m^3) is 0.950 m^3 in 7 days. Approximately 6kg of methane (CH_4) can be produced from 10kg of biomass. The residue left after production of the gas at the end of this process is used as a bio-fertilizer.

Keywords: Anaerobic Digestion (AD), Waste Management, Calorific Value, Biofertilizer

Introduction

Rapid increase in population, economic development and land scarcity it is very difficult to management of municipal solid waste become one of most critical environmental issues. Disorganized and inappropriate waste disposal has created severe environmental issues such as wild life habitat loss, air pollution, reduction of aesthetic value of the environment and destroying water bodies etc., that have direct impact on the society and the country's development. A growing country when shifts gear towards urbanization and industrialization, it produces a huge amount of waste which has to be disposed and due to the poor status of the active managing municipalities these are dumped by the old traditional strategy, the open yard dumping strategy. This type of dumping is happening since years as primitive actions for temporary solutions. But this approach is unscientific, outdate, and inefficient and the most important fact is, it is vulnerable to the atmosphere. Some urban areas in the country are plagued by acute problems related to solid waste. Because of the lack of serious efforts by concerned authorities, garbage and its management has become a tenacious problem and this notwithstanding the fact that the largest part of municipal expenditure is allotted to it. In the country, most local bodies suffer due to non-availability of adequate expertise and experience, there by the solid waste is not properly handled resulting into creation of environmental pollution and health hazards. It is reiterated that the local bodies lack technical, managerial, administrative, financial and adequate institutional arrangements. It is very necessary to provide

E-mail: [1]amar.das120@gmail.com, [2]shovan96nandi@gmail.com, [3]ritesh.rmohanty@gmail.com

[1]Asst. Professor, Department of Mechanical Engineering., Gandhi Institute for Technology, Bhubaneswar, Odisha–752054, India

[2]B.Tech (Final Year), Department of Mechanical Engineering, Gandhi Institute for Technology, Bhubaneswar, Odisha–752054, India

[3]B.Tech (Final Year), Department of Mechanical Engineering, Gandhi Institute for Technology, Bhubaneswar, Odisha–752054, India

proper guidance to such urban local bodies so as to make them efficient in managing the solid waste generated in their respective cities and towns. Human and resource capacity to carry out these studies which involves the collection of informative data on waste composition and quantity that is hauled to treatment sites or recycling canters or disposal sites is lacking (Kanat, 2010; Pichtel, 2005). Municipal or household wastes are often generated from several sources where variable human activities are encountered. Anaerobic digestion (AD) is one of the oldest processing technologies used by all the mankind. The main advantage of an anaerobic digestion is to production of biogas and can lead to efficient resource recovery and contribution to the conservation of non-renewable energy sources. Through the action organic nutrient present in the waste are converted into plants available forms Ndegwa and mixture (2001) and the process can reduce the mixture volume of (40–50)% by means of the metabolic heat generated in the thermophilic phase destroy.

It promotes activities such as waste is recycling and recovery followed by incinerating the waste to recover the energy with only the final inert material being considered for land filling. This will reduce the burden on the landfill and also open opportunities for new technologies in treating the MSW. Unfortunately, for such a system to work, basic data on the quantity and quality of waste that is generated are essential. This is essential for the design of any facility, as it will give an insight into the waste quality and quantity not only for now but also for the future and its effects on the treatment technology adopted.

Material and Methods

MSW Characteristic and Composition

The composition and characteristics of municipal solid wastes vary throughout the world, even in the same country depending upon social customs, standard of living, geographical location, climate, etc. A careful evaluation of percentage of bio-degradable/ combustible constituents/ moisture content of the waste and its chemical composition is necessary for selection of most appropriate technology. MSW is heterogeneous in nature and consists of a number of different materials derived from various types of activities. Different categories of urban municipal and industrial organic wastes are available in India. It is estimated that the estimated quantity of municipal solid waste is 30 million tons/ year and the estimated quantity of municipal liquid waste is 12000 million litres/ day. Municipal solid waste generally in solid or semi-solid form are commonly known as trash or garbage, consisting of everyday items (e.g., product packaging, grass clippings, furniture, clothing, bottles, food scraps, appliances, paint and batteries) that are collected by municipalities or other local authorities. The management of solid waste and valorisation is based on understanding of MSW composition and physicochemical characteristics.

Table 1 Waste composition category of msw

Type of Waste	Waste Components
Organic matter	Waste from foodstuff (e.g., food and vegetable refuse, fruit Skins, stem of green, corncob, leaves, grass, and manure).
Paper/cardboard	Paper, paper bags, cardboard, corrugated board, etc.
Plastic	Wrapping film, plastic bags, polythene, and plastic bottle.
Glass	Bottles, glassware, light bulbs, ceramics, and so on.
Metal	Both ferrous and non-ferrous metals including cans, wire.
Wood	Products comprised of wood (e.g., tables and chairs).

Table 2 Volume and time it takes to degenerate of different type of wastes in MSW

Type of Waste	% Volume of Waste Components	Approximate Time to Degenerate
Organic matter	59	A week or two
Paper/cardboard	12	10–30 days
Plastic	8	One million years?
Glass	4	Undetermined
Metal	7	100–500 years
Wood	2	1 year

During the process bacteria, fungi and other microorganisms, including micro arthropods, break down organic materials to stable, usable organic substances called compost Bernal *et al.*, (2008). It is also known as a biological reduction of organic wastes to humus or humus like substances. Extension or efficiency of the composting process is dependent on various factors Bernal.

Domestic Waste or Household Waste or Municipal Waste

Municipal solid waste includes the decomposable waste from household products during the preparation of meat, food, vegetable, and waste generated from shops, hotels, offices and other commercial units. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing. The characteristics of municipal solid waste collected from any area depend on a number of factors such as food habits, cultural traditions of inhabitants, life styles, climate etc. Total quantity of solid waste generated in urban areas of the country is about 1.15 lakh tonnes per day. Out of this 19643 tonnes of waste is generated in metro cities per day. More than 25% of the municipal solid waste is not collected at all, 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste.

Biomedical Waste or Hospital Waste

Hospital waste includes pathological, anatomical, infectious and hazardous wastes, which are produced from health care facilities and medical labs. It is generated during the diagnosis, treatment or immunization of human beings or animals and in research activities in these fields. It may include wastes like anatomical waste, cultures, discarded medicines, chemical wastes, disposable syringes, glucose bottles, cotton swabs, bandages, body fluids, human excreta etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific manner. The quantum of waste that is generated in India is estimated to be 1–2 kg per bed per day in a hospital and 600 gm per day per bed in a general practioner's clinic. It is estimated that only 5–10% of this comprises of hazardous or infectious waste (5–10 kg/day). After the notification of the Biomedical these establishments are slowly streamlining the process of waste segregation, collection, treatment, and disposal.

Hazardous Wastes or Industrial Waste

A large number of industrial organisations in our country produce various type of hazardous waste. These sources of hazardous waste from industrial processes, mining extraction, from pesticide based agricultural practices etc. they are corrosive, highly inflammable and explosive. The various types of Household wastes are hazardous waste include old batteries, shoe polish, paint tins, old medicines and medicine bottles. Hospital waste contaminated by chemicals used in hospitals is considered as hazardous. India generates around 7 million tonnes of hazardous wastes every year. As per the Ministry of Environment and Forest (MOEF), there are 323 hazardous waste recycling units in India and of these 303 recycling units use indigenous raw material.

Anaerobic Digestion

Anaerobic Digestion (AD) is a biological process that happens naturally when bacteria breaks down organic matter in environments in the absence of oxygen. Anaerobic digestion (AD) is a microbial decomposition of organic matter into methane, carbon dioxide, inorganic nutrients and compost in oxygen depleted environment and presence of the hydrogen gas. This process is also known as bio methanogenesis for rapid and controlled decomposition of organic wastes i.e. kitchen wastes and biomass feedstock to methane (CH_4), carbon dioxide (CO_2) and stabilized residue. In the generalized scheme of the anaerobic digestion, the feedstock is collected, coarsely shredded and placed into a reactor with active inoculums of methanogenic microorganisms. Since the methane is a significant greenhouse gas, anaerobic digestion has higher control over the methane production and contributes to lower the carbon foot print of the kitchen waste management in the way that the fugitive emissions are lower than then the emissions in the cases of the land filling and aerobic composting. Generally three main reactions occur during the entire process of the anaerobic digestion to methane: hydrolysis, acid forming and methanogenesis. Although AD can be considered to take place in three stages all reactions occur simultaneously and are interdependent.

Hydrolysis

Hydrolysis is a reaction that breaks down the complex organic molecules into soluble monomers (constituents). This reaction is catalysed by enzymes excreted from the hydrolytic and fermentative bacteria (cellulase, protease and lipase). End products of this reaction are soluble sugars, amino acids; glycerol and long chain carboxylic acids (Ralph & Dong 2010). The approximate chemical formula for organic waste is $C_6H_{10}O_4$ (Shefali & Themelis 2002) Hydrolysis reaction of organic fraction is represented by following reaction:

$$C_6H_{10}O_4 + 2H_2O \rightarrow C_6H_{12}O_6 + 2H_2$$

(Ostrem & Themelis 2004)

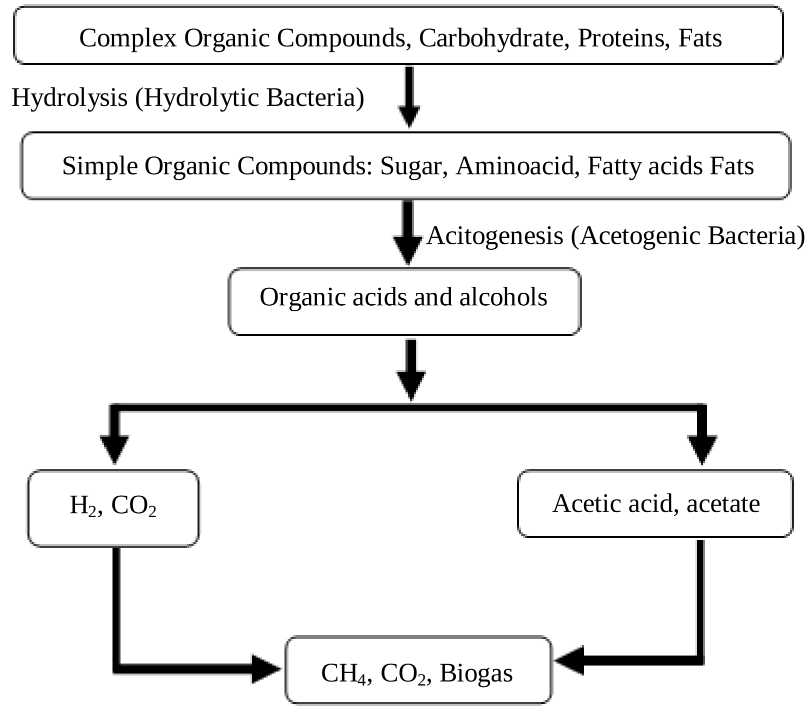

Fig. 1 Schematic diagram of anaerobic digestion process

Table 3 Properties of biogas, landfill gas & natural gas

Properties	Units	Landfill Gas	Biogas	Natural Gas
Lower calorific value	MJ/Nm3 $kWh/Nm^3 MJ/kg$	16 4.4 12.3	23 6.5 20	39 11 48
Density	kg/Nm^3	1.3	1.1	0.82
Relative density	–	1.1	0.9	0.63
Wobbe index, upper	MJ/Nm^3	18	27	55
Methane number	–	45	65	90
Methane	Vol%	35–65	60–70	85–92
Heavy hydrocarbons	Vol%	0	0	9
Hydrogen	Vol%	0–3	0	–
Carbon dioxide	Vol%	40	35	0.7
Carbon dioxide, range	Vol%	15–40	30–40	0.2–1.5
Nitrogen	Vol%	15	0.2	0.3
Nitrogen, range	Vol%	5–40	–	0.3–1.0
Oxygen	Vol%	1	0	–
Oxygen, range	Vol%	0–5	–	–
Hydrogen sulphide	Ppm	<100	<500	3.1

Acitogenesis

This stage is facilitated by microorganisms known as acid formers that transform the products of the hydrolysis into simple organic acids such as acetic, propionic and butyric acid as well as ethanol, carbon dioxide and hydrogen.). Acid forming stage comprises two reactions, fermentation and the acetogenesis reactions. During the fermentation the soluble organic products of the hydrolysis are transformed into simple organic compounds, mostly volatile (short chain) fatty acids such as propionic, formic, butyric, valeric etc., ketones and alcohols. Typical reactions occurring at this stage are the following Conversion of the glucose to ethanol; the acetogenesis is completed through carbohydrate fermentation and results in acetate, CO_2 and H_2, compounds that can be utilized by the methanogens. The presence of hydrogen is critical importance in acetogenesis of compounds such as propionic & butyric acid. These reactions can only proceed if the concentration of H_2 is very low (Ralph & Dong 2010). Thus the presence of hydrogen scavenging bacteria is essential to ensure the thermodynamic feasibility of this reaction (Ostrem & Themelis 2004) important reactions during the acetogenesis stage are as follow (Ostrem & Themelis 2004)

- Conversion of glucose to acetate:
- Conversion of ethanol to acetate:
- Conversion of propionate to acetate:
- Conversion of bicarbonate to acetate:

Methanogenesis

Methanogenesis is a reaction facilitated by the methanogenic microorganisms that convert soluble mater into methane. Two thirds of the total methane produced is derived converting the acetic acid or by fermentation of alcohol formed in the second stage such as methanol. The other one third of the produced methane is a result of the reduction of the carbon dioxide by hydrogen. Considering that the methane has high climate change potential the goal is to find an alternative in order to lower the environmental foot print of the organic waste treatment. Therefore this stage is avoided and instead of methane the production of volatile fatty acids is targeted. The reactions that occur during this stage are as follows (Ostrem & Themelis 2004).

Acetate conversion:
$2CH_3CH_2OH + CO_2 \rightarrow 2CH_3COOH + CH_4$
Followed by:
$CH_3COOH \rightarrow CH_4 + CO_2$

- Methanol conversion:
  $CH_3OH + H_2 \rightarrow CH_4 + H_2O$
- Carbon dioxide reduction by hydrogen:
  $CO_2 + 4H_2 \rightarrow CH_4 + H_2O$

Conclusion

The different technologies for recovering useful energy from Municipal Solid Wastes already exist and are being extensively utilized in different countries for their multiple benefits. It is necessary for the success of these technologies in India to evolve an Integrated Waste Management system, coupled with necessary legislative and control measures. A detailed feasibility study needs to be conducted in each case, duly taking into account the available waste qualities and characteristics and the local conditions as well as relative assessment of the different waste disposal options. Suitable safeguards and pollution control measures further needed to be incorporated in the design of each facility to fully comply with the environmental regulations and safeguard public health. The waste-to-Energy facilities, when set up with such consideration, can effectively bridge the gap between waste cycling, composting and land filling, for tackling the increasing problems of waste disposal in the urban areas, in an environmentally benign manner, besides augmenting power generation in the country. Ministry of Non-Conventional Energy Sources should provide financial assistance for energy recovery projects.

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A Review on Recovery of Crude Oil Extracted from Waste Plastics and Tyres using Pyrolysis Method

Amar Kumar Das[1], Ritesh Mohanty[2] and Himanshu Sekhar Pradhan[3]

Abstract Recent Challenges for disposal of non-biodegradable wastes and environmental pollution due to aggregation of such wastes, pyrolysis is carried out as an alternative, productive and presumptive process, rather than combustion, which is primarily marked as destructive one. Pyrolysis can be proved as an agreeable method for non-biodegradable wastes recycling, which seems to be very relevant for complex materials, such as plastics and tyres. This method could not only effectively actuate waste plastics with less pollution, but also effective in producing fuel that which diminish energy crisis. According to several research pyrolysis of tyres or rubber occurs at a temperature around 250^0C under atmospheric pressure and ends at a temperature of about 550^0C. In general, by pyrolyzing waste plastics and tyres three fractions are obtained: solid residue, liquid fraction and gas fraction. The general trend is an increase in output of liquid and gas fractions as the temperature increases. The works devoted to tyre pyrolysis, which are scrutinized on the reproduction of liquid fuels, results that the derived liquids are a complex dough of organic compounds containing a lot of aromatics. Thermal Pyrolysis is a process that converts waste plastics into liquid hydrocarbon products that can be employed as energy source for many intents such as diesel engines, generators, vehicles etc. Thus, thermo fuel process can be treated as another unique energy source. We all know that crude oil is the eventual source of plastics and most of the chemicals. Out of total 100 million tons plastics produced every year all over the world, 25 million tons is dumped. By dumping such tremendous amount of waste plastics, we are undermining lots of energy in the form of crude oil that is used to make plastics. The process acclaims a better alternative resource for energy security and makes the environment pollution free.

E-mail: [1]amar.das120@gmail.com, [2]ritesh.rmohanty@gmail.com, [3]himanshusekharpradhan083@gmail.com

[1]Asst. Professor, Department of Mechanical Engineering., Gandhi Institute for Technology, Bhubaneswar, Odisha–752054, India

[2,3]B.Tech (Final Year), Department of Mechanical Engineering., Gandhi Institute for Technology, Bhubaneswar, Odisha–752054, India

Keywords: Thermo Fuel, Plastic Wastes, Diesel Fuel, Pyrolysis, Cracking, Distillation

Introduction

Diesel engines are the better competent prime movers, from the point of view of conserving global environment and concerns for long-term energy security it becomes crucial to flourish surrogate fuels with equitiespro portionate to petroleum based fuels. Unlike rest of the world, India's requirement for diesel fuels is approximately six times that of gasoline, hence seeking substitute to fossil derived diesel is a reasonable choice. Surrogate fuels should be conveniently obtainable at low cost, environment friendly and fulfil energy preservation demand without obstructing engine's operational performance. Waste to energy is the contemporary movement in the selection of surrogate fuels. Fuels like alcohol, biodiesel, liquid fuel from plastics etc are some of the surrogate fuels for the IC Engines.

Plastics have become an essential part in today's world, due to their lightweight, durability, energy efficiency, coupled with a faster rate of production and design compliance, these plastics are engaged in entire spectrum of both industrial and domestic areas, hence plastics have become crucial and their applications in the industrial field are eventually increasing. At the same time, waste plastics have constituted a very severe environmental threat because of their massive quantities and their improper dumping problems. Waste plastics do not biodegrade in landfills, are not easily recycled, and degrade in quality during the recycling process. Instead of biodegradation, plastics waste goes through photo-degradation and turns into plastic dusts which can enter in the food chain and can cause complex health issues to earth habitants, through the thermal treatment on the waste plastic the fuel can be derive, by adopting the chemical process such as Pyrolysis can be used to safely convert waste plastics into hydrocarbon fuels that can be used for transportation.

Fuel Demand

The current rate of monetary growth is unfeasible without saving of fossil derived energy like crude oil, natural gas or coal. International Energy Outlook 2010 reports the world expenditure of liquid and petroleum commodity grows from 86.1 million barrels per day in 2007 to 92.1 million barrels per day in 2020 and 110.6 million barrels per day in 2035 and natural gas consumption increases from 108 trillion cubic feet in 2007 to 156 trillion cubic feet in 2035. This way, the oil and gas inventory available can meet only 43 and 167 years further. Thus, society must rely on the alternate/renewable energy sources like biomass, hydropower, geothermal energy, wind energy, solar energy, nuclear energy, etc. Waste plastic to liquid fuel is also an alternate energy source path, which can subsidize to deficiency of fossil fuel as in this process liquid fuel with comparable properties as that of petrol fuels is obtained.

Classification of Plastics

Typically, classification of plastics includes high-density polyethylene, low-density polyethylene, polypropylene and polystyrene. Also, plastics are classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, polyaddition, and cross-linking.

Low-density polyethylene (LDPE) is used for its toughness, flexibility, and relative transparency. LDPE is used to make bottles. To take advantage of its strength and toughness, it is used to produce grocery bags and garbage bags, squeezable bottles, shrink wrap, stretch films, and coating for cartons. It can also be found in toys, containers and packaging.

Polypropylene (PP) is known for its high melting point, which makes it ideal for holding hot liquids that cool in the bottles (e.g. ketchup and syrup). It can be manufactured to be flexible or rigid. PP is used to make containers for yogurt, margarine, takeout meals, and foods. It is also use for medicine bottles, bottle caps, and some household items.

Methodology

Pyrolysis

Pyrolysis is generally defined as the controlled heating of plastic ingredient in the absence of oxygen. In plastic pyrolysis, the macromolecular structures of polymers are broken down into smaller molecules and sometimes monomer units. Further degradation of these subsequent molecules depends on several different conditions including temperature, residence time, presence of catalysts and other process conditions. The pyrolysis reaction may be carried out with or without the presence of catalyst. Accordingly, the reaction will be thermal and catalytic Pyrolysis.

Thermal Pyrolysis of Polyolefin

The non-catalytic or thermal Pyrolysis of polyolefin is a high energy, endothermic process requiring temperatures of at least 350^0C to 500°C. In some researches, raised temperature as 700^0C to 900°C is essential to obtain proper product yields. The nature of these reactions depends both on the reaction temperature and on the residence of the products in the zone of reaction, an aspect that is primarily stirred by the reactor design. In other hands, the reactor design also plays a crucial role, as it must solve problems related to the low thermal conductivity and high viscosity of the molten polymers. Different types of reactors are used in pyrolysis; according to the literature review, but the most frequent being fluidized bed reactors, batch reactors and screw kiln reactors.

Fig. 1 Plastic gabages

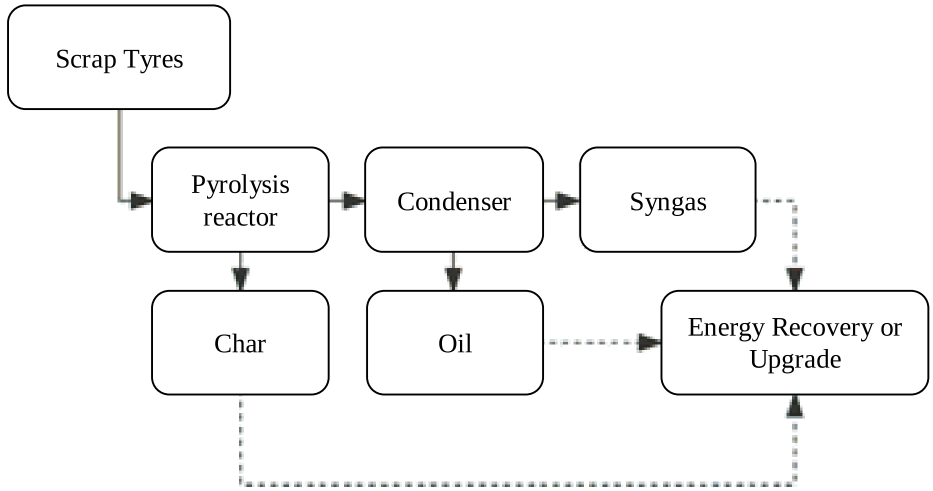

Fig. 2 Schematic diagram of thermal pyrolysis

Attributes of thermal degradation of heavy hydrocarbons can be stated by the following points;

- High production of C1s and C2s in the gas product.
- Olefins are less branched.
- Some olefins made at high temperature.
- Gasoline selectivity is poor.
- Gas and coke products are high.
- Reactions are slow compared with catalytic reactions.

Characteristics Analysis of Tyres

Tyres are produced by more than 100 different categories. The configuration of different tyre parts like the tyre sidewall or the tyre tread varies due to the different desired characteristics of product. Tyres are composed of rubber compounds and textile. Rubber compounds generally consist of elastomers (natural/synthetic rubber), carbon black, hydrocarbon oils, zinc oxide, sulphur and sulphur compounds and other chemicals like stabilizers, antioxidants, anti-ozonants, etc. The rubbers often consist of blends of two or three rubbers together with tyre preservatives. Due to these composite blend, the pyrolysis of tyres seems to be a sophisticated procedure comprise of many chemical reactions and complex interactions of the single components. To determine feedstock characteristics, analyses suitable for solid materials characterization are used such as proximate and elemental analyses.

Process Conditions of Pyrolysis Products

Temperature

Gas yield boosts with temperature due to more powerful thermal cracking in high temperatures and liquid's yield is approximately substantial on 500°C and decrease by increasing temperatures. Higher temperatures increase lighter products' yield, as benzene and kerosene content raise with temperature. Tar yield, does not show an obvious tendency in the studied temperature range and especially it has its maximum value at 600°C, with identical yields in lower temperatures of 425°C and 500°C. Char yield obviously decreases with temperature. The elimination of pyrolysis products from the high temperature zones, reduces the range of secondary reactions taking place that are known to raise char yield unlikely to oil yield. The specific surface of the produced char showed a significant increase by raising temperature.

Heating Rate

For a given temperature, the heating rate (°C/min) has a negligible impact on products output. In general, the faster the feed stock is heated to a given temperature, the less tyre-derived char and more oil and gas are obtained. The surface area of the solid product increases as heating rate increases. High temperature in small residence times along with the immediate cooling, favour liquid output as pyrolysis gas and vapours are condensed, before reaction cracks larger molecular weight molecules to gaseous products. At higher temperatures the main product is gas. Tyre pyrolysis at a low heating rate produces high amounts of char and gas. A high heating rate decreases liquid output, while this does not happen on balanced heating rates.

Particle Size

The particle size of tyres was found to influence not to great extent pyrolysis products. However, the larger the particle size is, the greater will be the amount of oils at high temperature range, while the yield of carbon black is almost constant under the same conditions.

Table 1 Proximate analysis of scrap tyre rubber

Author	Volatile (wt %)	Fixed Carbon (wt %)	Moisture (wt %)	Ash (wt %)
M. Juma *et al.*	61.65	22.65	1.72	14.02
Rodrigues *et al.*	58.7	21.8	-	3.9
Jong Min Lee *et al.*	67.5	28.5	0.6	3.7
Yu Min Chang et al	62.35	26.28	1.32	10.28
Gonzales *et al.*	61.8	29.24	0.8	8.0
Chen *et al.*	93.75	-	0.54	5.4
Loresgoiti *et al.*	59.6	27.8	-	3.6
Orr *et al.*	68.8	23.4	0.5	7.6
Williams and Bottrill	66.5	30.34	0.8	2.5
Atal and Levendis.	58.8	33.61	-	7.7

Table 2 Elemental analysis of scrap tyre rubber

Author	C (wt %)	H (wt %)	N (wt %)	S (wt %)	O (wt %)
M. Juma *et al.*	81.24	7.36	0.49	1.99	8.92
Rodrigues *et al.*	74.2	5.9	0.4	1.5	4.7
Jong Min Lee *et al.*	83.9	7.7	0.3	1.4	3.1
Yu Min Chang *et al.*	74.8	6.97	0.22	1.6	5.02
Gonzales *et al.*	86.7	8.2	0.4	1.4	1.3
Chen *et al.*	81.18	7.24	0.48	1.64	2.07
Berrueco *et al.*	88.5	6.7	0.5	3.0	3.1
Arion *et al.*	73.8	5.4	0.44	1.71	0.11

Fig. 3 Waste tyres

Gasoline-Range Hydrocarbons

The pyrolysis of plastic wastes produces a whole spectrum of hydrocarbons including paraffin, olefins and aromatics. But all these hydrocarbons are not suitable for gasoline usage. The qualities of gasoline are usually measured in terms of volatility and octane number of the hydrocarbons. For gasoline production, aromatics, naphthene's and iso-alkanes are highly desirable, whereas olefins and n-paraffin are least desirable.

Volatility

Adequate volatility is required for smooth operation of petrol engines. Light hydrocarbons have higher volatilities than heavy hydrocarbons. They may cause vapour lock when the engine is very hot. However heavy hydrocarbons have lower volatilities, but they may not be volatile enough to start the engine when the engine is cold. Suitable hydrocarbons are in the C5–C8 range. Some C9 and above may be added according to climate and season.

Octane Number

This is a measure of the gasoline quality for prevention of early ignition which leads to cylinder knock. Higher octane numbers are preferred for internal combustion engines.

Use of Catalyst

Advantages of using catalyst to enhance plastic pyrolysis reaction and to modify the distribution of pyrolysis products, catalysts are broadly used in research and industrial pyrolysis processes. Petroleum fuels, such as LPG, petrol, kerosene, and diesel, are hydrocarbons. The hydrocarbon ranges from C1 to C24. The PE pyrolysis products are significantly straight hydrocarbons from C1 up to C80, which contain much heavier molecular weight components. One of the main reason of using catalysts is to break down the carbon chain length of the pyrolysis products and thus to decrease the boiling point of the products. The products from non-catalytic PE pyrolysis contain high proportion of mono-alkenes and di-alkenes. Some catalysts are applied specially to reduce the unsaturated hydrocarbons and to promote the yield of aromatics and naphthene's. This can significantly increase the stability and cetane number of the oil products.

Results & Discussion

According to the diesel regulation, the elemental characteristics of plastic derived fuels are experimented in most research studies because the diesel fuel is obtained from synthetic hydrocarbon polymers that do not contain any other ingredients except carbon and hydrogen. The quality of the crude oils produced from plastics varies largely based on the process and the feedstock. The diesel range products in the LDPE derived fuels contain the same linear chain alkanes as those in the fresh diesel. The content of alkene in LDPE derived products is much higher than that in diesel, which reduces the storage stability of fuel. In comparison with naphtha, aromatic compounds, and branched hydrocarbons, linear alkanes have relative higher cloud point with the same carbon number or density. Therefore, many catalysts and processes are used during pyrolysis to eliminate linear hydrocarbons and to raise the proportion of others. From several case studies it is found that plastic derived fuel contains high proportion of linear alkane that has low solubility in diesel. This can significantly increase the cloud point that is the temperature at which the first crystals appear in diesel. Some other properties of plastic derived fuels are controlled in the producing processes such as distillation range and carbon residue in the fuel.

Conclusion

Plastics presents a big challenge to today's society and environment. Million tons of plastics are getting disposed into the oceans and other water sources annually, which is a massive quantity, killing about 1,000,000 species of oceanic life. Though human society has serious about this challenge and responded with developments in creating degradable bio-plastics, there is still no constructive effort has done to repair the damage already caused. In such situation, the catalytic Pyrolysis studied here presents an efficient, clean, economic and very effective means of eliminating the trash that we have left behind over the last several decades. By converting plastics to crude oil and further crude oil to fuel, we solve some issues, one of the large plastic seas, and the other of the fuel shortage. This dual benefit, though will exist only if the waste plastics last, but will surely provide a strong platform for us to build on a sustainable, clean, pollution free and green future. By considering the financial benefits of such a project, it would be a great boon to our economy. So, from the several studies conducted we can conclude that the properties of the fuel obtained from plastics are comparatively similar to diesel and further researchin this sector can yield better results in near future.

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A Study of Dam Break using P.M.P. and P.M.F. Data for Gunjawani Dam

Ashish Srivastava[1] and R.B. Magar[2]

Abstract Safety of Dam is based on its own capacity to safely bear the probable maximum flood that may arise due to heavy precipitation in the catchment area along with the breaches due to one or many tributaries which may be entering the channel. Based on the previous 30 or more years' data from the rain gauge stations, Probable maximum precipitation is found out & flood routing technique is used for finding out the flood hydrographs using the flood flow at various sections in upstream side. The flood forecasting, protection and the design of the dam and its spillway using hydrologic analysis is carried out which includes analysis of flood routing and flood routing is carried out either by hydrologic routing or hydraulic routing. The downstream channel routing with respect to the possible maximum design discharge from spillway, so as to contain the level of water lesser or equal to highest flood level of either the natural river or man-made canal. A case study of Gunjawani Dam Break is carried out using Probable maximum precipitation (PMP) and Probable Maximum Flood (PMF) data with respect to the design, height of the dam & the volume provided at the spill way based on the downstream routing.

Keywords: PMP, PMF, Dam Break Study

Introduction

Natural river or water flowing body either perennial or non-perennial finds its own course of flow with respect to the topography & natural gradients of the area, based on the highest flood level of the river, human habitation has been developed in form of cities, towns & or villages.

As the main resource of existence for human kind is water, thus from ages the storage of water in form of ponds, lakes & reservoir has been artificially created.

E-mail: [1]ash@structechindia.com, [2]rajendramagar69@gmail.com

[1]Managing Director, Structech Consulting Engineers India Pvt. Ltd., Vashi, Maharashtra, India

[2]Professor and Head, Civil Engineering Department, Kalsekar Technical Campus, School of Engineering and Technology, New Panvel, Maharashtra, India

The Modern world requires large amount of water for residential, commercial, industrial & agricultural purposes, thus to make available water for the entire year, large reservoirs are created by provision of rigid obstruction in the natural river course, these obstructions are known as Dams, which are either earthen, masonry, steel, concrete, RCC or combination of above.

Dam helps in controlling floods, providing perennial water for agriculture, generating power by providing hydro-electric plants and is used to store water with a large catchment area ranging from few kilometers to hundreds of kilometers for large basin.

Gunjawani Dam is a major irrigation project for storage of water, situated on KANANDI tributary of Kanand River in Krishna basin in Pune district of Maharashtra. The total culturable command area is 19.484 Th ha. &the ultimate irrigation potential of the project is 16.5 TH ha., The project was commenced in the year 1997 under 8th,5-year plan. There are around 23 small, medium & large dams in Pune district & Gunjawani ranks as a smaller dam among the above.

A comparison with respect to the highest flood that may arise in the future due to natural phenomenal & the capacity of the dam to resist the flood is carried out & presented in summary.

The dam break study is required before finalizing the top reduced level of the spillway along with the consideration of the height of gates or reassessing the dam by study of flood routing to check the capacity of dam as per the existing reduced level. There have been many catastrophic failures due to poor or no pre design data and analysis of a dam break.

The following failures of dams in India have been cited below with the reasons for its failure, starting from post independent era:

1. A gravity dam made by composites construction using earth fill and rock fill was built in Adilabad District of Andhra Pradesh completed in 1958 named as Kaddam Project Dam with a height of 30.78m and a crest of 3.28m width failed due to over topping above the crest of flood in August 1958 the failure was attributed in the left bank of the dam section.

Fig. 1 Arial view of gunjawani dam

Source: google

2. An earthen dam named Kalia Dam in the state of Gujarat of 23.08m height was constructed between 1952-1955 with a crest length of 213.36m, the capacity of reservoir in full storage was 13.98 million m3, it failed due to the energy dissipation structure failure followed by the collapse of embankment due to the failure of the foundation bed, this dam failed in year 1959.
3. In year 1977 an earthen dam of 11.45m height was constructed on a tributary of Kaveri River in the state of Tamil Nadu, the dam was provided with 5 vertical lift shutters of 3.05m width to regulate the river. The storage capacity of this dam was 12.3 million m3, due to unprecedented flood the water flow overtopped the dam due to which the rear slopes of earthen dam were eroded. Also a minor earthquake was recorded during the failure period, although the shutters of the dam were partially lifted so as to release the water but it did not help due to high inflow of flood.
4. A dam named Machhu II Dam was constructed in the state of Gujarat in year 1972 under an irrigation scheme. It was a composite dam with masonry spillway and earthen embankment on either side. The total height of dam was about 22.56m with a crest length of 164.50m in spillway section and 3742m of crest length in earthen embankment. The dam failed due to unstable flood pattern and inadequate capacity of spillway, the water overtopped the embankment which caused heavy loss of human life.
5. Nanaksagar Dam in the state of Punjab was constructed in year 1962 which failed in year 1967 due to heavy precipitation which caused the dam to failed at the downstream toe thereby causing sudden settlement of embankment.
6. Khadakwasla Dam in Pune District of state of Maharashtra was constructed in year 1879 as an masonry gravity dam with foundation on hard rock, the height of dam was 31.25m above river bed level with an crest length of 1.47m, this dam failed due to unavoidable discharge made by Panshet Dam on the upstream side when the Khadakwasla reservoir was almost full to its capacity with the spillway discharging the outflow at its peak the masonry gravity dam failed completely within 4hrs of incoming flood causing heavy loss to human life in Pune city.
7. Tigra Dam of 24m height masonry gravity type was constructed in 1917 in the Sank District of the state of Madhya Pradesh for the use of water supply scheme. The Dam failed due to the lesser capacity of holding the flood which, caused sliding away of blocks due to heavy pressure on the wall. Most of the Major or Minor Dams in India were constructed in post-independence era, in times when the dam failure analysis was not carried out due to non-availability of analytical and computing techniques for estimating the maximum design precipitation and flood. In modern times all the existing dams are being studied again for the dam break based on the reduced level of the spillway and the gate overflow capacity versus the inflow of flood in the reservoir.

The dams fail due to overtopping of spillway and embankment, erosion in downstream side, abrasion, cavitations and etc.

Literature Review

Despite technological advances in recent decades, the worldwide safety of dams does not appear to have greatly improved since the major failure rate in the period between 1946 and 1955 almost doubled in the following decade (Johnson and Illes 1976; Singh 1996), with a rising trend toward the end of the last century (Donnelly and Morgenroth 2005; Saxena and Sharma 2004).

At the same time, several survey and monitoring studies (e.g., Douglas *et al*. 1998) have reckoned that the annual probability of a major dam failure is in the order of 10-4, which is one order of magnitude lower than the probability usually assumed for the design of spillways. Similarly, apart from very rare situations the failure of dam is ineluctable; statistics show that around 60% of dam failures occur due to structural shortcomings, around 30% due to incapable spillway design and probable maximum flood computations & around 10% due to landslides, which results in overtopping of dams(Singh 1996).

In the future, climate change and progressive structural deterioration of the oldest dams might play a significant role in modifying these percentages, while the continuous and rapid growth of built-up zones in the tail water areas will significantly increase the exposure level. Given this state of affairs, the problem of dam safety assessment is of considerable importance, and in many countries national technical legislation requires delineation of areas that would be flooded in the event of dam failure. Accordingly, predicting the flood propagation effects following a hypothetical dam failure is an indispensable requirement both for land-planning purposes and for the formulation of disaster contingency plans. In this direction, the approach widely accepted is based on the shallow water equations (SWE), since they best combine computational efficiency and accurate reconstruction of the physical phenomenon, as clearly shown by recent scientific literature (e.g., SoaresFrazão *et al*. 2000, 2003) produced by the important European Projects Concerted Action on Dambreak Modelling (CADAM) and Investigation of Extreme Flood Processes and Uncertainty (IMPACT).

SWE is used to determine the waves that causes dambreak even in real topographical situations (Hervouet and Petitjean 1999; Valiani *et al*. 2002; Begnudelli and Sanders 2007; Aureli *et al*. 2008b; Natale *et al*. 2008; Pilotti *et al*. 2010).On the other hand in case of very non-uniform topography, which may by symbolized by mountainous zone as steep sloped areas, the primary assumption for SWE can be taken as negligible vertical acceleration & slight bed slope (e.g. Cunge *et al*. 1980; Toro 2001) are breached. Therefore, in this context it seems important to evaluate their applicability (Pilotti *et al*. 2006, 2010).

The ultimate confidence in the use of a mathematical model is based on the comparison of its performance with known test cases. Usually these test cases are analytical solutions that can be derived under restrictive geometrical conditions that are not satisfied in field applications. For this reason, it is desirable to have field test cases to verify the accuracy, robustness, and effectiveness of both the adopted mathematical model and numerical scheme. Although field tests do not allow comparisons as precise as analytical solutions, in our opinion they provide an overall direct evaluation of the actual engineering effectiveness of the tested model. Unfortunately, according to Garcia (2007), "there is very little information to test, calibrate and validate mathematical models that could potentially be used to mitigate the impact of catastrophic flows." Actually, in the literature only a handful of historical dam-break test cases is sufficiently documented, including the events of Malpasset (James 1988; CADAM 1999; Goutal 1999, Tous (Alcrudo and Mulet 2007), St. Francis (Begnudelli and Sanders 2007), and Sella Zerbino (Natale *et al*. 2008).

To our knowledge, in none of these cases did the dam-break wave propagate in very steep valley bathymetry. Only in a few other field cases, in which the flood wave caused geomorphic effects that in turn significantly affected the flow, do complete data sets well suited for testing morphological models exist (Jarrett and Costa 1986; Capart *et al*. 2007). Also experimental data derived from field physical models are very rare (e.g., De Marchi 1945; Hervouet and Petitjean 1999). On the contrary, more frequently, one finds in the literature laboratory data concerning dam-break flows in idealized configurations, both with movable bed (e.g., Capart and Young 1998; Spinewine and Zech 2007) and fixed bed (e.g., SoaresFrazão and Zech 2007; Aureli *et al*. 2008a).

To provide further data useful for model testing, we present in this paper the historical case of the Gleno Dam break, which happened on 1ST December, 1923, in the Italian Alps. This accident is the only important historical case of dam break produced by structural deficiencies that occurred in Italy. About 4:5 × 106 m3 of water retained in the reservoir were released in a few minutes when a central part of the dam measuring approximately 80 m collapsed, causing at least 356 casualties and huge destruction along the 21 km downstream valley. The aftermath of this catastrophe was so intense as to gain mention even in the international technical literature (De Martini 1924; Stucky 1924) and it deeply influenced the evolution of Italian regulations and their administration regarding dam design and hydraulic hazard evaluation (Maugliani 2004). In spite of its relevance, this accident, already well documented from a historical and structural point of view (Ganassini and Danusso 1924; De Martini 1924; Stucky 1924; Pedersoli 1973), has never been characterized from a hydraulic standpoint. In this paper, we reconstruct this event by recovering a great deal of information that can be used for modeling purposes. Because no topographic survey from before 1923 was available for the area of interest, we have carefully reproduced the valley bathymetry presumably existing before the accident by means of a 5 × 5 m digital elevation model (DEM) corrected based on available historical documents. The dynamics of the reservoir emptying is described through a two-dimensional (2D) shallow water simulation; the outflow discharge hydrograph computed at the dam location provides the upstream boundary condition for the one-dimensional (1D) simulation of the dam-break wave propagation along the downstream valley. The narrowness of this valley with respect to the huge discharges involved justifies the adoption of the 1D schematization. We have employed the finite-volume first-order numerical scheme presented by Capart *et al*. (2003), specifically proposed for flood modeling over natural bathymetries. This method is based on an approximate formulation of the momentum conservation equation where the geometric source terms due to bed steepness and lack of prismaticity are included in the flux term, thus allowing a strict fulfillment of the C-property. The flux term is computed according to the Pavia flux predictor (PFP) upwind technique proposed by Braschi and Gallati (1992).

Case Study and Methodology

A case study of Gunjawani Irrigation project with storage on river Kanand near Velhe village, taluka Velhe, district Pune, with direct left bank canal for irrigation of 37050 acres of Velhe, Haveli, Bhor and Purandar taluka of Pune district. The Kanand river is tributary of Gunjawani river which is a tributary of river Nira, which is a tributary of river Bhima, located on latitude 18*- 18’- 30” (North) and longitude 73* - 38’ – 27” (East).

The catchment area of the project is 50.613 Km^2. with a 50% dependable runoff of118.063 Mcum., the gross annual utilization is 118.56 Mcum.

The gross capacity of reservoir at F.R.L. is 104.69 Mcum., the capacity of dead storage at M.D.D.L. is 0.210 Mcum., the capacity of live storage is 104.48 Mcum.

F.R.L.: 727.20 m
H.F.L.: 727.80 m
River Bed R.L.: 677.975 m
Max height of dam: 52.825 m
Evaporation losses: 6.07 Mcum.
Area under submergence at F.R.L.: 641 ha
Type of dam: Earthen dam
Total length of dam excluding spill way: 1524 m
Total length of dam: 1730 m
Free board above H.F.L.: 3 m
Total quantity of Earthen dam: 3.84 Mcum.
Masonry dam: 0.028 Mcum.
Concrete: 0.008 Mcum.
Excavation in spillway and tall
And approach channel 0.037 Mcum.
Spillway Type: Ogee type gated waste weir (2 Nos. of 12 x 8 m)
Peak discharged designed: 1175 Cumecs
Depth after crest for designed
Flood: 5.6 m
Crest level: 722.20 m
Length of spillway: 41.00 m
Foundation level of spillway
Outlet
Location: Ch. 1125 m
Type: conduit type
Foundation level: 682.265 m
Full supply discharge required: 15.904 Cumecs
Sill level of outlet: 683.314 m
Discharge = 352.5 Cumecs
Discharge passing through tail channel = Q = A x V = 4804 Cumecs
Tail channel design to pass about 60% flood of 736.36 Cumecs is @ 441.40 Cumecs
Wave height by Mollitore formula = H_w = 1.2 m
Free board required = 4/3 H_w = 4/3 x 4 = 1.68 m
Using T Savillies method the required free board = 1.35 m.

Since the minimum free board required to be provided for major & medium projects should be 3.00 as suggested by C.W.C., So provided free board of 3.0 m.

Table 1 shows a final flood routing are as follows:

Table 1 Flood routing

Size of Gate	No. of Gate	Designed “Q”	Designed H.F.L.	F.R.L.	H.F.L.
12 x 8	2	736 m^3/sec	727.461	727.20	727.80

Fig. 2 Existing gujawani dam

Results and Discussions

To find P.M.P. and P.M.F, a unit hydrograph by Clarks method has been used under Non Submergence & with effect of submergence are calculated and reproduced in graph for relevant readings as follows:

From the below Fig. 5 shows the maximum flood level calculated using P.M.P and further P.M.F data. The final flood routing level is 727.438 m, which is lesser than highest flood level of 727.800m, which indicates the water will not overflow the top level of the dam and will not affect the stability of dam, thus this study of dam break concludes that, the dam is fit for intended use in case of probable maximum precipitation.

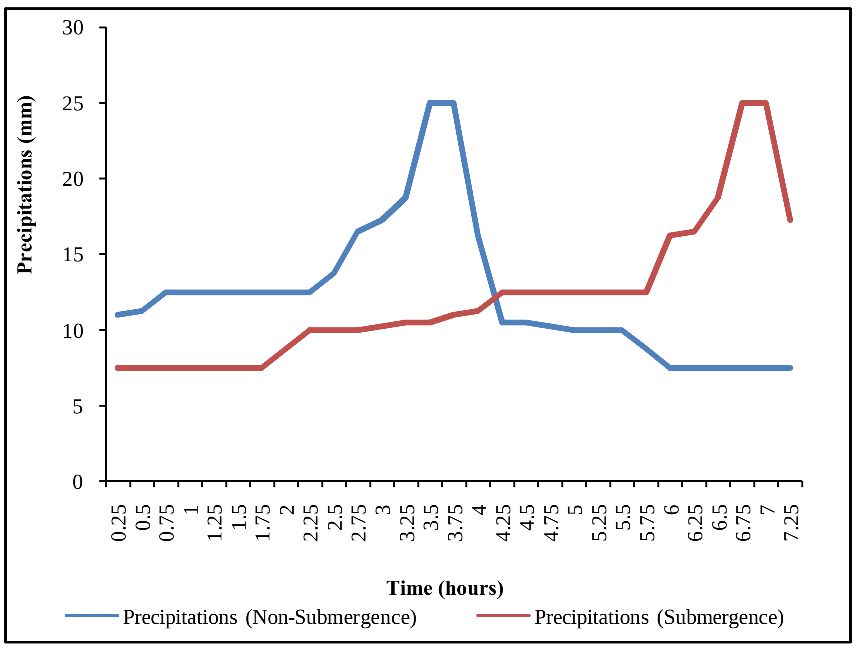

Fig. 3 P.M.P unit hydrograph for submergence and non-submergence conditions

From the above Fig. 3, the maximum total discharge for base flow and run-off has been found to be 1175 cumec for given unit time.

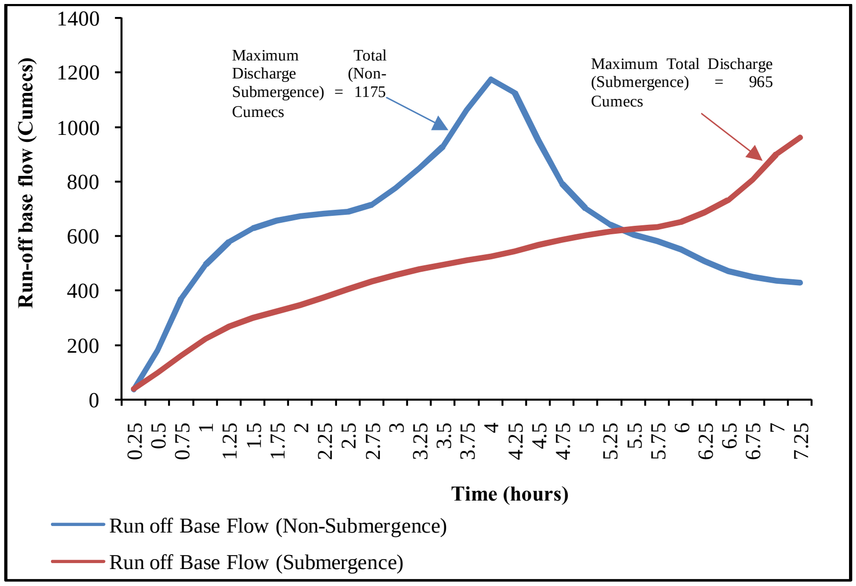

Fig. 4 P.M.F unit hydrograph for submergence and non-submergence conditions

From the above Fig. 4, the maximum total discharge for base flow and run-off has been found to be 965 cumec for given unit time.

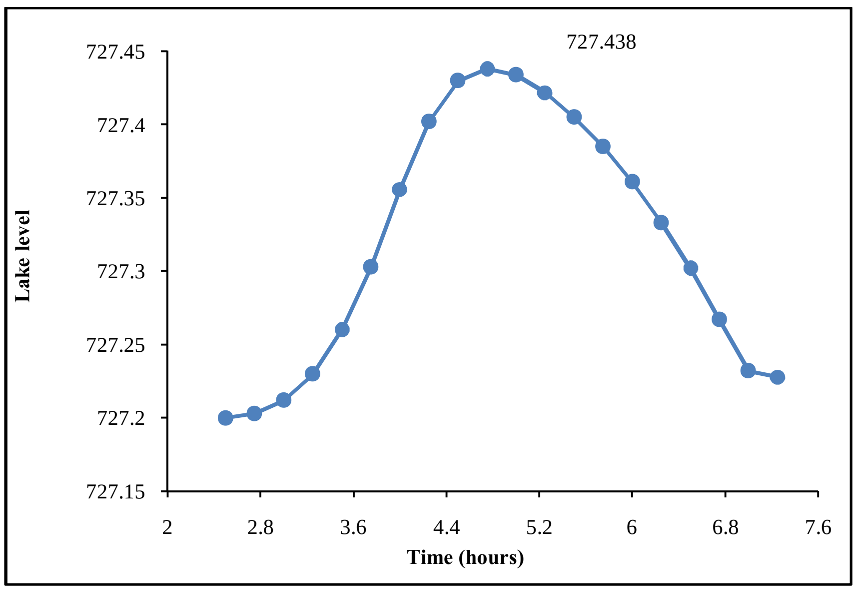

Fig. 5 Screened final flood routing

Final Controlling Levels for Gunjawani dam are as follows:

1. River Bed R.L. : 677.975 M.
2. C.B.L. R.L. : 682.800 M.
3. M.D.D.L. : 685.400 M.
4. F.R.L. : 727.200 M.
5. H.F.L. : 727.800 M.
6. T.B. L. : 730.800 M.
7. Submergence R.L. : 727.200 M. (@ F.R.L. being gated spillway)

Summary and Conclusion

Thus after calculating the maximum flood water level by using P.M.F and routing techniques it has been found that the Dam is safe further probable maximum flood that may arise in the life of the dam. The dam is safe for the intended use and shall not be damaged due to high precipitation.

- The storage at F.R.L. (Full Reservoir Level) 727.20 M is 3.698 T. M. C. (Thousand Million Cubic Feet), 104.69 M. Cum Maximum water level is kept at 727.80M as the gated spillway (2 Gates of 12X8 M) is provided.

- Flood routing studies has been carried out accordingly.
- T.B.L. (Top base level) is kept as 3.00 M above H.F.L (highest flood level) i.e. at 730.80 M. This is supported by T-Savilles studies where actual free board required is 1.35M only.
- The utilization plan for Kharif is 29.45 M. cum, Rabi is 51.178 M. cum, Hy. Wheat is 19.54 M. cum, Utilization losses are 5.761 M. cum and water supply is 12.25 M. cum which totals out to be 4.17 T.M.C. This is plan as against 50% available dependable yield of 4.17 T.M.C. thus it is seen that the irrigation requirement as planned can be fulfilled.
- The command area of the project is in water scarcity area. It is proposed to utilize 50% dependable yield (4.17 T.M.C). Necessary carryover of 0.45 T.M.C is provided in storage is order to achieve 75% reliability since, the reservoir operation table for 37 years is carried out which supports the success of reliability.

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A Suggestive Guide on Economic Bracing Pattern in Modular Steel Pipe Racks

Arun Dhiman[1], Tapas Kumar Manna[2] and Mangesh Amrut Sakpal[3]

Abstract Proper bracing arrangement plays a vital role in structural stability and an economical design. The paper describes the behavior of a pipe rack with vertical braced frame in longitudinal direction when it is subjected to independent application of wind loads, thermal loads and hog/sag loads. The study is done for different possible bracing patterns. And the effectiveness of a particular bracing layout is determined by tabulating the comparison of overall weight of the structure for all cases with structural members stressed to 80% of their capacities in each case. The paper categorizes the bracing layout best suited for different type of loadings. The analysis is carried out in computer aided program by constructing the structural frame in 2 dimensions. Member design is carried out with respect to AISC 360-05. All supports are pinned type supports. American sections are used for study.

Keywords: Modular, Bracing, Pipe Rack, Thermal, Transportation

Introduction

Since last few years, modularization is trending. Perhaps it has turned out to be preferable and efficient construction practice in certain circumstances. For instance, at some places, the construction activities can only be carried out in a specific time frame in the year due to severe weather conditions. With modularization came new challenges also. The response of a structure when subjected to different conditions like lifting, sea/land transportation or testing is different. While using modularization techniques, it has to be made sure to design the structure for all conditions through which the structure is expected to progress. The paper attempts to suggest the most economical brace pattern to cater for all such type of forces.

Methodology

For the purpose of this paper, a simple 2D frame of 30 m long and 12 m high is considered. All the beams are connected to columns by means of pinned connections. The lateral stability is achieved by diagonal members commonly known as braces. In this work, four different frames are analyzed and designed for wind, thermal and hog & sag loads. The frames differ in terms of brace patterns used. All the loads have been factored such that significant member utilization can be recorded. The maximum utilization ratio of any member is restricted to 0.80. As a base case, the member sizes were fixed to what has been shown in Table 1. And the change, if any, in member sizes is recorded in terms of percentage of weight increments from the base Material Take-Off *MTO* value (Table 1). The inferences are made based on weight. The results are based on an assumption that the structure would be experiencing all the loads viz. thermal, wind and hog/sag loads through its lifetime.

Results

Table 1 Member sizes for base case [1]

Sr. No.	Member Category	Member Size
1	All Beams	W10x22
2	All Columns	W12x65
3	All Braces	PIPE 0.114m x 0.008m
Material Take-Off *MTO* for base case = 12.908MT		

E-mail: [1]arun.dhiman@fluor.com, [2]tapas.kumar.manna@fluor.com, [3]mangesh.amrut.sakpal@fluor.com

[1,2,3]Fluor Daniel India Private Limited, New Delhi

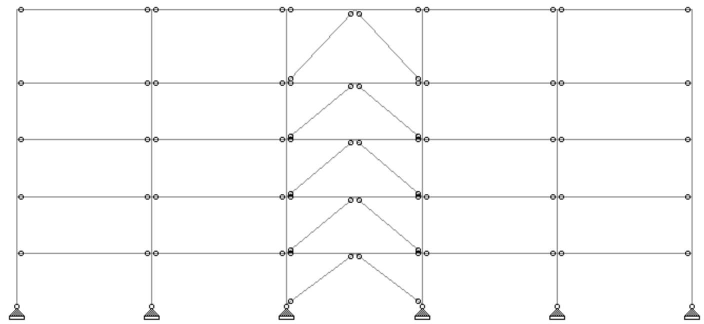


Fig. 1 Structural framing arrangement for case 1

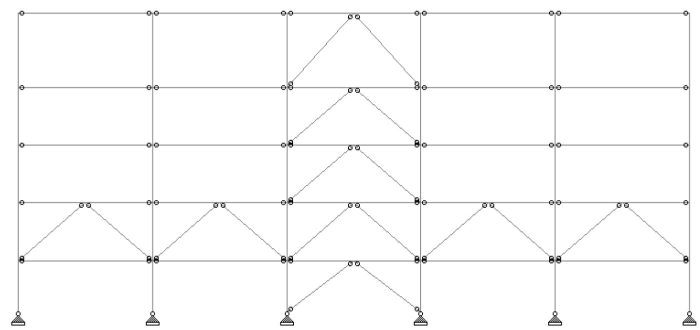


Fig. 2 Structural framing arrangement for case 2

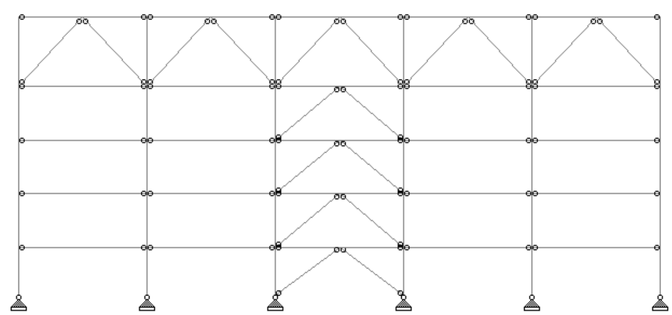


Fig. 3 Structural framing arrangement for case 3

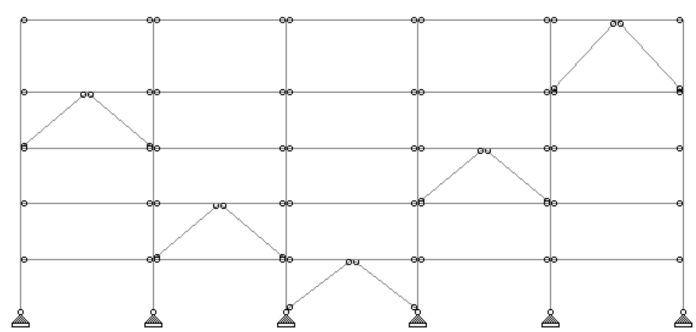
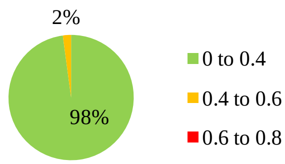
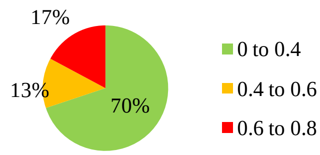
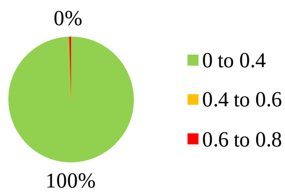
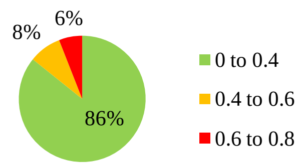
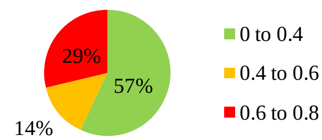
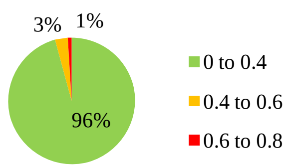
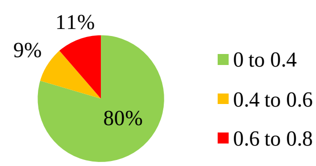
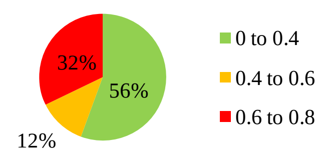
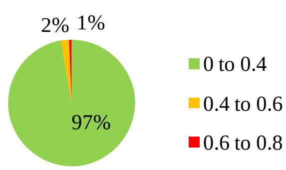
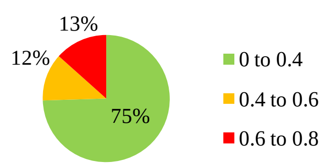
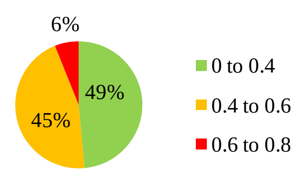


Fig. 4 Structural framing arrangement for case 4

Table 2 Summary of member utilization

Case	Wind Loads	Temperature Loads	Hog/ Sag Loads	MTO Difference from Base Value
Case 1			Not Applicable	1%
Case 2				35%
Case 3				46%
Case 4				8%

Discussion

Case 1: One vertical bay fully braced, generally the middle one *(Fig. 1)*. This type of structural bracing pattern is most widely used. And there is no doubt about efficiency and economy in using it unless the structure is subjected to hog and sag loads during marine transportation. This configuration is not suitable to be used for structures that are to be transported.

Case 2: One vertical bay and one lower horizontal bay fully braced *(Fig. 2)*. The braces in horizontal bay are introduced to resist forces induced during transportation.

While analyzing for thermal loads, as a result of temperature locking many of the structural members were not able to withstand the forces. Also, the results were not very supportive for hog/ sag loads. The member sizes were adjusted to resist all the forces. The cumulative weight increased significantly in comparison to base MTO value.

Case 3: One vertical bay and the topmost bay fully braced *(Fig. 3)*. Reason for considering such arrangement was to minimize the impact due to thermal loads. The effect of temperature was negligible and the results were similar to Case 1. But the effect of hog/sag loads was even more significant than Case 2.

Case 4: At least one cell in each vertical and horizontal bay braced i.e. scattered pattern *(Fig. 4)*. Expectations from this arrangement are; there will not be temperature locking and the forces induced during transportation will be more distributed rather than concentrated in a single line of beams. The results are fairly good for this case. There is only 8% change in MTO from base value and it is suitable to withstand all the loads in contrast to case 1. If the results be compared with case 2 and 3, this arrangement could very well be termed as economical.

Table 2 shows the member utilization in each case corresponding to particular load. For each case, the member sizes are kept same while tabulating the results for different loads.

Conclusion

The study suggests an economical structural arrangement for modular structures that include transportation of structure through sea. The most economical design could be achieved by arranging structural members similar to case 4; as it effectively caters for wind, thermal as well as hog/sag loads.

Acknowledgment

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Nomenclature

Cell: A closed region formed by beams and columns in the shape of a rectangle with no other beams or columns in between

Hog/ Sag: The deflection of barge/ship in the shape of a big arc due to sea waves

Modularization: The process of fabricating the structure at the fabrication site in parts or completely and then transported to construction site.

Achieving Green and Social Perspective: A Mixture of Safety and Environmental Aspects

S.S. Kathiresan[1]

Introduction

India is a still developing country after 70 years of Independence and enormous Industrial growth has contributed to a maximum level to Indian economy which is competing to the global world. However, the present modern industrial process has made major impacts on environmental pollution and caused health hazard issues by which general public is in distress and the condition is being viewed as social perspective by the society and this has to be controlled to have good health of the people and the growth of the industries should not affect the social status and health of the people under the concept of good environment, Health and safety.

On the other hand, Government machinery, social welfare organizations and Engineering consultants are working together to provide pollution free atmosphere by technological advancements to the people of India. Though the present system of treating the industrial pollutions are in progress, they are not effective to the expectation of the people.

Government Acts and Rules

After introduction of-The Air (Prevention and Control of pollution) Act 1981, Government of India had enacted the Environmental (Protection) Act 1986 after the major chemical accident happened at a factory in Bhopal in the year 1984 which had caused many public deaths. (Toxic Gas release). The above Act was introduced so as to control the Industrial pollution and safe guard the people. Following this Act, many rules were framed by the Government to control the pollution level in the area of manufacturing, storage of raw materials (M.S.I.H.C Rule 1989-Manufacture, storage, import of hazardous chemical rule 1989) and the Hazardous Waste Management and Handling Rule 1989 including the Factories Act 1948 which covers many of the environmental issues. In addition to the above, so as to absorb the pollution level, green plantation is being carried out every year which is providing pollution free oxygen system to the human living by absorbing the carbon from the pollutants and Government is planning this plantation of tree program periodically to achieve greenery system to absorb the pollutants.

Secondly, United States of American firms are providing project technical consultancy services to achieve pollution free level in waste water treatment / hazardous waste Management system (Solids and liquids) and air quality.

Our Planning and Action

Now, it is our duty to highlight the pollution levels in the following type of important industrial sectors, by conducting the study of environmental impact assessment in Air (Air quality impact-SOX, NOX, PM_{10} and $PM_{2.5}$ deposition-Sulphur oxides, Nitrogen oxides and particulate matters) and implement suitable control measures with new technologies which are very important to the development of New India.

1. Infrastructure Sector

   Process of Building activities/ housing complexes, roads, Railways, Ports, Airports and water supply system etc. causes dust pollution during construction activities in the atmosphere and causes a disease called Silicosis–Which is a part of Pneumonokosis, a general lungs problem to the working employees. In fact, a separate legislation-Building and other construction workers Act 1996 has been enacted with rules for ensuring the health and safety and condition of work of Employees in this construction sector by the Govt. of India.

   a. Petroleum Oil and Gas Industries,
   b. Petro Chemical Industries-Stack monitoring system has to be improved with introduction of new technology for controlling

E-mail: [1]ssakthikathiresan@yahoo.com

[1]K&K Associates, Chennai

The exhaust gas emission of Industrial out let system that is air pollutants in these industries/Inside process areas. Will be discussed which is having more social impact on the people.

c. Secondly the industrial process liquid waste in these industries i.e. trade effluent has to be monitored and treated for pollution free disposal. (Effluent Treatment Plants)

2. The Coal Based Thermal Power Stations-Best Engineering practice has to be introduced in the stack monitoring system (ESP system-Electro Static Precipitators) to control pollution level of the exhaust gas in the chimneys.
   For the above, provision of scrubbers, cyclone separators / dust collection filters, electrostatic, precipitators with modern technology arrangements are to be made to control the pollution of the environment in the above sectors as per the requirements. Mostly ESP System and Fabric Filter Dust Collection Systems are incorporated in the system
   Hazardous process waste water with chemicals treatment system has to be effectively implemented towards pollution as per the water (Prevention and control of Pollutions) Act 1974.
3. Diesel Engine Generators (Power Plants).
4. Environmental issues in automobile motor vehicles.
5. General automobile Engineering Industries
6. Textiles Industries / Leather Industries.
7. In sugarcane processing Industries.
8. Pollution of the atmosphere due to major Fire accidents in Industries and General buildings ill .
9. Global Warming.

Now, let us find out the details of the impact (Pollution) of the following industries in the environment and the type of control system to be provided to control and minimize the pollution levels.

In Fracture Sector

Construction industries as stated above, possess a legislation as-Building and other construction workers Act 1996 which has been enacted for ensuring health and safety and condition of the work towards achieving safety and health of the construction employees.

This Act involves the following activities.

1. The Registration of construction establishments.
2. Registration of Building workers as beneficiaries.
3. All Safety and Health Measures.

Following this Act, Tamil Nadu Rules were framed in 2006. The officials of Directorate of Industrial safety and health-Government of Tamil Nadu (DISH) are enforcing the above Acts and Rules in construction works in Tamil nadu towards maintaining safe and healthy atmosphere. Likewise, in the other states also, this Construction Rules are applicable and governed by the respective states officials.

Photo of the construction industry

Now, let us discuss in the detail about the pollution level and active measures taken in this Industry

i) Type of Industry	Type of Pollution	ii) Technologies used for Controlling the Pollution	iii) Health Hazardous
Construction Sector Activities and processes like construction of special building, Roads, Railways, Ports, Air ports , Power generation projects and major water supply system with housing etc.	a) Dangerous dust containing silicon materials as particles in the flying dust and cement dust. b) Asbestos fibers / dust (Asbestos material used in roof panels, old water pipes, boiler pipe insulation purpose and cement pipe etc. Workers employed in these areas are likely get affected by asbestos dust.	1. Implementation of safety procedures and appointment of safety officers in the construction site with responsibilities 2. Use of PPES-Personal Protective Equipments. In this construction industries, helmet, nose masks and gum boots are important PPES to be used by all the employees with identification jackets. 3. In some of the concrete mixing plant areas, water spray can be established to subside the flying cement dust. 4. Training and educating all the construction employees about the safety procedures, Rules and Regulations 5. Installation of dust extraction plants in concrete mixing areas. 6. In addition to the above, for preventing the breath of both cement dust and asbestos dust in this industry necessary PPE's Like Nose Mask is important one to be worned by all the construction employees and spraying of water should be done to subside the flying dust of both cement and asbestos. All the construction site should be surrounded by safety net system to prevent the flying dust of cement, asbestos and general dust in construction.	**Health Hazards.** a) Pneumonokosis Is a general lungs disease caused due to general construction dust, In this construction dust, one of the most dangerous kinds of dust that affects the human breathe is crystalline silica. That is Silica in sand, rock, masonry works flying cement powder,/ concrete mixtures and also present in the drilling and demolition of old concrete or masonry structures. These silica particles can cause a disease called silicosis by deposition of silica particles in the lungs (during breathing operation-shortness of breath & stop oxygen getting into the blooding system) Secondly there is a chance of getting / Tuberculosis (TB) and lung cancer due to the above silicosis.

Note: The asbestos dust is harmful substance that cause a disease called asbestosis (Occupational disease) to the construction workers. All the workers are advised to undergo medical test for PFT (Pulmonary Function Test and X Ray Test once in Six months towards prevention measures)

Note: In this Industry, two occupational diseases are possible-1) Silicosis, 2) Asbestosis

- 1.b) In these industries, the quality of air inside the operation of the site / industry can be measured by measuring instrumentation system as per NAAQ-National Ambient Air Quality monitoring system and also the air quality has to be measured outside the site and industry so as to maintain health of the working employees (The constituents of the air quality are PM, Particulate matter, Sox- Sulpher oxide and Nox –Nitrogen oxide).

Mostly cement is used in these industries and general chemical composition of cement is in the region of 67% CaO-Calcium oxide, 22% SiO_2-Silicon dioxide, 5% Al_2O_3-Aluminum oxide, 3% Fe_2O_3 –Iron Oxide and 3% other components like sulfate etc.

In the above, generally cement dust is harmful and 22% silicon content is responsible for causing special disease called silicosis. (Cement dust is in flying condition). It is to be noted that particles of the silicon 22% and cement dust are harmful. So, it is advised to have a temporary water pump system with spray nozzles and water should be sprayed during concrete mixing operations. This system should be available in concrete mixing areas so as to subside the flying cement dust.

- 2a). Petroleum oil and gas and petro-Chemical industries-Treatment of pollutants
  In petroleum oil and gas processing industries-
  Petroleum oil exploration is the oldest process of drilling the earth both in off shore and on shore and crude petroleum is obtained and the same is processed by using petroleum distillation process to produce various products under different temperatures and are mostly classified as Class A, Class B and class C products as per petroleum Act 1934. (Petrol -Class A, Diesel and Kerosene -Class B and LSD and Furnace oil -Class C) In this process of extracting crude petroleum, the exhaust gas evolved form the process is vented out through chimneys and exhaust pipes and they are called pollutants.

As per the norms of the pollution control board these pollutants that are out let gases are called green house gases. (Emission gases). The following are the details of the green house gases.

1. Combustion gases-Consisting of carbon dioxide, minor amounts of carbon mono oxide, nitrous Oxides-N_20, sulpher dioxide -SO_2 etc
2. Hydro Carbons-Consisting of methane and primarily aliphatic Volatile organic Components-(VOC)
3. Halon and CFC-Release of halon and other flouro carbon gases

In the above, major harmful exhaust products are let out through gas flaring system i.e continues burning in the exhaust pipe system in this Industrial process and that produces mostly CO_2 and Methane gases

Photo of the Petroleum Oil Industry

Note: In these industries, the quality of air inside the operation of the site / industry can be measured by measuring instrumentation system as per NAAQ- National Ambient Air Quality monitoring system and also the air quality has to be measured outside the site and industry so as to maintain health of the working employees (The constituents of the air quality are PM particulate Matter, Sox- Sulpher oxide and Nox-Nitrogen oxide).

a1). Now let us see the stack monitoring system of these Petroleum oil and gas industries

i) Name of the Industry/ Type of Products	ii) Control Measures	iii) Health Hazards
Petroleum oil processing industries As mentioned above, the following pollutant gases are emitted from the process out let chimney / exhaust pipes.	Stack monitoring system (Chimney and out let gas) As per pollution control board norms.	As these gases are dangerous and hazards to human health, scientific control systems are incorporated to maintain the air quality for this, National ambient air quality standards are established by pollution control board, Government of India and monitoring the air quality in these industries. Note: Air quality measurement system is carried out by

• Carbon dioxide • Carbon mono oxide • Nitrogen oxide • Sulpher dioxide • Unburned hydro carbons like methane and VOC etc.	Present control systems are controlled in the process itself & major component emission is CO_2 and methane and it is being vented by gas flaring system. These gases are vented out by continuous burning in the atmosphere. However, both CO_2 and Methane are the major Pollutants in this Industry. All the workers, staff and Engineers are strictly Instructed to use the respective PPES during the operation in this Industry and they should also follow the safety rules and regulations.	pollution control board, Government of India with reference to the standards specified in American Petroleum Institute, America. Secondly, oil and natural gas commission-(ONGC) Government of India is doing the off-shore and on-shore drilling operations and they are also monitoring these out let gases during oil drilling & extraction and processing system.

- Special Note (i) In the above mentioned pollutants, methane and VOC emission from oil production and other sources like Agricultural system contribute to the global warming since it is more efficient in trapping radiation than CO_2 gas and thus this methane gas contribute to the total warming of the atmosphere. So effective control of these gases (CO_2 and Methane) is very important and effective control should be implemented to meet the limit levels specified by the Govt. Pollution Control Board.
- Special Note (ii) In these industries, the quality of air inside the operation of the site / industry can be measured by measuring instrumentation system as per NAAQ- National ambient air quality monitoring system and also the air quality has to be measured outside the site and industry so as to maintain health of the working employees (The constituents of the air quality PM Particulate Matter, Sox-Sulpher oxide and Nox-Nitrogen oxide).
- Special Note (iii) In this industry, Govt. of India project–GAIL (Gas Authority of India)-Natural gas transmission- is being laid from Kerala State to Karnataka state via Tamil Nadu in Tanjore district. Since gas lines are laid in the agricultural lands, the agricultural activities are stopped due to this and all the agriculturists are agitating to stop these projects as they feel that both ground water and agricultural activity will be spoiled by this project. Thus, this project is creating Social Impact on the people and creating an unhealthy situation among the people.

In Petro Chemical Industries

In petrochemical industries, petroleum based many products are produced by the process and **out let** of the process system emit considerable quantities of the dangerous fumes and the gases. The same are treated as per the pollution control board's norms of the Government. The details of the process out let / exhaust gases / flue gases in these petro chemical industries are given below.

- These gases are evolved from the process due to the combustion system inside the process i.e gas burner system, oil burner system, coal powder burner system and brown coal roasting system etc. and they are having following contents. CO2-Carbon di oxide, Water vapour, CO-Carbon mono oxide, Nitrogen Oxides, Sulpher dioxides, H_2S-Hydrogen Sulphide, Hydro Carbons, Hydro Cyanic acid, Ammonia & Solid dust (Dust and Soot)

- Chemical fumes out of Acids / Alkalis (H_2SO_4– Sulphuric acid/HCL-Hydro Chloric acid and Sodium Hydroxide and hydroxyl groups Gases etc from the process.
- Sulpher dioxide fumes from combustion process specially treated through scrubber system (Special Treatment for SO_2 -Sulphur di oxide in special process system).

The treatment systems for the above are the control of the emission that is, controlling the combustion process in normal operating conditions and stack monitoring system for outlet gases and incorporation of scrubbers of both wet and dry types for inside process gases. The above mentioned inside process gases are passed into the scrubber vessel and water-sea water or fresh water are circulated into the scrubbers and this water is mixed with pollutant gases and diluted from their harmful effects. The treated out let water and sludge are collected separately and disposed off safely as per the directions of the pollution control board and most of the treated water is used for gardening purpose and the sludge is disposed off as per Hazardous waste (Management handling and transboundary movement) Rules 2008 to a safer designated place.

Photo of the Petro Chemical industry

c) Stack emission controls in these industries.

i) Name of the Industry/ type of products	ii) Control measures	iii) Health Hazards
All exhaust gases / flue gases from the process as highlighted above in 2.b Dangerous fumes and gases– Acids and gases Sulpher Dioxide fumes from the process Process Liquid waste-Trade Effluent with oil waste etc.	Installation of Stack controls & monitoring system by controlling the combustion process to have more combustion efficiency. Installation of both wet and dry scrubber system and circulation of water system. The pollutants are treated and made as non harmful products. The water vapour exhausted from the scrubber is non hazardous. Installation of chemical treatment process for neutralizing the acidity of the liquid waste and controlling the harmful effects as per PCB-Pollution Control Board norms (Effluent Treatment System)	General Health Hazards are experienced due to outlet gases and the same are controlled as per the pollution control board norms and the SPM-Suspended particulate matter is maintained. Health hazards of chemical fumes and gases- Respiratory problems to the people-working employees. The out let of the scrubber is treated as per process norms and neutralized with chemicals. Trade Effluent as process liquid waste has effect on land pollution. So, it is treated to the Non-harmful status by the Effluent treatment system and this waste is disposed OFF to the designated safer area as per the pollution control board norms as per Hazardous waste (management, handling and trans boundary movement) control rule 2008. P_H and chemical contents should be at safer limits.

Special Note (i) In these industries, the quality of air inside the operation of the site / industry can be measured by measuring instrumentation system as per NAAQ- National Ambient Air Quality monitoring system and also the air quality has to be measured outside the site and industry so as to maintain health of the working employees (The constituents of the air quality-PM, Particulate Matter, SOX-Sulpher oxides and NOX –Nitrogen oxide).

In any chemical process industries, the process outlet gas will have both toxic and hazardous gases and the same will be treated through wet scrubbers system as explained before. The liquid trade Effluent generated in this industry will be also treated as per the trade Effluent treatment system as per the pollution control board norms as explained above. Any waste / sludge generated will be disposed off safely as per Rules and Regulations. In the Wet Scrubber System, SOX –Sulpher oxide Vapours are neutralized by lime or $CaCO_3$ –Calcium carbonate and NOX-Nitrogen oxides are neutralized with Urea or Ammonia.

Coal Based Thermal Power Stations

In these Industries, the mixture of burned coal powder with air produces the combustion process and after passing through the boiler system and other accessories, the hot flue gas will pass through the ESP –Electro Static Precipitator System to absorb all the burned carbon particles (collected as ash) from the flue gas and the treated flue gas is vented off through the chimney system with stack emission controls. i.e. ESP- Electro Static Precipitator with electrical system & controls are installed to control the emission. Flue gas / stack emission details are given below for reference from a practical study conducted in a coal based thermal power station with ESP System in Annexure-I.

Note: initially LDO-Light Diesel Oil and furnace oil are used for combustion process in the boiler system.

Photo of the Thermal Power Station

Annexure-I

Stack Emission Monitoring Results

Month & Year: May 16

Time Monthly Basis	Unit no.	Load (mw)	Flue gas Composition % CO_2	% O_2	Flue Gas Pass Monitoring	Average Flue gas Vel. M/sec.	Average Flue gas Flow Rate lpm	Flue Gas Temp. ^0c	Spm on 12% co^2 Basis (mg/n m^3)	No.of oil Guns in Service	So_2 (ppm)	No_x (ppm)
---	I	210	Around 16	Around 3.5	----	26.00	39.00	130	119	-	325	263
---	II	210	Around 16	Around 3.5	----	28.00	40.00	131	135	-	494	340
---	III	210	Around 16	Around 3.5	----	27.00	41.00	129	148	-	245	352

Legend: AV-Average; Lt-Limit; F.G-Flue Gas;mg/Nm^{3-} Milli gram per normal meter cube; m/sec-meter per second; ppm-parts per million; SPM – Suspended Particulate Matter; SOX- Sulphur Oxides; NOX-Nitrogen Oxides (SO2-Sulphur di oxide, CO2-Carbon di oxide)
Note: TNPCB-Tamil Nadu Pollution Control Board standard emission norms-PM Particulate matter-150 mg / Nm^3

By incorporation of ESP system in the stack emission, 0.1 to 1.8% of electrical energy generated is used and removal efficiency up to 96.5% is possible up to <1µm – (micron millimeter) size particles. Secondly other Fabric Filter System is also used to recover the particles in Dust Extraction System Method mg/Nm^3- milli grams per normal meter cube

Air Quality

In these industries, the quality of air inside the operation of the site / industry can be measured by measuring instrumentation system as per NAAQ- National Ambient Air Quality monitoring system and also the air quality has to be measured outside the site and industry so as to maintain health of the working employees (The constituents of the air quality-PM particulate matter, NOX-Nitrogen oxides and SOX-Sulpher oxides).

One Practical measured air quality is given below in two areas.

Annexure-II (A)

Table : Ambient air quality monitoring results

Time period Monthly	Particulars of Ambient air Quality Survey – AAQS in Different Location	Approx Aerial Distance of AAQS w.r.t Stack (km)	Direction of AAQS w.r.t. Stack	Wind Speed mtr/s	Wind dir deg.	Weather	Particulate Matter µg/m^3	Sox µg/m^3	Nox µg/m^3
-	FUEL OIL PH	1 KM	EAST	--	--	CLEAR	77	25	22
-	COOLING WATER PH	1 KM	SOUTH	--	--	CLEAR	74	-19	21
-	NCTPS MAIN GATE	1.5 KM	WEST	--	--	CLEAR	75	-26	23
-	VALLUR CAMP	4 KM	SOUTH WEST	--	--	CLEAR	71	20	17
-	KAMARAJ PORT	6 KM	NORTH	--	--	CLEAR	72	22	21

Sl. No.	Description of the plant	Air Quality pm 10-µg/m^3	Air Quality pm2.5-µg/m^3	SOX µg/m^3	NOX µg/m^3
a)	Inside the plant operation at a height of 3 to 4 mtrs of pump house.	54	-	12	17
b)	Security gate	80	-	76	21
c)	NAAQ standards in industrial, residential and rural area (standard norms)	100	60	80	80

LEGEND: AAQS-Ambient Air Quality Survey; Lt-Limits, µg/m^3-Micro gram per meter cube; Mtr/sec-meter per second; KM-Kilo Meters; SPM-Suspended Particulate Matter; SOX Sulpher Oxides; NOX-Nitrogen

Oxides; W.R.T-With Respect of L.Rain-Light Rain; H.Rain-Heavy Rain; N-North, N.N.-North North

Annexure-II (B)

Secondly, ambient air quality survey results taken from the other thermal power plant are also given here.

Legend:

NAAQ-National Ambient air quality

pm_{10}-Particulate matter (micron size 10), $pm_{2.5}$-Particulate matter(micron size 2.5) $\mu g/m^3$ Micro grams per meter cube; SOX-Sulpher oxides; NOX-Nitrogen oxide

Diesel Engine Generators

In all the industrial plants, Diesel generators are installed to produce the electrical power as a stand by unit in place of normal electrical supply from electricity board. In this, diesel engine is coupled to the electrical generator and the total system is connected in parallel to the common electrical system. In this diesel engine, the petroleum product-Class II diesel is used as a fuel for combustion of the diesel engine and after the combustion process, the exhaust diesel engine gas posses the following pollutants.

Diesel Exhaust

Diesel exhaust is composed of a mixture of many different toxic chemicals. Diesel engines relay on heat, generated during the compression cycle, for ignition rather than an electrical spark as in gasoline engines. Because of this needed compression, diesel engines are heavier and bulkier than gasoline engines. Gasoline engines emit fewer particulates in their exhaust than diesel engines, so the exhaust looks “cleaner”. However, gasoline engines still emit toxic chemicals similar to those in diesel exhaust, but in different concentrations.

Toxic Chemicals in Diesel Exhaust

The toxic chemicals of most concern in diesel exhaust are the oxides of nitrogen (nitric oxide, nitrogen dioxide) sulfur dioxide, primarily formaldehyde, acetaldehyde and acrolein and various hydro carbons particles. Carbon Mono Oxide is also present. The higher average temperature of combustion of diesel engines generates more oxides of Nitrogen than gasoline engines.

Health Hazards of Diesel Exhaust

These toxic chemicals can cause health effects, some of which are immediate and others which take years of exposure. High concentrations of the oxides of nitrogen can cause headache, dizziness and loss of consciousness as well as respiratory irritation. Sulfur dioxide, a pungent gas may cause immediate respiratory distress. The aldehydes are also pungent and cause eye, nose and throat irritation. Prolonged exposure to diesel exhaust can increase the risk of cardiovascular, cardiopulmonary and respiratory disease and lung cancer. In June 2012, the International Agency for Cancer Research (IARC) classified diesel exhaust (Including diesel particulate matter) as a known human carcinogen (Group I)

(e) Now let us see the details of exhaust gas coming out from the diesel engine of the generators installed in all the industries as one of the main utility

Details of diesel exhaust (High Speed Diesel-HSD) gas

General constituents of the exhaust gas are given below.

N_2-Nitrogen
O_2-Oxygen
H_2O-Water
CO_2-Carbon dioxide
CO-Carbon mono oxide
NO_2-Nitrogen dioxide
SO_2-Sulpher dioxide
Pb-Lead
HC-Hydrocarbons
PM-Particulate matter
Acetal dehyde & Formal dehyde

(f) Now let us see the control measure done in the stack / chimney – exhaust pipe connected to the diesel generator in a plant / industry towards monitoring system of the pollutants.

In this, TNPCB guide lines are to be also referred. Now here with given below the actual measurement done in the stack emission of one diesel generator – 1000 KVA capacity-fuel used HSD-in a controlled condition of the engine operations-Best Performance System.(Refer Diesel Generator Set operation and maintenance catalogue)

- Unit capacity – 1000 KVA DG Set
- Fuel used – HSD(high Speed Diesel)
- Stack height / Diameter – 12m / Dia 0.30metre
- Ambient temperature – 29^0C to 30^0C
- Stack temperature (Out let temperature of exhaust gas)-240^0C
- Fuel / Exhaust gas velocity – 22m/sec
- Total gaseous emission – 3260 Nm^3/hr
- SPM particulate matter – 35mg/Nm^3
- SO_2- Sulfur dioxide – 7.6 mg / Nm^3
- Oxides of Nitrogen – 123 mg /Nm^3
- Note- TNPCB Standards – SPM – 150 mg / Nm^3 (Normal meter cube)

(g) Like this, the emission gas coming out from the combustion process by using LDO and furnace oil will have the following pollutants and the same are controlled by incorporation of wet scrubbers for treating the sulpher compounds / gases and other components by controlling the stack emission in the industrial process system.

1. SPM particulate matter
2. SO_2- Sulfur dioxide

3. NOX-Oxides of Nitrogen
4. CO_2-Carbon dioxide
5. CO-Carbon mono oxide

(h) Mostly all the gases coming out from the process are treated in wet scrubbers by spraying fresh water with alkalinity solutions. The acidity and toxic effects of all the above gases are neutralized with full alkalinity and sulphur reduction up to 0.10% i.e. after scrubbing system is achieved.

Emissions from Automobile Motor Vehicles

(a) Most of the automobile vehicles are using both petrol and diesel- fossil fuels- as main combustion fuel and the power obtained by this combustion process is transferred to the vehicle wheels through transmission gear system. In this petrol is used in petrol engine with air fuel mixture and diesel is used in diesel engine with air fuel mixture and the ratios are different for both engines. Mostly petrol engines are used for high speed and light vehicles and diesel engines are used for medium / heavy vehicles / trucks. Thus the exhaust of each engine varies accordingly and responsible for polluting atmosphere. Now, the details of the exhaust gas components comparison are given below with reference to foreign countries as pollutants.

Sl. No.	Light Vehicles and Cars (Petrol Engine)	Medium and Heavy Vehicles (Diesel Engine)	Remarks
1	Carbon dioxides-CO_2-65%	Carbon dioxides-CO_2-35%	The Indian Standard is to be referred for Indian vehicles for both petrol and diesel. However, the emission will have mainly -CO_2 –Carbon di oxide& CO – carbon mono oxide
2	Nitrogen oxide-NOX-42%	Nitrogen oxide-NOX-58%	
3	Carbon mono oxide-CO-85%	Carbon mono oxide-CO-15%	
4	Hydro carbons-HC-76%	Hydro carbons-HC-24%	
5	Particulate matter-PM-26%	Particulate matter-PM-74%	

Note:

In the above, both CO_2 & CO emissions are to be noted and the engine performance is to be controlled and tuned to have normal operation of fuel firing system to have normal combustion with allowable emission limits. Each vehicle should be tested once in 3 months for the emission test and for any abnormal condition of combustion, it should be serviced perfectly and this procedure should be mandatory and controlled by Government authorities. The smoke test should be done once in three months.

Emissions from Automobile Manufacturing Industries-

- Exhaust gases and process gases from chimneys
- Liquid process waste from the process (Trade Effluent)

In the above for Sl.No. i mostly diesel generators will have emission and the same is already explained in the previous pages are also applicable to this industries.

In addition to the above, in this industry, acid fumes and paint fumes will be evolved in the manufacturing system and they possess toxic characteristics and the same are treated by incorporating wet scrubber system to remove the harmful effects of these acids and paint fumes under required designs and operation of the scrubber system to meet the pollution control board norms.

In the above for Sl.No.ii, the process liquid waste as trade Effluent will be treated by chemical process system under Effluent treatment process outside the plant premises and the acidity of the process waste will be neutralized as per the process design and the processed liquid-waste water will be used for gardening purpose and sludge generated will be collected separately and disposed off safely to the designated places as per the directions of pollution control board under Hazardous waste (management, handling and trans boundary movement) control rule 2008.

Textile and Leather Industries

In these Industries, the main process liquid waste called trade Effluent evolved in this process is treated separately through Effluent treatment plant situated very near to the industries under the approval from pollution control board. In fact, a cluster arrangement is done to club many textile industries and the process liquid out lets-waste are collected at a common point and treated as per the pollution control board norms and the pH is maintained with neutralizing chemical agents. The treated out let liquid waste are to be collected separately with sludge and used for gardening purpose in the respective industry. After drying the sludge, the same can be used as manure in agricultural forming.

Like this, in the leather industry also, treatment system should be installed for hazardous liquid waste treatment-Trade Effluent Treatment System in a cluster arrangement. The treated waste-sludge can be collected separately and used for agricultural forming and the waste water should be used for Gardening purpose.

Note: It is highlighting to note that such chemical based treated / non treated liquid waste from a textile industry is being diverted to mix with the river water in Krishnagiri district and Salem district in Tamil Nadu and polluting the good river water used for both agricultural and drinking purpose with uncontrolled chemical foams creating toxic and bad odour. Due to this, both agricultural activities and drinking water supply are stopped in these areas. Necessary actions are to be taken by the pollution control board-Govt. of Tamil nadu as this is creating social impact on the people living in this area and their regular activities are stopped.

In Sugar Cane

Processing industry also, the liquid trade Effluent treatment should be done properly as per the pollution control board Norms as the process waste are toxic and dangerous to human health in this industry.

Fire Accidents-Pollution Problems (Environment and social impact)

Fire accidents cause the release of the CO_2-carbon di oxide and CO-Carbon mono oxide gases and also sulphur compounds due to the flammability of the solid, liquid and gases materials and the nature of flammable material is responsible (Class-A, Class-B, Class-C and Class-D fires) for high pollution in the atmosphere and high intensity of heat and creating different stages of fire. That is, insipient fire, simmering fire and flammable fire. As these fires are viewed as an accident, it really pollutes the atmosphere extensively by emission of CO_2 / carbon compounds etc and contributing additional pollution load to the environment. So, all precautions and preventing measures should be taken well in advance so as not to meet any fire accidents in industries, domestic cum commercial complexes and multi storied business complexes by adopting all safety rules and regulations and fire safety systems.

Global Warming

Global warming is the most serious threat facing our planet today which is due to the Green house effect. The Green house effect is result of the emissions of green house gases like carbon dioxide, Sulphur di oxide, Hydro Carbons, chloro fluro carbons (CFCs), methane, Nitrous oxide, Carbon mono oxide etc. as already stated above by the emission from automobiles, thermal power plants, industries and other sources. The sun makes the globe warmer. The emission caused by automobiles and industrial sectors forms as a gas blanket over the earth, traps a part of the Sun’s heat and causing Global warming.

Note: According to India’s green house gas emission published in Hindu Paper by Netherlands Environmental Assessment Agency states that the green gas emission goes up to 4.7% in 2016. In the total global emission of green house gas CO_2 is 72%, and other Non-CO_2 gases like methane CH_4 -19%, N_2O-6% and CFC gases-3%.[Nitrous oxide and chloro fluro carbon gas]

Conclusion

So, it is our duty to install all scientific methods by analyzing the impact of pollution from industry and other sources on environment and suitable controlled system should be implemented effectively to control the emission within the allowable limits to have pollution free atmosphere. In addition to above, massive project of Green Tree plantation should be done periodically as this will absorb all the above gases effectively and give good oxygen for human living. For information, Amazon forest in America is contributing 60% (Sixty Percentage) to the global need of good oxygen. So, we will also effectively implement all the technological advancements in industries to control the pollution as well as develop the green fields towards achieving “GREEN AND SOCIAL PERSPECTIVE” among the people of India for providing good healthy life.

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Assessment of Core Strength of Concrete

S. Herald Lessly[1] and R. Senthil[2]

Abstract Core test is commonly required in the area of concrete industry to evaluate the concrete strength and sometimes it becomes the unique tool for safety assessment of existing concrete structures. Concrete coring is one of the methods to evaluate the in-situ compressive strength of concrete. Rebar always makes the coring of reinforced concrete structures difficult. The effect of rebar in core compressive strength makes some serious considerations. Normally the in-situ strength of concrete is usually compared to standard cylinder and cube test. There is no strength correction for the effect of rebar in the core strength of concrete. Cutting of the rebar affects the quality of the rebar due to the formation of cracks between the concrete and rebar. The reason for going core test is that the test results on standard cylinder test (or) cube test to determine the 28 day compressive strength is non-compliance with the specification.

This may happen due to several reasons. For example due to improper consolidation they may be damaged in transit and when subjected to freezing at very early age, bad curing procedure may have been followed (or) incorrectly tested. As advancement in core testing to determine the core strength of concrete, many researchers have formulated empirical relationships considering the various parameters affecting the core strength and also the damage factor while cutting & drilling process.

Keywords: Core-compressive Strength-cylinder Test-cube Test

Introduction

The compressive strength assessment of concrete is usually influenced by various parameters which are difficult to measure. Determination of actual strength of concrete is not easy since it depends on the age of curing and various other factors including drilling operations. Moreover in a country like India concrete cast is usually carried out by a unskilled and inexperienced workmen which can cause lack of homogeneity in the concrete mix.

The question where to take the cores depends on the engineer. Over the whole structure, cores can be taken at various locations. The areas which are less stressed and undamaged are mostly preferred.

Nowadays core test is therefore introduced in most of the international standard codes. There are several factors which influences the core compressive strength. The factors affecting are moisture and voids, aspect ratio of the core, diameter of the core, orientation of the reinforcement and the type and size of the aggregate. The earlier performed investigations have established that presence of the reinforcement located close to the surface of the tested concrete specimen have lead to the doubts about the relevance of reinforcement effects on core strength of concrete. As for IS: 516-1959 the method of preparation of cores after drilling and procedure for testing the prepared specimen is described. There are no code provisions (or) empirical formula available to evaluate the core strength of concrete by considering above all parameters.

Factors Influencing the Characteristic Concrete Strength

In this paper, the most recent international standards together with an alternative formulation that provides techniques for estimating in-situ characteristic concrete compressive strength are presented.

Effect of L/d Ratio

The (L/d) ratio is normally kept 2/1 because the value of length-diameter ratio of a standard cylinder is 2. Supporting arguments for the choice of length-diameter ratio 2 were given by Murdock and Kesler [1] in 1957. The value 2 is appropriate only when standard molded test cylinders have that value. According to ASTM C 42-99, concretes having strength above 70MPa are even less affected by the value of

E-mail: [1]herald_lessly@yahoo.co.in, [2]senthilr68@gmail.com

[1]Research Scholar, Division of Structural Engineering, Department of Civil Engineering, Anna University, College of Engineering, Chennai–600025

[2]Professor, Division of Structural Engineering, Department of Civil Engineering, Anna University, College of Engineering, Chennai–600025

(L/d). The test data observed by Murdock and Kesler [1] whose L/D less than 0.5 was erratic. It is also interesting to figure out that the same ASTM C presents various different sets of correction factors. Tuncan [6] have experimented with different L/D ratio ranging from 2 to 0.75. From his observation, the compressive strength of cores is increased when L/d ratio of the core specimen is decreased. Bartlett and Macgregor stated that, the effect of L/d ratio was pronounced for 50mm cores than 100mm diameter cores. Tuncan [6] observed that the strength of the core has decreased when the aggregate size increased. So from the above discussions it is concluded that cores with L/d smaller than 1 should never be used. The correction factor for L/d of cores in determining the compressive strength is required only when the L/d ratio is less than 1.8.

The strength of the core with L/d = 2 is equal to the strength determined on a core with the actual L/d multiplied by the correction factor.

Effect of Rebar

Reinforcement bars which are present in the core part of in-situ concrete is always a questionable subject. Many researchers have stated that existence in the concrete will increase the strength of the concrete while others have the feel that it will decrease the strength of concrete and some others have only a little belief in rebar presentation. Tadayon and Moghandam [4] have specified in their literature review that certain codes like ACI, ASTM, EN and Cranian concrete code do have any provision for rebar effect in core strength. In BS 1881:1983 Concrete society gave some correction factors for samples and rebar which are parallel to the ends of the sample.

Strength Correction Factor $=1+\frac{3\sum_{i=1}^{n}(d_{r,i}h_i)}{2d_cL}$

Where $d_{r,i}$ is the rebar diameter , d_c is core diameter, h_i is rebar axis distance to next core surface and L is core length. From the above equation we can clearly see that the effect of rebar depends on diameter, location and number of rebar and this correction does not exceed 25% of core strength. Two groups of experimental program were carried out by Tadayan [4]. They are as follows,

- Beams without rebar.
- Beams with rebar.

Standard beam size of 15cm x 15cm x 60cm is used here and core with 10cm diameter and 15cm height is used. Rebar sizes ranging from 10mm till 32mm were used. Normal curing was adopted for all the specimens. After experimenting with samples containing with and without rebar Taydan [4] concluded that it is only possible to predict the core results not accurately given by the concrete society. Further from his experimental work he says the compressive strength of core with cut rebar is always less than the corresponding strength of core without rebar. He found out that the strength reduction is about 25–60% in core strength due to the existence of rebar. Taydan [4] specifies that cutting of rebar leads to reduction in the compressive strength due to crack formation between concrete and rebar.

Effect of Core Diameter and Aggregate Size

The diameter of core extracted from the specimen always have an influencing effect in in-situ (or) core strength of the concrete. Tuncan [6] in his research work have experimented with two different core diameters of size 69mm and 46mm. Barlett and MacGregor [7] stated that the effect of L/d ratio was more significant for 50mm diameter cores than 100 diameter ones. The development of core strength to the diameter of the core is shown in Figure 1. Yaqub [12] in his research program has experimented with two different core diameters of 75mm and 48mm. It was found that the 48mm diameter cores showed greater strength as compared to 75mm diameter cores. In this research article no rebar was used. He further developed a relationship between core compressive strength and cube compressive strength. It was found that the 48mm diameter core strength is 0.724 times the compressive strength of cube strength (150mm x 150mm x 150mm).

Tuncan [6] in his research article have experimented and found out that the standard cylinder and cube strengths of concrete produced from crushed limestone aggregate was found to be some percentage higher than those concretes produced from natural aggregate even when the w/c ratio of natural aggregate was kept lower than crushed aggregate. The reason for this can be, due to the process, structure of the natural aggregate and also because of the weaker interfacial transition zone (ITZ). From his experimented work he was able to find after 90 days the cube compressive strength was found to be 33 and 30 MPa for crushed limestone and natural aggregate respectively.

Table 1 Correct factors for l/d according to astm c 42

Year of ASTM C42	**Strength Correction Factor Value of L/d**				
	2.00	**1.75**	**1.50**	**1.25**	**1**
1968	1	0.99	0.97	0.94	0.91
1999	1	0.98	0.96	0.93	0.87

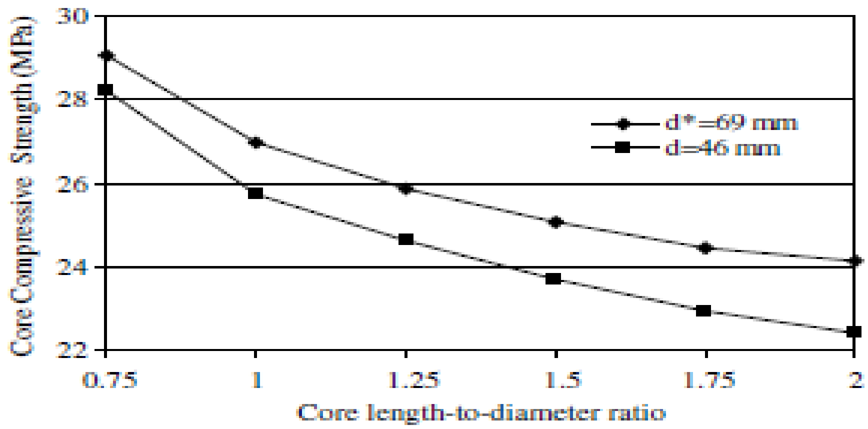

Fig. 1 Development of core strength *vs.* Length to diameter ratio

The effect of maximum aggregate size was not much significant towards the strength factor. The test result obtained by Tuncan [6] showed that the maximum aggregate size considerably affect the strength of cores. It was found that when the size of aggregate is increased, the core strength has gradually decreased. He further came with the result that the effect of maximum aggregate size on the core compressive strength seems to reduce with age. From his article, it can be concluded that the effect of maximum aggregate size was found to be more significant for 46mm diameter cores than 69mm diameter cores.

Assessment of *In-situ* Characteristic Concrete Strength

Determination of Characteristic Strength of Concrete According to NTC 08

The Italian code NTC 08 [2] gives out an expression to determine the characteristic strength of the core.

$$f_{cm} = \frac{f_{m,car}}{0.85} \; R_{cm} = \frac{f_{m,car}}{0.83*0.85}$$

f_{cm} *and* R_{cm} represents the cylindrical and cubic design value and $f_{m,car}$ is the core strength. 0.85 represent a part of safety factor in NTC 08 and EN 1992 while 0.83 is the coefficient governing the transformation from cylindrical strength to concrete strength.

Certain adjustments were made following the instructions of EN1992.

$$f_{ck,cyl} = f_{cm} - S(MPa)$$

$$f_{ck,cub} = R_{cm} - \frac{S}{0.83}\ (MPa)$$

Where $f_{ck,cyl}$ *and* $f_{ck,cub}$ are cylindrical and cube compressive strength respectively. S is the standard deviation and its value is 8. If at least 15 cores are available, then the below expression written based on the Italian code can be used.

$$f_{ck,cyl} = f_{cm} - 1.48 * S(MPa)$$

$$f_{ck,cub} = R_{cm} - \frac{1.48*S}{0.83}\ (MPa)$$

Determination of Characteristic Strength According to EN 1990

The characteristic concrete strength can be determined by the following expression.

$$f_{ck} = f_{m,car} * \exp\left[-t_{n-1}, p = 0.05 * S(Y) * \sqrt{1+\frac{1}{n}}\ \right] (MPa)$$

Where $f_{m,car}$ represents the mean of in-situ measured strength values, ‘n’ is the number of cores, S(Y) is the standard deviation of natural logarithm, t_{n-1} according to student distribution.

Determination of Characteristic Strength According to EN 13791

EN 13791 provides an empirical relationship in order to determine the in-situ compressive strength of existing structures. EN 13791 uses two different approaches. Approach A and Approach B to evaluate the core compressive strength of existing structures.

Approach A is possible where at least 15 cores are available. According to this approach, the estimated core characteristic strength of the test region is the lower value of below specified equation.

$$f_{ck,is} = \min [\ f_{m(n),is} - K_2 * S$$
$$f_{is,lowest} + 4$$

Where ‘S’ is the standard deviation of the test results (or) 2.0 MPa which is the higher value. K_2 *is* 1.48.

Approach B is applicable where 3-14 cores are available. The expression given by EN 13791 to determine the core compressive strength of concrete using approach B is the lower value of

$$f_{ck,is} = \min [\ f_{m(n),is} - K$$
$$f_{is,lowest} + 4$$

where K value depends on the number (n) of test results. K is 5 for a number of cores (n) comprised between 10 and 14; K is 6 for a number of cores (n) comprised between 7 and 9; K is 7 for a number of cores (n) comprised between 3 and 6.

Determination of Characteristic Strength According to TS EN 12504

50mm standard diameter core is used for evaluating the core compressive strength of concrete as per Turkish Standard TS EN 12504. But no correction factors are mentioned in the code provision to convert the strength of 50mm cores. From the above discussions, the various code provisions does take into the account of various effects caused due the geometry of drilled specimens, direction of drilling and drilling operations.

Experimental Program and Materials

In order to evaluate the core strength, a testing program was carried out to investigate the effect of length to diameter (L/d) ratio on core compressive strength of concrete and effect of reinforcement bars. To determine the strength of concrete and strength of reinforcement bars, ordinary Portland cement, natural aggregate, fine aggregate and High Range Water Reducing Admixture (HRWRA) were used. The details of the mix proportion are given in Table 2. 150mm x 150mm x 600mm concrete beams were cast and moist cured under lab conditions. Different L/d ratio cores were removed from the beams. The compressive strength is the average of three specimens. The maximum size of coarse aggregate used in this experimental program is 20mm.

To evaluate the influence of rebar on concrete core strength, two sets of concrete beams are used. In the first set, there are beams without rebar and in the second set there are beams with rebar, the size of the rebar used in this program was 10mm, 12mm, 16mm.

Results and Discussions

In this experimental study, the cores with same diameter and three (L/d) ratio were tested and the factors influencing the core strength were examined. The compressive strength developments are listed in Table 3. The effect of the compressive strength for different L/d ratio can be explained from the below figure. As the L/d ratio of the specimen increases, the core compressive strength of concrete decreases. The core strength of concrete for different L/d ratio with different ages after applying correction factors given by the various code provisions were listed in Table 2.

The reduction in the core strength when the L/d ratio is increased may be due to end effect and also the reduction in the volume of specimen. The effect of reinforcement bar to study the core compressive strength of concrete is presented in Table 4. The correct factor given by the concrete society is also applied and the corrected core strength is also mentioned in Table 4.

Table 2 Details of mix proportions

Grade of Cement	Cement (kg/m^3)	WC	SSD Fine Aggregate (kgm/m^3)	Coarse Aggregate (kg/m^3)	Shamp (mm)	HR WRA (kg/m^3)
M25	350	0.41	938	872	132	3.0

Table 3 Compressive strength of 150mm diameter cores with different l/d ratio

L/d	Compressive Strength (Mpa)		Compressive Strength after Applying Correction Fractors (MPa)					
			ASTMC 42		NTC08		EN 13791	
	7s Days	2s Days	7 Days	2s Days	7 Days	2s Days	7 Days	2s Days
2	14	21	14	21	16.47	24.70	11.04	18.04
1.5	17	23	16.32	22.03	20	27.05	14.04	20.04
1.0	13	26	17.38	24.96	20.47	29.36	15.04	23.04

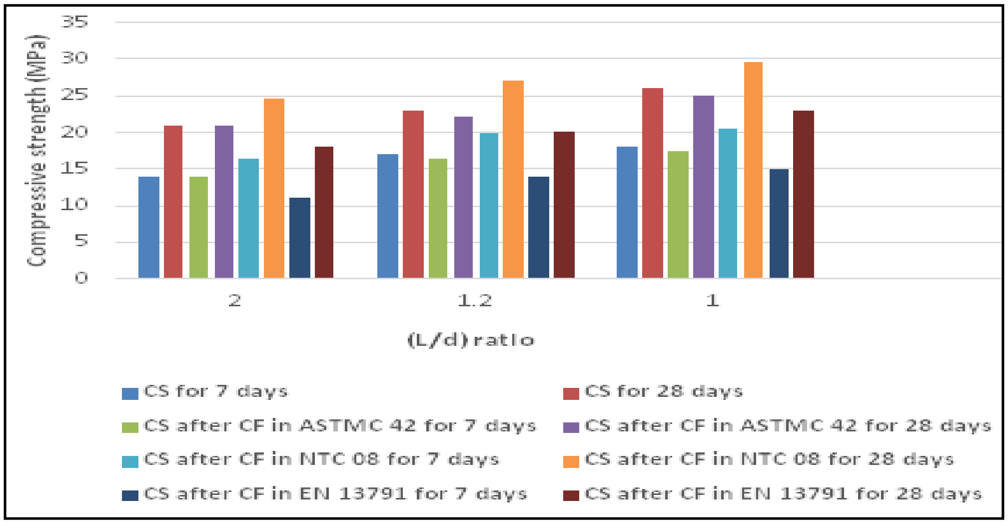

Fig. 2 (L/d) ratio *vs.* compressive strength (MPa)

Table 4 Concrete cores test result

S. No.	Rebar Quantity and Diameter (mm)	Core Weight (kg)	Measured Compressive Strength (MPa)	Corrected Strength by Concrete Society Equation (MPa)
1	2 ø 10	2.268	24.70	26.50
2	2 ø 12	2.192	27.05	30.96
3	2 ø 16	2.278	29.36	31.45

CS – Compressive Strength
CF – Correction Factor

In this experimental program L/d ratio is kept as 2. It is found from Table 4, in all the cores with the presence of rebar there is a reduction of strength up to 30-65% than cores without rebar. This reduction of core strength due to the effect of rebar may be due to rebar cutting of concrete samples.

Conclusion

From the various literatures, we can draw to the conclusion that:

1. Core test is the best reliable test to evaluate the quality of concrete in existing structures.
2. The core strength of concrete is increased when the (L/d) ratio of the core is decreased.
3. The provision of rebar in concrete affects the core strength. Only BS 1881: 1983 gives an empirical relationship to determine the correction factor.
4. The effect of maximum aggregate size was not much significant in evaluating the core strength of concrete.
5. From the above discussion, we can say that after applying correction factors from codes NTC 08 and EN 13791 the compressive strength has been increased to 27%, 25% and 22% for L/d ratio 2, 1.5 and 1.0 respectively.

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Buckling Analysis of Web-Tapered Steel I Beam-Columns

M. Karpagajothi[1] and R. Senthil[2]

Abstract Buckling analysis is a technique used to determine critical loads at which a structure becomes unstable and the characteristic shape associated with a structure's buckled response. The effective length concept (Linear Buckling Analysis) is the common method for prismatic column design without non-linear structural analysis. But for Web-Tapered columns, the critical load is determined using Finite element analysis and approximation methods as there is lack of standards of practice and also it requires software program to carry out analysis. Since to provide simple equations for calculating critical load so many equations from various literatures are reviewed and compared in this paper with Numerical studies for a sample steel I beam-column with simply supported boundary conditions. The Numerical studies for determining critical load are based on different formulae like Slope-Deflection equations, Governing differential Equations, Energy equations and Metal Manufacturer's Manual (AISC Specifications).From the comparison of results, it has been found that the elastic buckling load considering member as individual and in gabled frames with rafter gives different results due to account of its lateral sway drift factor. The various approaches from literatures give various results due to non-linearity and material failure effect consideration.

Keywords: Buckling Analysis, Gabled frame, Web-Tapered member, Effective length factor

Introduction

Steel structural elements like rafters and columns can be designed as tapered members made of steel welded plates for single story frames with pitched roof and pinned column base, respecting the bending moment diagrams for gravitational load combination. In frame design, the concept of effective length is the only available common method for column design without non-linear structural analysis and also used extensively for explanation of interaction influence of other frame members on compressive strength of the considered member. From the theoretical view point, the effective length factor k of a column is determined by structural stability analysis. The Stability analysis of columns and two-dimensional frames incorporating tapered beam and column elements has been reported in many literatures with different approaches. These approaches are based on Slope-Deflection related equations, Equilibrium equations and Energy equations etc. The buckling load based on effective length factor is determined by two ways i.e. considering Web-Tapered columns individually and in association with rafters in gabled frames. The analysis of Web-Tapered member elements is difficult due to its varying Moment of Inertia along its length. It has been approximated as parabolic function. The Variable Moment of Inertia restricts the use of any section Moment of Inertia in the Buckling load calculation, instead it drives to locate and use the critical section moment of inertia. Various approaches have been resulted in different critical section locations. In this work, a sample steel I Web-tapered Column as shown in Fig. 1 is taken as example for Numerical analytical studies. The column is analyzed individually and also in combination with rafter connection for simply supported boundary conditions. The numerical studies are based on Slope-Deflection equations in the work by H. Saffari *et al*. [2], Differential equations from Theodore G. Konstantakopoulos *et al*. [3], Energy equations i.e. Rayleigh-Ritz method with suggestions from Vaidotas Saplas *et al*. [4] and some numerical methods from R. K. Ingle *et al*. [7] which has been referred from Metal Manufacturer's Association Manual (AISC specifications) [6].The critical load values are compared and the Causes for variances are discussed. Finally, from the Numerical studies the quick and efficient methodology is suggested.

Buckling Load Calculation for Web-Tapered Columns

Using Slope-Deflection Equations

Many literatures have been come up for elastic stability analysis of Web-tapered members based on slope-deflection

E-mail: [1]mkjo.civil@gmail.com

[1,2]Structural Engineering Division, Department of Civil Engineering, College of Engineering Guindy, Anna University Chennai

equations as it can include effects of shear, bending and second-order axial load effects. In the literature, An efficient method for computation of effective length factor of columns in a steel gabled frame with tapered members by H. Saffari *et al*. [2], the solution of the non-linear equilibrium equation, which gives the critical loads on the basis of the slope-deflection method, have been taken from the literature of Ermopoulos JC. [1] as transformation equations which are for tapered bars. Using the presented equations the slope-deflection equations for I-type sections are developed. Then, by setting up the equilibrium equations in symmetrical buckling mode for a gabled frame and applying boundary conditions, the equation for determination of critical load is produced. Having solved the equation the results are presented as two dimensionless charts. By using these charts the calculation of critical loads of gabled frame can be carried out very easily.

Figure 1 shows the considered sample section for Numerical studies.

For the gabled frame shown in Fig.1

$\frac{L}{H} = 2$, $I_{b\text{-}b} / I_c = 4.57$, $I_{b\text{-}c} / I_a = 4.57$, and $I_a / I_c = 1$.

I_a, $I_{b\text{-}b}$, $I_{b\text{-}c}$ and I_c are the Moment of Inertia at the respective locations as shown in Fig.1.

$P_{cr} = \frac{\Pi^2 E I_m}{(kL)^2}$

E, L and Π represent Modulus of Elasticity, Length of the column, a mathematical constant with value of 22/7 and I_m the moment of inertia of the middle section of column. Using the chart shown in Fig.2 and above parameters, the effective length factor is k=2.35, the critical load is calculated as P_{cr} = 1952 kN.

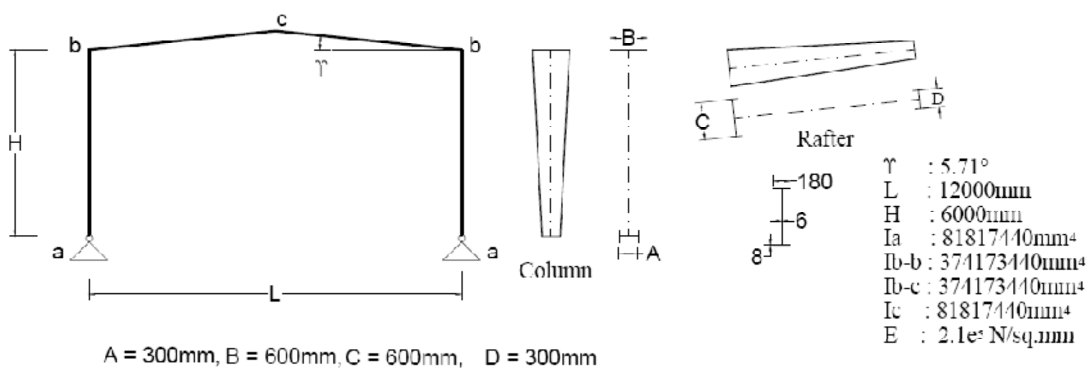

Fig. 1 Gabled frame with sectional properties

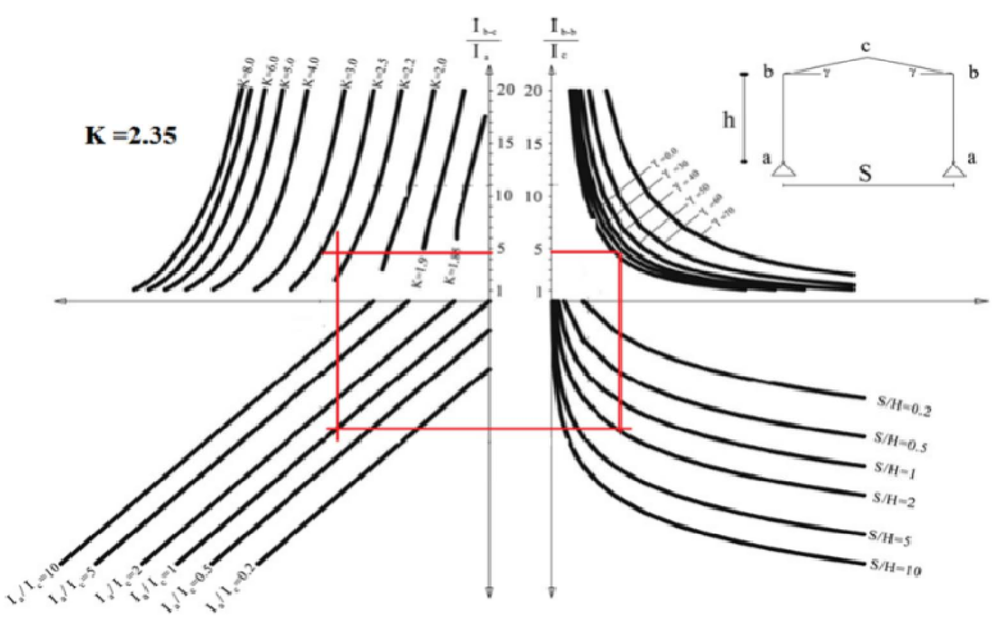

Fig. 2 Dimensionless chart for hinged base gabled frame

Using Differential Equilibrium Equations

Solution by Galerkin Method

In the literature of Stability of Steel Columns with Non-Uniform Cross-Sections by Theodore G. Konstantakopoulos *et al*. [3], the beam-column with variable cross sections and simply supported boundary conditions analyzed for in-plane stability. In the process, in-plane buckling has been initiated by restraining other weak axis buckling to satisfy assumed Eigen mode shapes. To find, the critical section moment of Inertia the following equations are proposed.

$$I(x) = \frac{4}{3}\,t_w\,.\,z^3(x) + 2\,b\,t_f\left[z(x) + \frac{tf}{2}\right]^2$$

$$z(x) = \alpha_o\,(n\text{-}1)\,\frac{x}{L} + \alpha_o$$

$$n = \alpha_o / \alpha_f$$

$I(x)$, α_o ,α_f, t_w, $z(x)$,t_f, L and b represent moment of inertia at section x(=482158080 mm^4), the web depths at top(=600mm), the web depths at bottom(=300mm), thickness of web(=6mm), the distance of the extreme fiber of the member's cross-section at position x(=300mm), thickness of flange(=8mm), length of column(=6000mm) and breadth of flange(=8mm).

In order to study the buckling behavior of steel members with non-uniform cross section, members having section properties at x=0 have been used to calculate the elastic stability force.

$$P_{cr} = \frac{(n\pi)^2 EI(x=0)}{L^2}$$

Using the above equation for buckling mode shape n=1, the elastic buckling load has been calculated to 20516 kN.

Solution by Finite Element Method

The buckling analysis for a tapered column under the combination of axial load and moment cannot be obtained just by adding solutions obtained separately as the dependency is non-linear. So the stability problem of tapered columns can be solved by knowing separate buckling mode shapes as well as corresponding load factors for axial force and bending moment.

In the literature, FEM Stability analysis of tapered beam-columns by Vaidotas Saplas *et al*. [4] the flexibility differential equation for the axially loaded columns are developed based on differential equations by A.N. Dinnik [8].By applying a standard finite element approach using COSMOS/M, the correction factor based on relative second moment area for calculating critical load for tapered column from prismatic buckling load equation has been developed. The details of section from literature is shown in Fig. 3.

Relative second moment of area $\frac{I\,y1}{Iy2} = 0.218$

$$N_{cr\ tr} = \alpha_n \frac{\Pi^2}{(\mu L)^2} EI_{y2}$$

α_n, E, L, Π, μ and I_{y2} represent correction factor, Modulus of Elasticity, Length of the column, value of 22/7, Effective length factor for prismatic column with simply supported conditions and second moment of area at bigger end. From the above numerical results, the correction factor α_n from Fig.4 is 0.7486 and the Elastic stability force equals to 15359 kN.

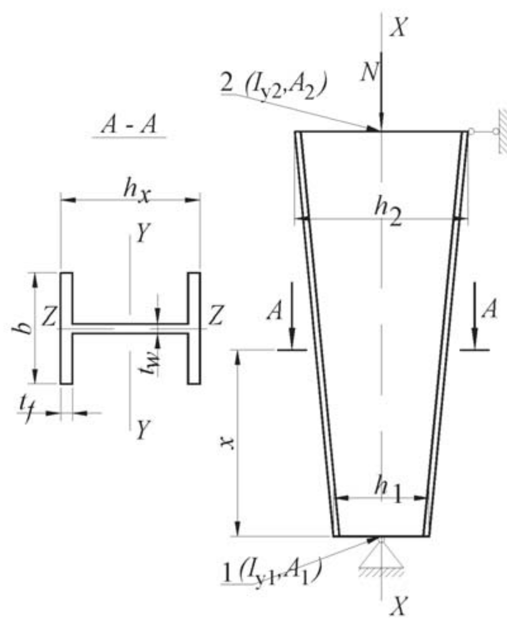

Fig. 3 Axially loaded tapered column and its cross section

I_{y1}/I_{y2}	0,010	0,050	0,100	0,200	0,300	0,400
α_n	0,563	0,629	0,676	0,740	0,788	0,829
I_{y1}/I_{y2}	0,500	0,600	0,700	0,800	0,900	1,000
α_n	0,864	0,895	0,924	0,951	0,976	1,000

Fig. 4 Correction factor αn for relative second moment of area

Using Energy Equilibrium Equations

In the literature, Rayleigh-Ritz procedure for determination of the critical load of tapered columns by Liliana Marques *et al.* [5] based on the Rayleigh-Ritz energy method, a formula for determination of the in-plane critical axial force of simply supported linearly web-tapered axial force is provided by simulating in- plane buckling. The total potential energy provided by member has been approximated according to Rayleigh-Ritz method. The Rayleigh-Ritz method often leads to over conservative results due to error in exact approximation of displacement function.

$N_{cr\ tap} = A.N_{cr\ min}$

$N_{cr\ min} = \frac{\pi^2}{L^2} EI_{small}$

$\Upsilon_I = I_{y\ max} / I_{y\ min}$

$A = \Upsilon_I^{0.56} (1\text{-}0.04.\tan^{-1}(\Upsilon_I - 1))$

$N_{cr\ tap}$, $N_{cr\ min}$, $I_{y\ max}$ and $I_{y\ min}$ represent critical load of the tapered section, critical load of the smallest section, moment of inertia at maximum web depth section and minimum web depth section.

Based on the numerical calculations the in plane buckling load equals to 20744 kN.

Using Metal Manufacturer's Association Manual

In the Design Guide for web-tapered members from Metal manufacturer's Association Manual by Kaehler RC *et al.* [6], the nominal elastic flexural buckling strength (P_{eL}) of a prismatic member having ideal pinned-pinned end conditions is taken as equivalent parameter (Υ_{eL}) multiplied by the required strength of the member at the point (P_r). The equivalent parameter is used because the internal axial force may vary along the member length due to second order effects. But for Web-tapered I-shaped members, there is no solution for the equivalent parameter. The following procedures are recommended for calculating P_{eL} and Υ_{eL} for tapered members.

1. Equivalent moment of Inertia method
2. Buckling Load factor Method
3. Effective length factor method

And also in the literature of R.K. Ingle *et al*. [7], the above methods have been brought up in the graph form. So the methods are followed from the said literature.

Equivalent Moment of Inertia Method

For tapered members subjected to constant internal axial loading, with a single taper angle and no change in the web or flange plates over the length, the following empirical equation gives results accurate the equation provides the flexural buckling strength of a web-tapered member of the same length using an equivalent moment of inertia.

$P_{eL} = \frac{\pi^2}{L^2} EI'$

I', I_{small}, I_{large} and L represent the equivalent moment of inertia or strong axis moment of inertia of the segment calculated using the depth at 0.5L $(I_{small} / I_{large})^{0.0732}$ from the small end, strong-axis moment of inertia at the small end, strong-axis moment of inertia at the large end and length of the tapered member.

Critical section location for the section shown in Fig. 1 is 2684 mm and using above mentioned formulae the in plane flexural buckling load comes around 9964 kN.

Buckling Load Factor Method

The buckling load factor (BLF) is an indicator of the factor of safety against buckling or the ratio of the buckling loads to the currently applied loads. But for the calculation of buckling load factor, linear buckling analysis by a software program is required. Since for pin ended symmetrically tapered columns, R. K. Ingle *et al.* [7] have developed ready to use charts for various relative second moment of area.

$P_{Taper} = R_{ppin} * P_{Euler}$

$P_{Euler} = \frac{\pi^2}{L^2} EI_{base}$

Here Ri, I_{top}, I_{base} and R_{ppin} represent the taper ratio I_{top} / I_{base}, top second moment of area, bottom second moment of area and buckling load factor for pinned end conditions. The Euler buckling load equals to 4486 kN and the buckling load factor from Fig.5 arrived to 2.22 for taper ratio of 4.57.So the flexural buckling load for web-tapered member equals to 9969 kN.

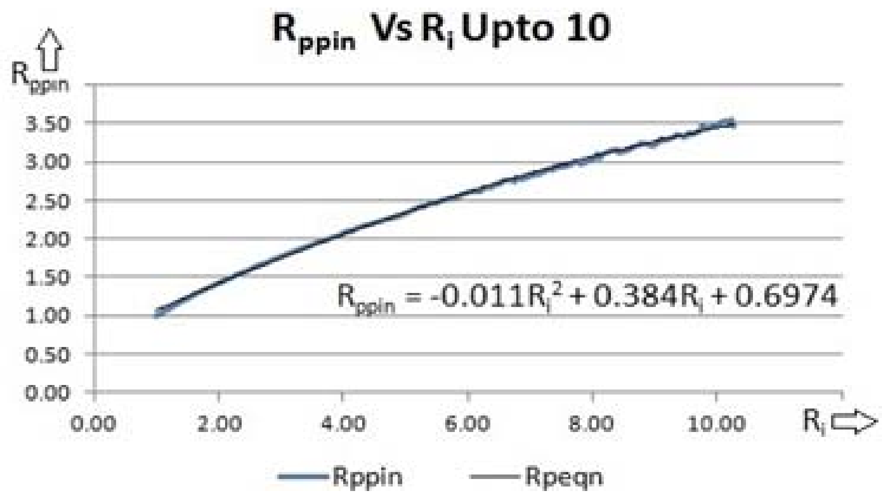

Fig. 5 Buckling load factor for relative second moment of area

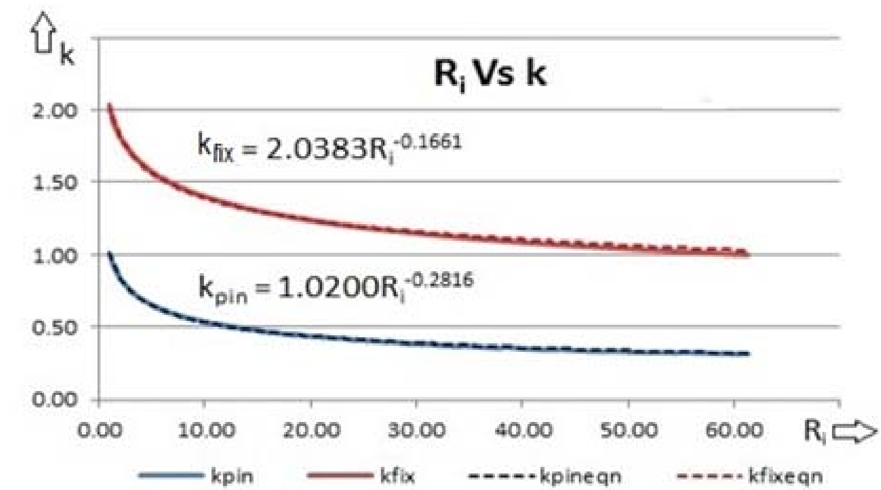

Fig. 6 Effective length factor for relative second moment of area

Effective Length Factor Method

In most of design steel members and frames, specifications for the design of compression columns or of beam-column use the effective length factor; *K*. The effective length factor is employed to facilitate the design of framed members by transforming an end-restrained compressive member to an equivalent pinned-ended member. The effective length factor is obtained by solving the exact equations numerically. For any member geometry, the effective length factor is tied to the ratio of the buckling load accounting for the interaction of the member with adjacent components and with the overall structural system and the buckling load using idealized pinned-pinned end conditions. Especially for non-prismatic members, the preceding effective length factor is useful only as an indicator of the effect of adjacent components and the overall structural system on the member stability.

$k_{pin} = 1.02\ R_i^{-0.2816}$

$P_{Euler} = \frac{\pi^2}{(kL)^2}\ EI_{base}$

The effective length factor from Fig.6 claims to be 0.665 for taper ratio of 4.57 and the Elastic buckling load for web-tapered member equals to 10,147 kN.

Conclusion

From the various literatures, the methods used for calculation of critical load has been calculated and tabulated in Table 1.

Table 1 Comparison of elastic buckling load of web-tapered columns obtained from various methods

Source	Method	Critical Load kN
H. Saffari *et al*. [2]	Slope-deflection Relation	1952
Th. G. Kons. *et* al [3]	Equilibrium equations	20516
Vaias *et al*. [4]		15359
Liliana *et al.* [5]	Energy Equations	20744
R.K. Ingle *et al.* [7]	Equivalent Moment of Inertia	9964
	Buckling Load Factor	9969
	Effective length Factor	10147

From the tabulation, it has been concluded that:

1. The elastic buckling load considering member as individual and in gabled frames with rafter gives different results due to account of its lateral sway drift factor.
2. The Galerkin method solution for Equilibrium equations gives higher elastic buckling load as a plasticity criterion has been applied in order to predict material failure due to buckling deformation.
3. The accuracy of method using energy equations is based on approximation of displacement function.
4. As the methods from Metal Manufacturer's Association manual has taken the account of second-order effect, the variation of results among methods are less than or equal to 1%.
5. From the above discussion, it has been found that the literatures are considering in plane buckling calculations only. And also except Metal Manufacturer's Association manual, second order effect is not considered to account for geometric non-linearity of sections.
6. A new relationship has to be formulated incorporating all the factors influencing the elastic stability of Web-tapered column based on Indian codes of practice.

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Case Study on Dynamic Responses of Onshore Modules Supporting Pumps with Different Foundation/ Pile Arrangement

Puspanjali Roy[1], Abhishek Harne[2] and Surajit Mukherjee[3]

Abstract The intent is to study the dynamic response of a modular steel structure due to vibratory equipment supported on it. Such situations are generally encountered in Modularization project where modules are transported from the fabrication yard and then finally erected at site. This study enables us to understand the dynamic effect on the steel base frame in terms of deflections at the rotor CoG, equipment anchor bolt locations and the accessible points on the base frame due to the variation in dynamic behavior of the structure contributed primarily due to change in foundation / pile configurations. [1]

The integral part of this study comprises of 2 main components–Single Pile Impedance calculation based on the dynamic soil properties and the Dynamic Analysis of the module based on the Pile Impedance. The dynamic soil properties as received from the Geotechnical Report of a sample project along with the pile locations are used to calculate the pile stiffness and damping in all 6 directions (3 translations and 3 rotations) with the help of Dyna N. Single pile impedance is then used to simulate the stiffness and damping of the structure modeled in SAP. Four trials are carried out based on different pile cap layouts. These are then used for the dynamic analysis of the base frame subjected to the entire dead load of total module. The unbalanced loads are applied at the rotor CoG locations. The directions are simulated with the help of Trigonometric Functions–Sine Function and Cosine Function to replicate the rotating effect of the shaft transferring the load from the motor to the pump. The effect of these loads on the base frame member sizes in terms of deflection amplitudes and velocity amplitudes are compared for various configurations of the pile cap and an optimum configuration is suggested.

Keywords: Modularization, Vibratory Equipment, Pile Impedance

E-mail: [1]puspanjali.roy@fluor.com, [2]abhishek.harne@fluor.com, [3]surajit.mukherjee@fluor.com

[1,2,3] Fluor Daniel India Pvt. Ltd., New Delhi, India

Introduction

The initial step for performing the dynamic analysis is the procedure to calculate the pile impedance of all the three foundation layouts from Dyna. These values are based on the operating frequency of the machine.

The second part of the analysis is to model the foundation system along with the superstructure till the base frame level in SAP. The dead loads from the entire structure is applied on the base frame and the piles are modeled as single joint links with properties as obtained in Dyna for a single pile.

The total base reactions are checked with the static model for the loads which are applied in SAP. The modal participation is then checked till 99% of the total mass participates in all 6 degrees of freedom. The structure is checked for no resonance condition by checking the individual participation at each mode with a frequency within the range of 0.8 to 1.2 times the operating frequency of the machine.

The unbalanced load is then applied with the help of sinusoidal function with a phase difference of p/2 radians. The output is then studied at regular intervals to attain the displacement and velocity amplitudes of the machine for two critical cases.

Methodology

The number of piles derived based on in-place analysis is 90. Based on this number three different layouts have been worked out; the number of piles remaining constant. The trial pile layouts are described below:

Case 1: Number of piles being maintained at 90, pile cap is a continuous strip with dimensions 39.40 m x 2.50 m x 1.00 m deep. Intermediate pile caps are triangular in shape each with 3 piles and 0.80 m deep (Fig. 1)

Case 2: Number of piles being maintained at 90, pile cap is split. For the grids with the vibratory equipment the strip has a dimension of 15.40

m x 2.50 m x 1.00 m. The other foundation are on another strip of dimensions 21.00 m x 2.50 m x 1.00 m. Intermediate pile caps are triangular in shape each with 3 piles and 0.80 m deep (Fig. 2)

Case 3: Number of piles being maintained at 90, pile cap beneath each column is separate. For the first 4 grids, each pile cap comprises of 6 piles and is of size 3.40 m x 2.50 m x 1.00 m. The other 3 grids has a pile cap with 4 piles each of dimensions 2.50 m x 2.50 m x 1.00 m. Intermediate pile caps are triangular in shape each with 3 piles and 0.80 m deep (Fig. 3)

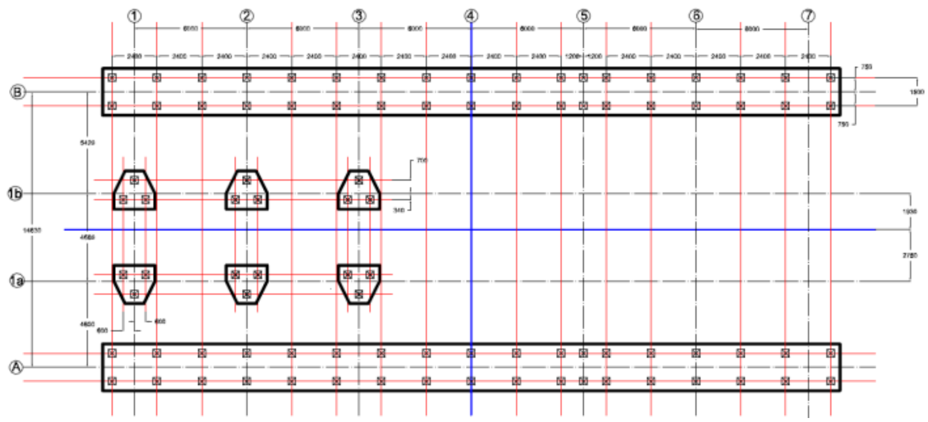

Fig. 1 Single longitudinal strip pile cap

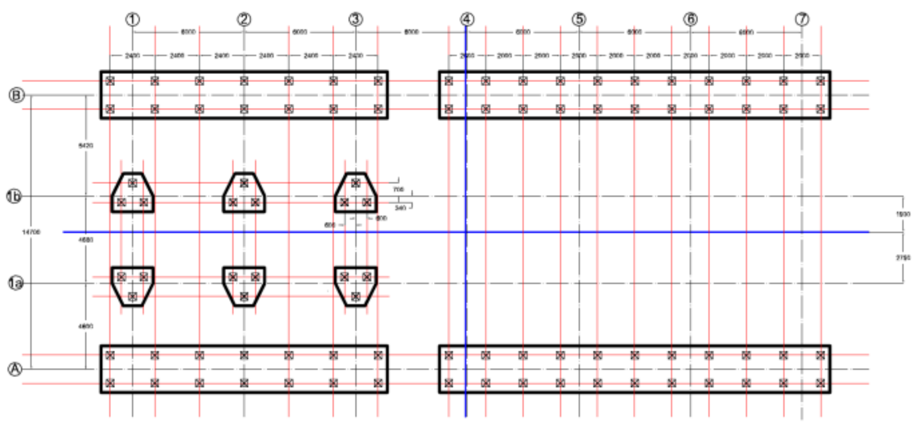

Fig. 2 Longitudinal strip pile cap split into two

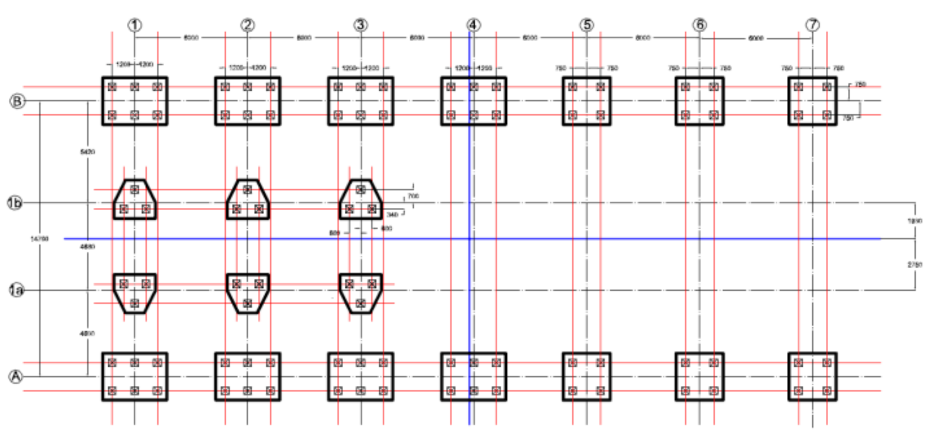

Fig. 3 Individual pile cap

The soil properties used to achieve the group effect is tabulated below.

Table 1 Dynamic properties of soil strata

Soil Layer	Depth of Layer, m	Density, kN/m^3	Shear Wave Velocity (Vs), m/sec	Poisson's Ratio (μ)
1	1.08	19	71	0.39
2	2.5	9	170	0.32
3	2.2	9	267	0.3
4	2.8	9	175	0.4
5	0.5	9	303	0.39
6	3.92	9	400	0.35

Floating Fixed head piles of length 13 m and 400 mm square piles with material damping 2%, Poisson's Ratio 0.17, Dynamic Elastic Modulus 3.5+e07 kN/m^2 and unit weight of 23.5 kN/m^3 are used.

Speed of the Motor and Pump is 3000 rpm. Unbalanced load of the Motor is 28.50 kN and that of the Pump is 11.88 kN as illustrated in Section D. These unbalanced forces are applied with the help of sine and cosine functions in the time history function definition. These replicate the vertical and the horizontal components in which the tangential force is split.

Results

The values highlighted above show the cases with least values. Considering vibration amplitudes, Case 2 i.e. with two split pile caps have limiting amplitudes at the rotor CoG and the anchor bolt locations for the case when the two shafts have the same rotation.

Table 2 Results for both pumps operating in phase

	In Phase					
	Displacement, mm			Velocity, mm/sec		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Motor CoG: Long	2.10	1.89	2.40	0.66	0.59	0.76
Motor CoG: Trans	5.68	5.26	5.98	1.78	1.65	1.88
Motor CoG: Vertical	4.71	4.53	5.35	1.48	1.42	1.68
Pump CoG: Long	2.10	1.89	2.40	0.66	0.59	0.76
Pump CoG: Trans	3.80	3.95	3.74	1.19	1.24	1.17
Pump CoG: Vertical	0.38	0.37	0.44	0.12	0.12	0.14
Pump 1 AB: Long	1.65	1.51	1.81	0.52	0.47	0.57
Pump 1 AB: Trans	4.40	2.57	5.40	1.38	0.81	1.70
Pump 1 AB: Vertical	5.13	5.45	4.45	1.61	1.71	1.40
Pump 2 AB: Long	2.14	1.83	2.67	0.67	0.58	0.84
Pump 2 AB: Trans	3.48	2.46	4.35	1.09	0.77	1.36
Pump 2 AB: Vertical	6.10	6.21	5.98	1.91	1.95	1.88

Similarly, Table 3 below shows the values for both the shafts operating at a phase difference of p radians.

Abbreviations and Acronyms

CoG: Centre of Gravity
Rpm: Rotations per minute

Equations

Unbalanced load for the Motor as per ACI 351.3 Eq. 3-4,

$$F_0 = \frac{m_r \times Q \times \omega_0 \times S_f}{1000}\ N = 28.50\ kN$$

where, m_r = rotating mass, kg which is considered as 30% of the motor weight i.e. 19200 kg

Q = Normal balance quality considered as 6.3

ω_0 = circular operating frequency of the machine in rad/sec = $\frac{3000 \times 2 \times \pi}{60}$

S_f = Service Factor which is considered as, 2.5

Table 3 Results for both pumps operating out of phase

	Out of Phase					
	Displacement, mm			**Velocity, mm/sec**		
	Case 1	**Case 2**	**Case 3**	**Case 1**	**Case 2**	**Case 3**
Motor CoG: Long	2.05	1.88	2.35	0.64	0.59	0.74
Motor CoG: Trans	5.27	5.12	5.31	1.65	1.61	1.67
Motor CoG: Vertical	4.58	4.41	5.10	1.44	1.39	1.60
Pump CoG: Long	2.05	1.88	2.35	0.64	0.59	0.74
Pump CoG: Trans	2.38	2.37	2.48	0.75	0.75	0.78
Pump CoG: Vertical	0.38	0.37	0.43	0.12	0.12	0.13
Pump 1 AB: Long	2.01	2.07	2.14	0.63	0.65	0.67
Pump 1 AB: Trans	3.13	3.26	3.14	0.98	1.03	0.99
Pump 1 AB: Vertical	5.07	5.10	4.95	1.59	1.60	1.55
Pump 2 AB: Long	2.22	2.28	2.40	0.70	0.71	0.75
Pump 2 AB: Trans	3.28	3.31	3.49	1.03	1.04	1.09
Pump 2 AB: Vertical	6.17	5.87	6.47	1.94	1.84	2.03

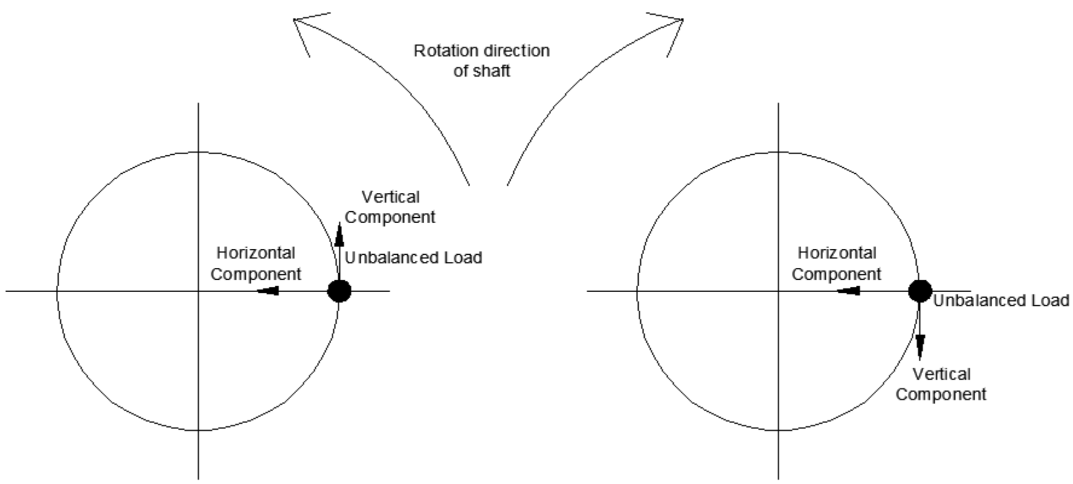

Fig. 4 Components of two shafts with opposite rotation

Conclusion

As per the results section, Case 2 gives the limiting values for amplitudes due to the dynamic behavior of the equipment and may be used if there are no other underlying criteria at the site.

Acknowledgment

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Constructed Wetland: A Green Initiative for Waste Water Treatment

J.S. Sudarsan[1], Rajitha J. Rajan[2] and B. Anishaa Harshinee[3]

Abstract Pollution has been a great concern for decades. Tanning industries discharge untreated effluents and highly toxicities like Chromium into the environment which is hazardous to human existence. This project is mainly focused on purifying tanned water by two economical techniques. Its main objective is to evaluate the efficiency of constructed wetland by using coconut shell biochar. To compare the pollutant uptake efficiency of biochar amended constructed wetland and conventional constructed wetland in treating tannery and domestic wastewater. Constructed wetlands (CWs) are engineered systems which are designed and constructed to utilize the natural processes like wetland vegetation, soils, and the associated microbial assemblages to assist in treating wastewaters. Biochar is a stabilized, organic carbon compound, created when biomass is heated to temperatures usually between 300 and 1000°C, under low (preferably zero) oxygen concentrations. Biochar derived from the agricultural biomass waste is increasingly recognized as a multifunctional material for agricultural and environmental applications. Biochar mixed into the substrate of constructed wetlands has been shown to immobilize toxic metals. It is an organic material, produced by means of pyrolysis, to treat water and reduce carbon footprint. Combining both of these technologies can greatly augment the efficiency of the system.

In primary treatment, biosorption is the phenomenon which has been utilized. The biomass is burnt in a controlled environment at low temperature so that the carbon emitted is less and more quantity of burnt biomass is obtained. The biochar acts as a purifying media which makes the water colorless when passed over it and also removes toxicities like chromium present in tanned water.

In secondary stage, this purified water is passed over an artificial channel or basin with a barrier to prevent seepage, with a bed of suitable depth and porous media which is called as constructed wetland. Filtration and bisorption mechanism plays a vital role in this type of arrangement. The objective of RRR (Reduce, Reuse and Recycle) is achieved.

Keywords: Constructed Wetland, Biochar, Pyrolysis, and Filtration

Introduction

Environmental Pollution has been the major concern for a very long time now. The pollution of water bodies by disposal of waste untreated water directly in them has caused many rivers and other water bodies to be unfit for use. Other pollutions include air pollution, land pollution etc. The problem of water pollution is increasing at a brisk pace. The unrestrained dumping of municipal, industrial and agricultural waste, solid and gaseous wastes to the environment establishes one of the greatest grave fears to the sustainability of human civilization by polluting the water, land, and air and by adding to global warming.[1,2]

Constructed Wetland is similar to that of the normal wetland but is artificially constructed in a controlled environment. These systems utilize wetland plants, soils, and associated microorganisms to remove contaminants from wastewater. They are cost effective, reliable systems with no energy sources or chemical requirements and a minimum of operational requirement.[3] There are two types of constructed wetlands, surface flow wetlands, with shallow flow of wastewater over saturated soil substrate and subsurface flow wetlands which have gravel as the main media to support the growth of plants. The classification of subsurface flow wetlands include vertical flow (VF) and horizontal flow (HF) systems and a combination of VF and HF systems are recently developed combining both principles of vertical flow (VF) and horizontal flow (HF) systems which are known as hybrid wetlands.[4,5]

E-mail: [1]sudarsanjss@yahoo.com

[1]Assistant Professor (SG), Department of Civil and Environmental Engineering, SRM University, SRM Nagar, Kattankulathur, Kancheepuram, Tamil Nadu–603203, India

[2]Post Graduate Student, Department of Civil and Environmental Engineering, SRM University, SRM Nagar, Kattankulathur, Kancheepuram, Tamil Nadu–603203, India

[3]B.Tech Student, Department of Civil and Environmental Engineering, SRM University, SRM Nagar, Kattankulathur, Kancheepuram, Tamil Nadu–603203, India

The most important removal mechanism occurring in constructer wetland is filtration, several microbial-mediated processes, chemical networks, volatilization, sedimentation, sorption, photo degradation, plant uptake, ammonification, nitrification, denitrification and many more.[6,7]

Different unconventional wetland media are used for treating different types of wastewaters. The treatment efficiency offered by each type of media is different due to variations in pH, conductivity, porosity and the bacterial composition offered by them.[8] One of the recent developments in the modification of wetland media is the use of biochar. Biochar is a steadied, organic carbon based compound, produced when biomass is heated to temperatures more often than not in the vicinity of 300 and 1000°C, under low oxygen fixations. It is produced from a variety of raw materials which includes horticultural buildups, wood chips, compost, coconut shells and municipal solid waste.[9,10]

Indian Leather Industry–sixth biggest in the World is plentifully supplied with a fortune of crude materials, gifted labor, inventive innovation and expanding industry consistence. Tannery wastewater contains an intricate blend of both natural and inorganic contaminations. The significant worry over tanneries has been about scents and water contamination from untreated releases. Critical contaminations related with the tanning business incorporate chlorides, chromium, colors and also synthetic solvents.[11] Biochar consists of certain bacteria along with activated carbon or zeolite which acts as an adsorbing media which adsorbs chromium ions and other associated contaminants from tannery waste water. In this paper we focus on the treatment of tannery wastewater and the reduction of chromium content in it using a cheaper and rather sophisticated technique of Construction Wetland coupled with Biochar. Chromium occurs in the earth basically in two valence states: trivalent chromium and hexavalent chromium. Introduction may occur from typical or mechanical wellsprings of chromium. Trivalent chromium is significantly less hurtful than hexavalent chromium. Hexavalent chromium has had extensive, whole deal use in industry for its ability to thwart the course of action of rust. It is in like manner a known human disease bringing on operator.[12,13] The tannery waste water is allowed to pass through the constructed wetland where biochar present along with the soil in the constructed wetland media adsorbs the chromium ions either hexavalent or trivalent in state and allows considerably good and harmless water to be disposed of in the natural water bodies.

Methodology

The overall experimental method is represented in a schematic diagram (Fig. 1). The experiment starts with the collection of raw materials and wastewater. The experimental trial was carried out of a retention time of 5 days.

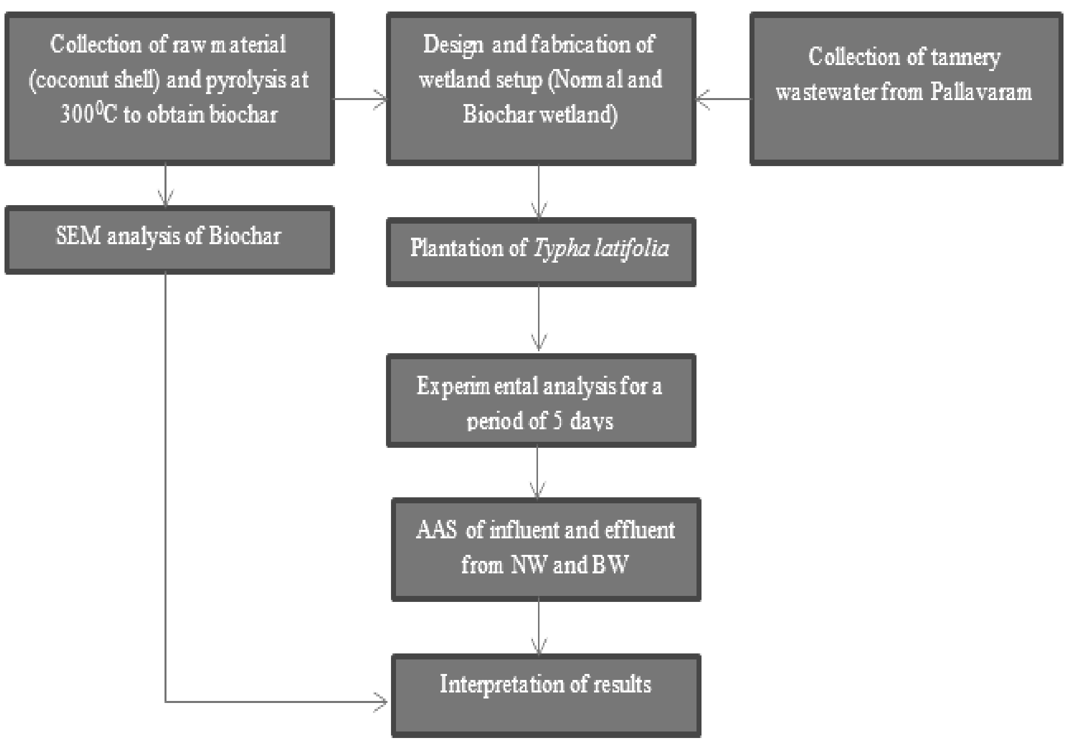


Fig. 1 Methodology adapted for the study

Fig. 2 Stages of development of constructed wetland setup and experimental trial

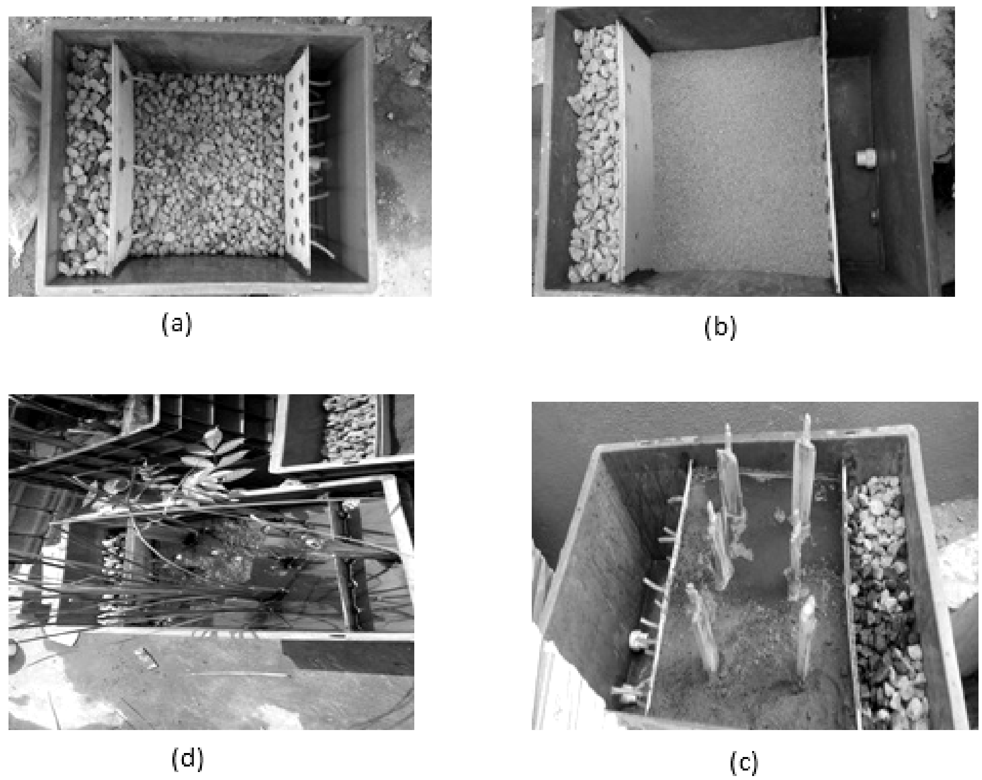
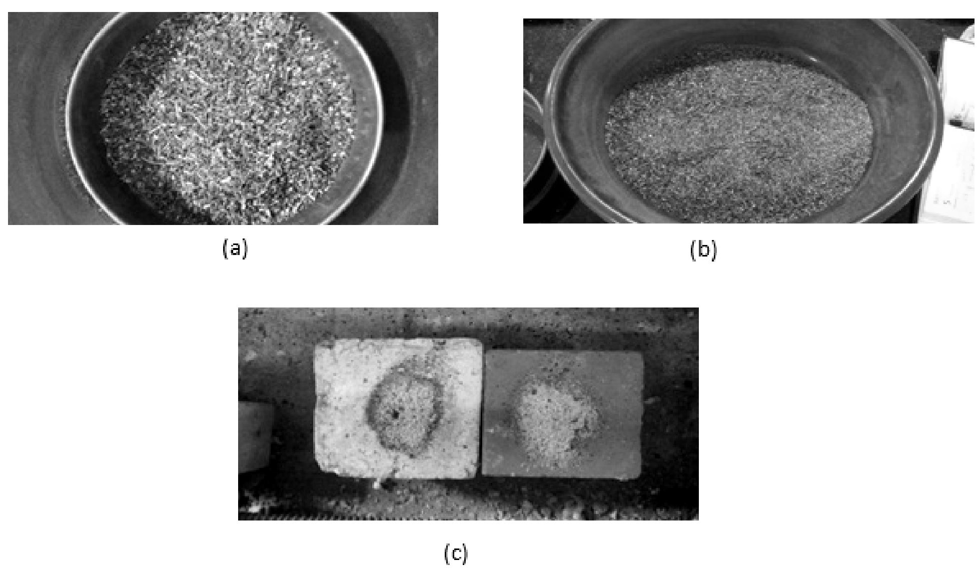


Fig. 3 Preparation of biochar



1. *Study Area*: The exploratory work was done in SRM University, situated in SRM Nagar of Potheri Village (12º 9 N to 12° 49 N and 80° 2 E to 80° 3 E), in Kancheepuram locale, Tamil Nadu, India. The temperature ranges from 20-40°C and a yearly precipitation of 1213 mm.
2. *Design of Constructed Wetland*: The study included two experimental setups. Each constructed wetland setup consisted of a PVC tub which is 0.6 m in length, 0.4 m wide and 0.3m deep. The two wetland systems were named as Normal Wetland (NW) and Biochar Wetland (BW) and were constructed with a slight inclination of 1–2% between inlet and outlet region. The setup was divided into three parts. The first part consisted of gravel alone for the elimination of bigger grit particles existing in the domestic wastewater. The second region of setup NW consisted of gravel, sand and soil while setup BW contained layers of gravel, sand and soil mixed with the coconut shell

(CS) biochar.[14] The different stages of the wetland unit design are shown in Fig. 2. Fig. 2(a) shows lining of constructed wetland unit with Gravel (b) lining of constructed wetland unit with sand (c) plantation of *Typha latifolia* and (d) experimental trial using Tannery wastewater.

3. *Wetland Vegetation*: Plants in wetlands utilize the phytoremediation system in built wetlands. *Typha latifolia*, a local wetland species is to be used for the study.
4. *Biochar Preparation*: The utilization of coconut shell biochar for treatment of wastewater is picking up significance in the present world. The coconut shells produced from oil industry and different employments of coconut should be used legitimately. The coconut shell was bought from the nearby markets and pounded into little pieces. The crushed pieces were cleaned and dried under sun and afterward sieved through a standard test sifter of 1.18 mm strainer. Coconut shell when pyrolysed under 250–600°C by slow pyrolysis method showed effective biochar properties. For the production of biochar, the sieved coconut shell was undergone pyrolysis in a muffle furnace at the temperature range of 300°C for a time period of 5 hours. Fig. 3 shows the different stages of biochar preparation which include (a) Coconut shell before sieving through 1.18 mm sieve (b) Coconut shell after sieving through 1.18 mm sieve and (c) Coconut shell biochar after pyrolysis.
5. *Collection of Tannery Wastewater*: The tannery wastewater was collected from the CETP (Common Effluent Treatment Plants), Pallavaram, Chennai, which has a cluster of 150 tanneries. The tannery wastewater was collected according to the Standard Methods for Examination of Water and Wastewater, APHA.[15]
6. *SEM Analysis*: Scanning Electron Microscopy (SEM) investigation is used for the morphological examination of the biochar. It is a kind of electron amplifying instrument that produces photos of a case by separating it with a drew in light discharge. SEM images clearly demonstrate the physical nature of the compound, the surface topography and association. Illustrations can be found in high vacuum, in low vacuum, and in wet conditions.
7. *Experimental Trial for Analysis of Chromium*: The tannery wastewater was passed through the wetland systems A and B and the water samples were collected after a retention time of 24, 48, 72, 96, and 120 hours from the outlet zones. Chromium in tannery wastewater was analyzed using Atomic Absorption Spectroscopy (AAS).

Results and Discussion

SEM Analysis Results of Coconut Shell Biochar

The SEM analysis of the coconut shell biochar was conducted. Fig. 4.1 shows the SEM analysis images of coconut shell biochar under 2500X magnification. Fig. 4 shows the particle lengths of different particles. The figure shows that coconut fiber pyrolysed at 300°C has an irregular structure. The mean length of the particles was calculated as 6913.184 nm and the mean area as 2784519 nm^2. It can be observed from the image that the biochar does not exhibit a porous structure but rather an irregular structure. Table 1 shows the particle size analysis of coconut shell biochar using Image.

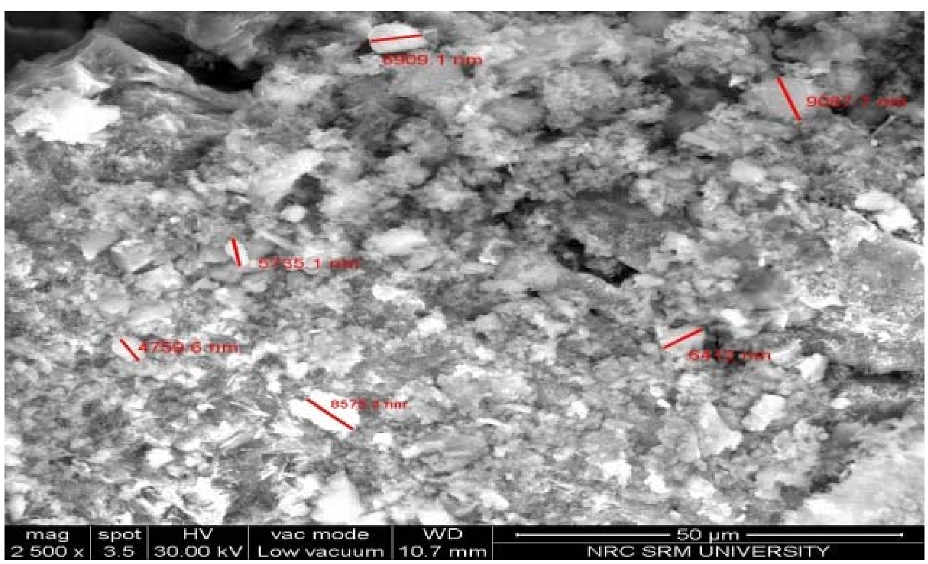


Fig. 4 SEM image of coconut shell biochar under 2500X magnification

Table 1 Particle size analysis of coconut shell biochar using image

Sr. No.	Label	Area	Angle	Length
1		1027703	-45.556	8575.355
2		3249763	9.782	6909.181
3		4388569	-71.801	9087.76
4		2013742	-60.255	4759.651
5		3249763	-143.13	6412.046
6		2777575	-79.38	5735.108
7	Mean	2784519	-65.057	6913.184
8	SD	1156411	49.7	1659.417
9	Min	1027703	-143.13	4759.651
10	Max	4388569	9.782	9087.76

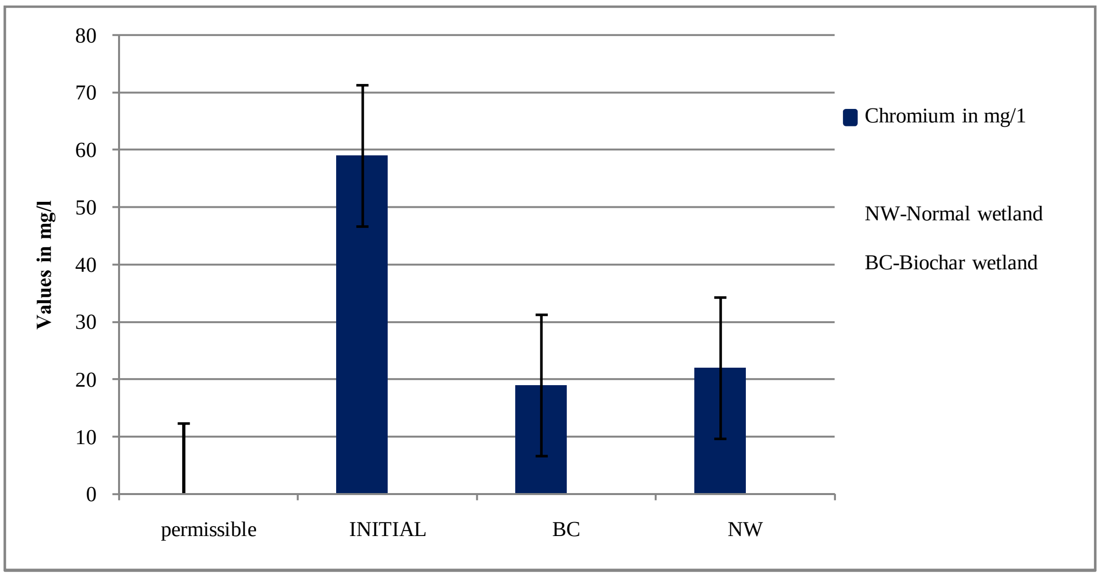


Fig. 5 Chromium tannery wastewater

Reduction of Cr in Constructed Wetlands

The analysis of Cr by Atomic Absorption Spectroscopy (AAS) revealed that the initial levels of Cr in tannery effluent reached approximately 60 mg/l against the permissible limits of 2.0 mg/l. Again when the tannery effluent is passed through normal constructed wetland and biochar wetland the concentration reduced to less than 20 mg/l in biochar wetland and less than 25 mg/l in normal constructed wetland.

Conclusion

Concentration of Cr has been diminished marginally more in biochar wetlands, but there is no much significant difference in reduction of chromium from biochar wetland and normal wetland. The adsorption of chromium by using coconut shell biochar should be studied for future works.

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Construction of an Intake Pit with Diaphragm Wall Design

Tarun Hazarika[1]

Abstract The Sea Water Intake pit is constructed with Diaphragm wall to collect fresh sea water from the sea with gravity flow through the laid pipes in sea bed for uninterrupted supply to the Open Rack Vaporizer to process Liquefied Natural Gas through the designed system, it also includes the supply of sea water to the fire water network.

Keywords: Sea Water, Intake Pit, Diaphragm Wall

Introduction

This sea water intake pit structure is executed for Liquefied Natural Gas Re-gasification terminal in the western part of the India. The structure is basically a reinforced concrete structure, constructed first time in India with the help of diaphragm wall design. The structure is very close to the sea coast of Bay of Bengal. It is a marvelous structure of civil engineering design, done with many surprises, field difficulties and lesson learned in execution period.

The activities involved in Sea Water Intake pit includes construction of Diaphragm wall, fabrication-installation of structural struts, excavation work for deep pits construction within diaphragm wall area, bottom raft, intermediate walls, and top roof slab concrete, water proof coatings on inner surfaces of pit wall, concrete core cutting on diaphragm walls to install duplex puddle flanges for sea water entry to the pit, grouting and concrete encasing on pipe flanges, backfilling and handover to customer.

This structure is done first time in India by designing with diaphragm wall, that too in Sea shore area close to the Sea. While executing the structure from excavation to top covered roof slab, lots of field difficulties faced due to high soil and ground water pressure with Sea Tides. It was really critical & challenging task to overcome from the situation of practical difficulties to achieve the milestones.

Methodology

Key construction chronologies of this structure are mentioned below while executing i.e., Diaphragm wall, Steel structural struts fabrication and installation, Excavation inside diaphragm wall area, Bottom raft-Intermediate walls-Top covered roof slab concrete, Water proof coating of internal wall surfaces and puddle flange pipe installation and grouting.

1. *Diaphragm Wall Construction:* Total fourty eight numbers diaphragm wall panels done for intake pit, where length of diaphragm wall was 21.60 meter (70.866’) from the existing ground level with thickness 800 mm (2.625’). Figs. 1−3 shows layout and section of diaphragm wall, Fig. 4 shows grabbing techniques.
2. *De-watering System:* This was the prime requirements to construct the structure, de-watering system was established to control & monitor the ground water table to keep stable water table at excavated level to expedite construction activities, because depth of the intake pit was 16.50 m (54.134’) from the Existing Ground Level. Fig. 5 shows the dewatering layout.
3. *Installation of Structural Struts:* The structural struts were provided to keep stability of diaphragm walls due to heavy soil pressure, so that work can be carried out safely inside the excavated pit to complete bottom raft and intermediate walls.
4. *Excavation Inside the Diaphargm Wall Area:* Excavation inside the diaphragm wall area is done in stage wise by counter balancing the bottom soil pressure to avoid soil heaving, for safety of the

E-mail: [1]thazarika1967@gmail.com

[1]Toyo Engineering India Pvt. Ltd., Mumbai, India

installed diaphragm walls to construct bottom raft and intermediate walls. Refer to Fig. 6 for counter balancing.

5. *Bottom Raft, Intermediate Wall & Top Slab Concrete:* Base raft is constructed in five parts alternatively with construction joints in consideration to maintain bottom soil and water pressure, sequentially intermediate walls, aprons and top roof slab concrete is completed. Fig. 7 shows top view of the intake pit.

6. *Puddle Flange Pipe Installation:* Total six numbers of puddle flanges are installed in south side of the intake pit through diaphragm wall after concrete core cutting on it, these pipe flanges were fixed after completion of sea water intake pits construction, so that sea water can be taken inside the pit for utilization in LNG process.

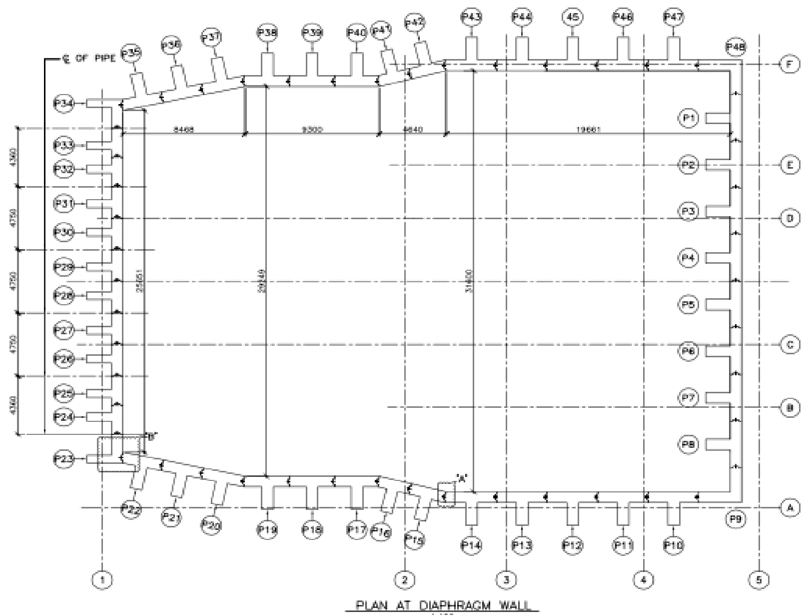

Fig. 1 Layout plan of diaphragm walls

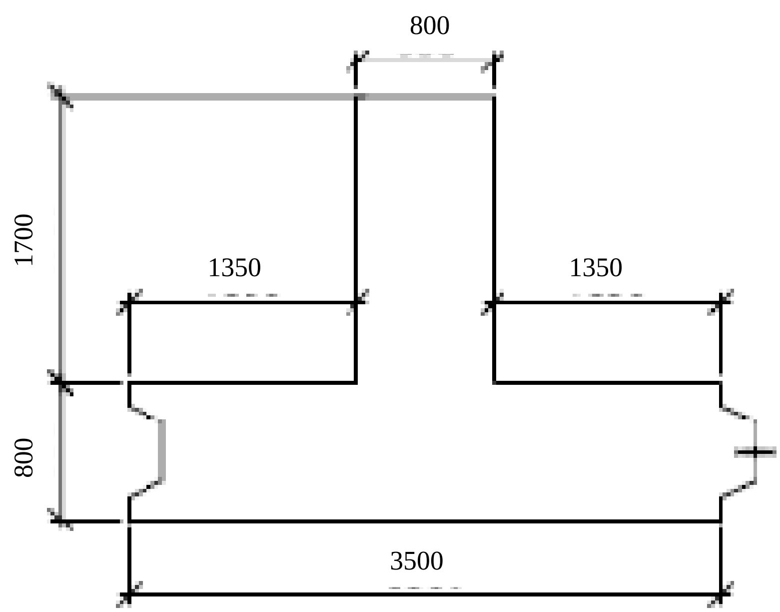

Fig. 2 Horizontal section of diaphragm wall

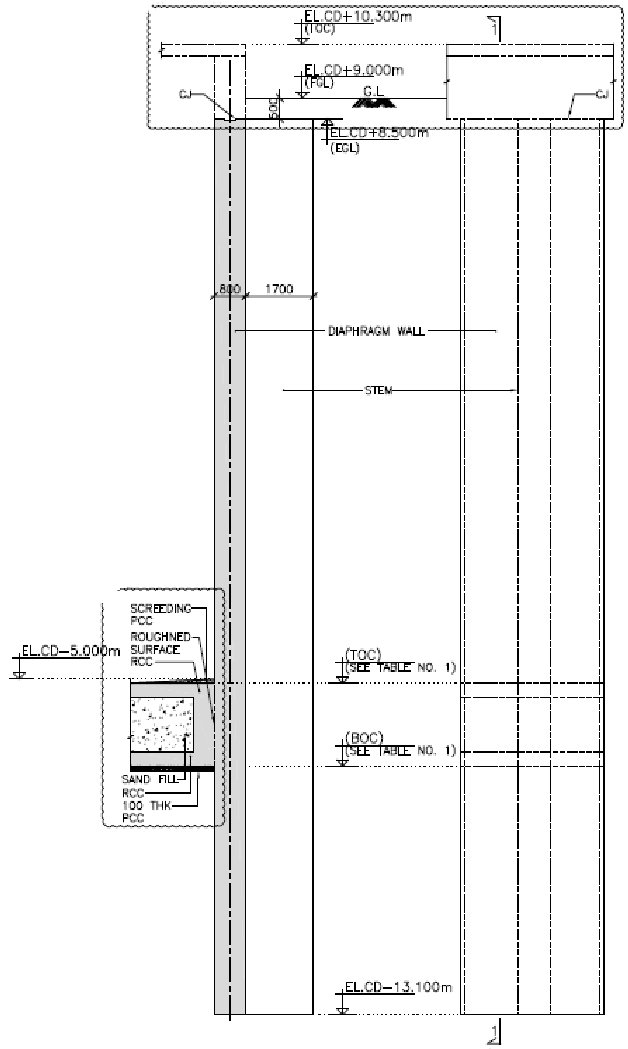

Fig. 3 Vertical section of diaphragm wall

Fig. 4 Diaphragm wall grabbing technique

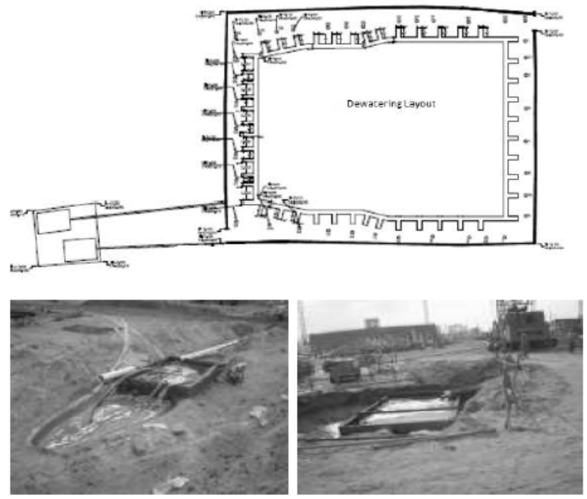

Fig. 5 Dewatering layout of intake pit

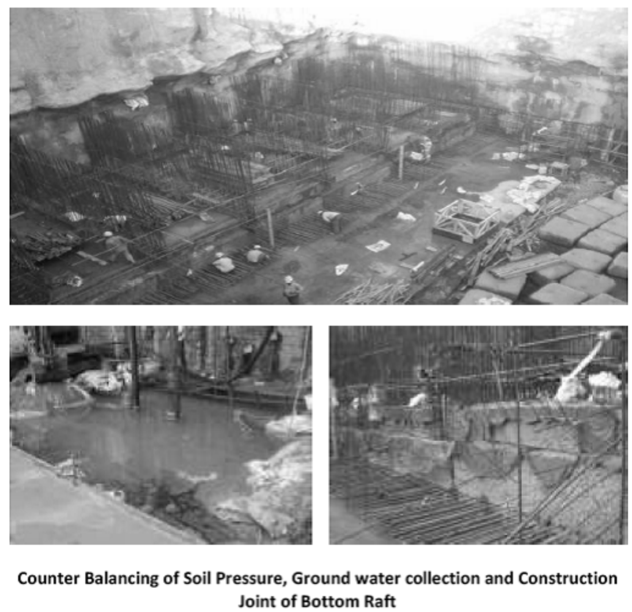

Fig. 6 Counter measures for soil pressure

Fig. 7 Field photograph of intake pit

Field Execution

Construction activities are detailed below sequentially as completed the structure.

1. *Ground improvement work* done with Vibro compaction technique in periphery of the structure first.
2. Constructed the guide walls to start diaphragm wall grabbing.
3. *Reinforcement bars anti-corrosive coating* done with Cement Polymer Composite Coatings to prepare reinforcement cages of the Diaphragm wall.
4. *Grabbing activity* of Diaphragm wall continues by using Geo Polymer to required depth and installation of stop ends.
5. *Lifting of Diaphragm wall reinforcement cages* with two numbers of 75 Metric Ton (75000 Kilograms) cranes for placement to grabbed bore and alignment work.
6. Insertion of Tremie pipes simultaneously to start pouring continuous concrete for diaphragm wall.
7. Continues diaphragm wall construction with two numbers of grabbing tools i.e., Matt.
8. Completed the diaphragm wall and starts 1st. level excavation up to two meter depth to facilitate the installation of fabricated structural struts.
9. Installed fabricated struts after completion of diaphragm wall prior to start of 2nd level excavation.
10. Started 2nd Level excavation after completion of structural struts installation in ten stages.
11. Continues excavation in stage wise to execute bottom raft concrete work by maintaining soil pressure to avoid soil heaving.
12. Simultaneously monitoring de-watering system to maintain the water table along with the progress of excavation, which is very essential.
13. During excavation process, wherever concrete bulbs are found in diaphragm walls inner surface, started chipping to match with diaphragm wall profiles.
14. As reached to required level of base raft, levelling, compaction, GSB (granular sub base) used as water filter media to continue with Plain Cement Concrete (PCC) work and completed.
15. Installed pressure release valves at bottom of PCC i.e., 100 mm (3.937”) dia. PVC pipes to release water pressure.
16. Installation of reinforcement bars started for bottom rafts along with for intermediate walls in five parts by providing construction joints.
17. Continuously taking measures for practical difficulties because of high water pressure at 16.60 m (54.462’) depth from existing ground level finally started first part of concrete for bottom raft, simultaneously completed entire bottom raft alternatively in five segments.
18. Started intermediate walls concrete in lift wise, considering five lifts in each wall from bottom raft to the top roof slab by avoiding direct vertical joints and continues wall concrete.
19. Simultaneously started concrete for diaphragm wall capping beams at ground level.
20. Completed the intermediate walls and starts removal of struts in step wise and segment wise, started preparation for top slab concrete in four parts alternatively and completed.
21. Started surface preparation of internal wall & aprons of inside pit area for water proof coatings. Fig. 8 shows inside the intake pit area after water proof coatings.
22. Thereafter, completes the pits top roof slab and continues superstructure work of intake pits shade.

Fig. 8 Inside intake pit

Interface Activities

Interface activities are related to installation of six numbers of duplex puddle flanges in south side of intake pit. This has to be connected with the pipes as already laid in the Sea bed by offshore contractor. Activities area as follows:

1. Steel sheet piles are driven in south side of intake pit to facilitate excavation work to install duplex puddle flanges.
2. Excavation work continues in south side of the pit in stage wise to install onsite fabricated structural struts in two different elevations to facilitate safe guard to driven sheet piles, so that activities can be carried out safely to install flanges.
3. Installed 1st level structural starts to facilitate excavation work, continues installation of 2nd Level structural struts to proceed final excavation work for puddle flanges installation at elevation 12 meter (39.370') from EGL.
4. Completes excavation work up to required elevations, started 1800 mm (5.906') diameter concrete core cutting with diamond cutter in the face of diaphragm wall to install the duplex puddle flanges.
5. While completes core cutting, installation of puddle flanges done along with non-shrink grout, concrete thrust blocks in outer face of the intake pit to stabilize flange pipes and backfilled in step wise to remove structural struts of level 2 & level 1.
6. Coordination completes with other concerned disciplines and agencies so, finally area is handed over to the related agencies to remove sheet piles and starts other activities.

Lesson Learned, Intake Pit Area

This is very important while we had encountered field difficulties, these are elaborated below point wise,

1. *Soil settlement* outside pit area after completion of diaphragm wall, while excavation was in progress. *Reason:* This happened due to heavy seasonal rainfalls and internal settlements of continuous de-watering process.
2. *Major soil heaving* occurred, during excavation stage at lower level of intake pit up to 300 mm (11.811") average. *Reason:* Heavy ground soil pressure.
3. Concrete pouring of intermediate walls considering five lifts in each wall, maintaining of schedule was really tough.
4. *Safety Hazards* because of space constrains while constructing the intermediate walls and top slabs in four parts.
5. Delay occurred because of sheet pile failure and its re-installation by offshore contractor.
6. Maintaining of work sequence is tough while excavation and installation of structural struts were done simultaneously for puddle flange installation.
7. Excavation could do with the help of mini excavators only for puddle flange pipe installation at lower level and removal of excavated soil done with the help of crane & buckets.
8. Removal of 1800 mm (5.906') diameter concrete core of diaphragm wall after cutting from bottom of the pit.
9. While grabbing continues for diaphragm wall in three stages for diaphragm wall, major collapse happens, which is very unsafe for workmen working in that vicinity.
10. Application of anti-corrosive cement polymer composite coating on reinforcement bars, used paint coting is hazardous and unsafe to workmen because of its odor smell, which affects to human body such as headache.
11. While lifting reinforcement cages, objects falling from the height while putting it in vertical position.
12. Placement of stop ends should be vertical, otherwise while placing the reinforcement cage it will foul and struck on it.
13. Inspection of bore holes of diaphragm wall after grabbing, shall be done perfectly with the help of "KODEN" leaser instrument for vertical surface otherwise, it will obstruct reinforcement cage while lowering to the borehole pit.
14. Design of reinforcement cage lifting hook and its position considering CG points, which are very important to lift reinforcement cages, otherwise, cage will be bent and damage the whole re-bar cage.
15. While doing bore wells of dewatering system, bore was frequently collapsed, it was happening due to laid stone columns nearby for RCC structure.
16. Unexpected concrete bulbs exposed, while doing excavation inside pit area, due to additional collapse of sand/ soil while grabbing.
17. Location finalizations of pressure relives valve, needs to be checked correctly to reduce ground water pressure considering surface area and it is to be extended up to the existing ground level to avoid water dropping during high tides.

Lesson Learned, Flange Pipe Installs

1. Installed sheet piles as per designed methodology was collapsed due to supporting issue, so area clearance was delayed from the agency.
2. By observing sheet piles failure, taken additional precautionary measures to install structural struts in two layers for safe working to start the activities of puddle flange installation.

3. Continues the activities for installation of puddle flanges, during this phase we have faced the difficulties i.e., due to improper locking of sheet piles in many places, heavy leakages happened, so stopped the activities of puddle flange installation, mainly in corner joints and close to the concrete surfaces of diaphragm walls. Because of sudden huge sea water leakage, while continuing the excavation work at below 11 meter (36.089') level from the EGL, one excavator was totally submersed because of leakage water, we could not get chance to extract the excavator from the intake pit.
4. To restore the activities of puddle flange installation due to heavy sea water leakages, additional activities had to carry out by installing concrete touch piles to stop the leakages from sea side, where schedule delay and financial losses happened.
5. Pouring huge quantity of concrete & grout materials to arrest leakages on the locking joints of sheet piles.
6. *Leakages* found even after continuous operation of dewatering system to lower the water table in that vicinity, after close inspection about the source of leakages we have found that there were stone columns installed for the foundation work of sea water intake pits shade where stone aggregates were the mediator or filtering media to pass the water from the sea during high tide situation, finally it was cement grouted to stop the sea water leakages.

Core Cutting in Diaphrgm Wall

Concrete core cutting of 1800 mm (5.906') diameter was done with the help of diamond core cutting machine to install six numbers of duplex puddle flange pipes in the diaphragm wall of the intake pit and installed the puddle flange pipes including its alignment, grouting and concrete encasing as thrust block.

Counter Measurers and Result

1. *Design Change:* In first stage of design, it was sandwich type raft filled with normal sand in between the top and bottom raft of base raft, later on it was changed to solid concrete raft considering thickness up to 2.50 meter (8.202'). *Reason:* To provide more counter weight against soil uplift pressure from the bottom of the pit to avoid uplift of the structure, also construction of sandwich raft is more time consuming considering the activities involved on it, also construction has to be done on priority basis for the safety of the intake pit because, bottom excavated surface cannot be kept open for long duration due to huge ground water pressure. So, bottom raft done successfully.
2. *Pressure Relieve Valves (PRV)* of 100 mm (3.937") diameter pvc pipes are fixed at bottom of the pit, i.e., provided from the bottom level of excavation pit or below level of Plain Cement Concrete (PCC) and it was extended up to the concrete top level of the pits roof slab. By installing this PRV's ground water pressure is released through these pipe holes, which helped to execute the construction work of bottom raft. So, water is rising up through this PVC pressure relieve valves and maintaining the natural water levels.
3. *Utilization of Filter Media:* This filter media is introduced to allow or divert the continuous percolated ground water to free flow through this media to collection pit from which, it is to be lifted out by 30 Horse Power submersible pumps from the pit bottom. This filter media contains of course stone aggregates of size 45 mm (1.772") to 75 mm (2.953"), so that ground water can be easily flow through this provided media. Wherever PCC work continues this technique is used to complete the bottom raft concrete work including other sequential activities. Even though pressure relieves valves were provided lots of water pressure observed during this stage, because pressure relieve valves were most effective only after completion of bottom concrete raft. These techniques were functioning well while constructing the bottom base raft.
4. *Application of Counter Weights Against Bottom Soil and Water Pressure:* To prevent soil heaving at bottom level of the pit, which occurs due to huge soil pressure after excavation, while reaching to the desired excavation level of the pit, total excavated area should not be kept open, so counter balancing method to control the soil pressure is very much essential and important. Therefore, solid concrete blocks, sand filled jumbo bags or excavated earth shall be kept in open excavated area as a counter weight to fulfill our counter balancing work. This method is very effective for deep pit excavation work, where soil pressure is very high. We have developed and utilized this method to construct the base raft of the intake pit alternatively and completed successfully. Fig. 6 shows the counter measures to maintain the soil and water pressure.
5. *Concrete Construction Joint on Bottom Raft:* We have provided construction joints in the bottom raft of the intake pit, while constructing it in alternative manner to control the soil and water pressure. The Construction joint is designed such a way that to make it structurally and leakage wise safe. We have done the construction joints by providing additional reinforcement and hydro seal to avoid water leakage from the bottom of raft. Base raft is completed in five parts alternatively, also considering site situations while finalizing the work sequence in order to maintain the ground water pressure.

Fig. 9 Outer view of intake

Conclusion

This Sea Water Intake Pits construction was the most challenging tasks in civil engineering field while designing for coastal area at the depth of 16.50 meter (54.134’) from the existing ground level, faced many un-expected construction difficulties and uncertainties while executing the structure.

Topic of this construction journey is prepared and written to this paper form based on practical experience gained by the author at field while executing. Finally, the structure was successfully completed, commissioned and handed over to the client. Fig. 9 shows outer view of the intake pit after completion.

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6. IS: 1893-2003 (Part I) criteria for earthquake resistant design of structures

Critical Reviews on Utilization of Steel Industry Waste in Concrete Considering Environment Issues and Solution

Damyanti G. Badagha[1] and C.D. Modhera[2]

Abstract The manufacturing process of Portland cement is the key factor of CO_2 emission in environment. In present, the total cement production is responsible for about 5 to 8% of global CO_2 emissions in environment as per the research data addressed in different papers. Due to high demand for cement and increased level of greenhouse gas emissions because of it, are drawing attention to give better alternatives for handling the emission of green-house gas due to cement production and use. As per the research study, the United Nations Intergovernmental Panel and the International Energy Agency for climate-change gave the report that the green-house gas due to cement industry vary from 480 to 1700 million metric-ton in the year of 2030. There is serious matter in front of the whole world to fight against green-house-gas emission. To overcome such serious issues, the different industrial wastes and by-products can be utilized in place of cement. For the research survey, use of steel making industry in a glassy pellet converted in 90 micron IS sieve passing was introduced in place of cement. Every year annual worldwide production of steel industry waste is around 530 million ton. To dispose this waste in open land fill, dumping in land and water causing environmental issues as well harmful for agriculture land for cultivation. The use of steel industry waste can be used in concrete to reduce CO_2 emission in environment. There was lots of research works carried out across the world to understand the use of steel industry waste as a cement replacement. The effect of steel industry waste in concrete has been studied considering different parameters like rheological behavior of concrete, morphology, mechanical strength, porosity, durability, permeability, resistance to chloride migration, wear and tear effects, carbonation etc. were studied across the world in past few decades. The critical remarks for different parameter for this waste give the detailed investigation of utilization of steel industry waste in concrete considering environment issues and solution. As an outcome of this investigation, the research gap and future objectives were addressed in this paper to enhance this research area in broad manner.

E-mail: [1]damyantibadagha@yahoo.in, [2]cdm.amd@svnit.ac.in

[1]Ph.D Research Scholar, SVNIT Surat, India

[2]Professor, SVNIT Surat, India

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Introduction

Today entire world is facing the problem of global warming and climate changes due to different type of pollution in an environment, there are several problems arise related to pollution. As per the research data, one group of researcher said that the pollution is a problem due to manmade activity and another group said it is because of natural changes [1]. During the concrete production, maximum CO_2 is produced which is directly concerned with cement-production. While the production of cement, the limestone calcination contributed the 50% CO_2 emission and the fuels-combustion is responsible for 50% CO_2 emission in environment and average 5% of CO_2 emitted in cement-production [2]. Concrete is the most demanding material used in worldwide compare to all other materials in the field of construction-industry. Due to this, there is a tremendous growth of infrastructure in fast developing countries [3]. From the research survey and high demand of cement in construction-sector, CO_2 increases drastically in environment. The demand of cement was 55% in the year of 1990 in developing countries and will increase 115–180% in the year of 2020 [4–5]. From the transportation and quarry mining process in cement production, approximately 5% CO_2- emission have been reported in environment and 10% in the local electricity-mix [6].

In the last 200 years, CO_2 levels have risen from 200ppm to 365ppm (2010) and rising. The rate of increase of CO_2 has gone up by a factor of ~2.3 from 0.55ppm per year to 1.25 ppm per year. 4. It is projected that by 2025 the cement industry will be producing approximately 3.5 billion tones of CO_2 per year. That is about the same as the total CO_2 from Europe in 2010/11[7].

The production of 1metric-ton is responsible for the 0.73t to 0.99t CO_2 per ton, which is depends upon the ratio of clinker per cement and some other factors. The fuel-consumption is also responsible for carbon-dioxide generation in the cement production compare to other industries. As per the research survey, 540kilo-gram CO_2

generated to produce 1ton clinker and approximately 50% for the cement-manufacturing process [6]. Several work reported to reduce serious environment pollution due to CO_2 emission and to use advanced energy-efficient technologies [7]. In the year of 1994, the total efficient- energy saving was 45% use of that year in U.S. [8] which is reported by Worrell *et al.* While in China, for 16NSP kiln-plants 40% and 8% of total electricity and fuel consumed respectively in 2008 and save same energy in that year reported by Hasanbeigi [9]. The development in the different arena and the innovation in the field of cement-industry store the CO_2 emission. This development is mainly responsible for the environment-pollution due to green-house gas and CO_2 emissions.

The primary use of cement to produce concrete with adequate properties but its directly associated with CO_2 generation. Because of this fact, concrete is the most carbon-efficient and more energy consumable material in the civil engineering field. From the all manmade material, cement-concrete highly responsible for CO_2 emission, though we expect that this problem can be resolved by the cement industry with more effort s by finding out the alternatives [10].

To capture and compress the CO_2, an emerging-technology was introduced which is Carbon-capture and storage (CCS). From this technology, CO_2 can be permanently stored in the certain depth ground which is not appreciable for the cement -sector. The CO_2 capture technologies are advisable to use in the process of cement-production. There is an advanced technology namely Oxy-fuel technology which uses oxygen instead of natural air in cement production. This technology is introduced in a small plants but more investigation is required to make this technology available for the cement plant.

In California and UK, few pilot-projects have implemented. Approximate 20 to 35 metric-ton/years, CO_2 emission reduction are made depend on 80% efficiency which will be introduced in 2020 [11]. Barker *et al.* [12] reported few technical problems associated with post-combustion amine in new cement plants. Bosoaga *et al.* reported the benefit of higher concentration of CO_2 in fuel gas of cement-plant over power plants [13]. In Canada, CO_2 emission captures from concrete curing is invented from their plants which stores CO_2 in precast-concrete process. As per the experts belief it will be more helpful, if proven successful [14]. The feasibility of the said technology for CO_2 absorption-capacity of masonry-block, fiber-board, paving-stone and cement-board were examine by the Shao *et al.* [15]. The researchers from Mc Gill University are also introducing the same concept [16–17].

Present need identified several options in the cement-industry which are: (i) Alternative use of fuels and raw materials to reduce CO_2 emission due to cement-production. (ii) Replacement of Portland-clinker with low carbon containing material (or directly use these raw material in place of cement). (iii) Produce alternative binders having low carbon (and required new specifications for the same). (iv) CO_2 Capture and sequestrate by cement-plants.

Fresh and Harden Properties of Concrete Containing Steel Industry Waste

Bo Pang investigated the possibility for replacing common natural aggregate like limestone, quartzite, etc. and steel slag aggregate by producing carbonated granulated steel slag aggregate (CSA). The high water absorption of CSA does not significantly affect the workability of concrete. The porosity of concrete was reduced even bleeding, and segregation were slighter [18].

Self-compacting concrete (SCC) made with stainless steel with reduced slag was studied by Yeong-Nain Sheen *et al* for workability and viscosity. Without the use of viscosity-modifying-agent, the workability and viscosity found satisfactory. Slag containing SCC with 20% stainless steel reduced slag (SSRS) increases the slump flow and V-funnel flow time was prolonged. But the compressive strength is reduced when the SSRS ratio increases. For the M30grade concrete, 30% or less SSRS achieves the desired strength. The SSRS replacement in 10% provide the highest sulfate-resistivity which was evaluating by weight-loss-test [19].

The inclusion of slag was found to increase sodium sulphate resistance of cementing blends containing high-calcium fly-ash. Blends with 60% Slag and high calcium fly-ash showed superior performance regardless of the individual level of slag or ash. Enhanced resistance to sulphate attack could not be explained based solely on the reduced ion diffusion through the mix. The resistance to sulphate increased with reduced calcium hydroxide and dilution of Portland cement [20].

An enhanced intrinsic porosity model was proposed by Tetsuya Ishida [21] for the BFS matrix. The formation of gel and hydration product increases with the hydration process increasing. This gel efficiently fills the capillary pores which results in higher strength in a later age. Based on the surface area computed by the current model, the pore structure of the BFS matrix at a later age becomes too coarse. Two key parameters representing the equivalent gel size and specific surface area of gel pores were studied in detail, and it was found that they are closely related to pore fineness.

The addition of slag can decrease the amount of calcium hydroxide by the pozzolanic reaction which reduce the volume of capillary pores. This implies the reduction in permeability which makes the concrete more dense and durable. The addition of slag in high performance concrete can increase the strength and reduce the corrosion effect as it reduce the permeability and increase the electrical resistivity [22].

The concrete produced with 50% waste powder as cement replacement experiences a higher rate of flexural strength due to homogeneity in the distribution of hydration products in concrete. [23]

Badagha *et al*. reported the replacement of cement by steel industry increases 28 days strength of HPC mixes, due to the improvement in the effectiveness of the mineral admixture. The pozzolanic action of steel industry waste reacts with OPC, which yields early strength at lower *w*/*b* ratios. at the age of 28 days, the value of charge passed through for HPC lesser than that for conventional concrete. This may be due to the reaction of pozzolanic materials like steel industry waste reacting with $Ca(OH)_2$ to form C-S-H gel. The C-S-H gel considerably reduces pores between fine aggregate and coarse aggregate, so charge passed values may be significantly reduced through the steel industry waste in HPC [24].

Slag has some major beneficial effects on the performance of concrete. The most important is reduction in cost and also reduction in CO_2 emission. Slump value for concrete is achieved well even after one and half hour so this design is advisable to be used in ready mix concrete plant [25].

Durability

The ability of concrete to resist physical and chemical deterioration during its service life is known as durability [26]. leaching, sulphate attack, acid attack, carbonation, alkali-aggregate reaction, freezing-thawing and abrasion are some common attacks. The major reasons for physical and chemical attacks are humidity, temperature and the mechanism of chemical transports [27]. The most important and the factor which increasing deterioration of concrete is water ingress and a quality product that meets requirements like impermeability is said to be durable concrete. Design life of structure, the serviceability requirement, the acceptable level of risk and the permissible extent of maintenance are the key issues for durability of concrete [28]. Now a day's fine powdered GBFS is utilized in cement industry by grinding it but the grinding process an energy consuming process. Therefore for the utilization of this industrial waste or by-product, some new usage forms should be developed [29–30].

It is assumed that the autogenous shrinkage does not contribute to total deformation and it is purely because of hydraulic shrinkage for concretes with lesser values than high performance concrete as per ACI Committee 209 [31]. Thus, studies on concrete with slag has been referenced in which the hydraulic shrinkage was investigated.

The shrinkage values are almost equal for GPC mixtures containing slag and REF G without the effect of curing period. Previous investigations has also experienced the similar behavior for compositions of hydraulic cement and slag [32–33]. Inclusion of slag increase the drying shrinkage nearly by 3% in comparison of control mix which was studied by Hooton *et al.* [34] in a literature survey. Some studies reviled that the shrinkage amount doesn't depends on water cement ratio [33]. The concrete doesn't have the shrinkage amount which has large quantity of vaporizable water because shrinkage amount depends on the quantity of water evaporates from pores [35].

Microstructure

At the age of 90 Days, The Scanning Electron Microscopy images were examined for different concrete specimens. A dense structure was examined for the control mix in which natural sand was used as fine aggregate as shown in Fig. 1(a) which shows the nonporous structure. Fig. 1(b) indicates the concretes with less than 30 % replacement whose microstructure is similar to control mix. The microstructure becomes porous for more than 30 % replacement ratio as shown in Fig. 1(c). The attachments of the grains observed decreasing with the increase of replacement. Therefore, the main reason for lesser strength would be the generation of different sized grains and porous area near the aggregate surfaces. GBFS larger than 30 mm in diameter combined same as aggregate with the hydration products as shown in Fig. 1.

Conclusion

From the results of discussed literature, it is clearly concluded that the civil industry need to find alternative arrangement of cement. There is an environment pollution, global warming, and CO_2 emission due to cement utilization which can be resolve using different types of waste in concrete. From the discussed papers it is found that the use of steel industry waste in optimum quantity of cement and sand replacement with different water cement ratios can save natural resources as well as give better alternative to cement consumption. As per the critical reviews from the literature, waste utilization minimizing the CO_2 emission due to reduced use of cement which can prevent environment. As well the use of waste as fine and coarse aggregates also saves natural depletion of aggregate which can also prevent environment. From the different research finding the fundamental properties in a paste form with cement, mortar and concrete found satisfactory comparing the conventional cement paste, mortar and concrete. The basic properties of concrete, compressive strength found desirable in strength point of view with compare to conventional concrete. The use of steel industry waste gave better results in view of tensile strength. The behavior of concrete under different extreme conditions found satisfactory. From the addressed literatures, it is clearly concluded that the steel industry waste utilization in concrete is giving good alternative solution for cement and aggregate replacement, which is also prevent the environment.

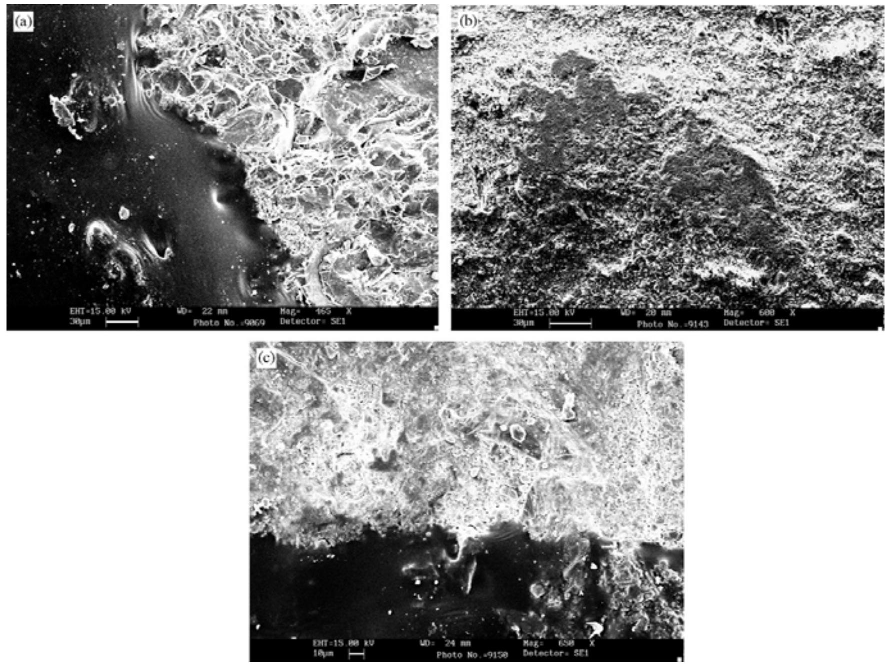

Fig. 1 Scanning electron microscopy images of (a) control mix concrete, (b) concretes with less replacement, (c) concrete with replacement ratio is greater

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Current Issues and Challenges-Relating to Agriculture

Ashutosh Patra[1] and Sanjaya Kumar Moharana[2]

Abstract Agriculture has enabled man to live a settled life and to develop the beginning of civilization. It is the major source of food, fibre and raw materials essential to human life. Consequently, it is one of the basic occupations of man all over the world. Agriculture is said to be backbone our country. The economic status of the country is mostly governed by it also. In spite of rapid industrialization in recent years agriculture still drafts into service more of country's aggregate man power than all other occupations combined together. A substantial portion of total population are engaged with subsistence agriculture and allied activities since centuries. Yet, the yield is very meagre despite availability of fertile soil, favourable climate, water and various inputs such as seeds, fertilizers, insecticides and pesticides. Growth of population is increasing in arithmetical progression and per capita cultivated land is going on decreasing in geometrical progression effecting shortage of production. This has given a profound effect on improvement of agriculture so as to get more produce without shattering ecology and environment. Indian agriculture has been given a boost with the commencement of five year plans to meet the food shortage and also to improve the socio economic condition of the people. Agricultural development programmes have been reoriented now to respond promptly and efficiently with watershed development techniques as the green revolution although led to the utilization of land to a great extent, could not be so successful due to want of heavy demands of water, energy and out lay too.

Keywords: India, Agriculture, Based, Country

Introduction

Owing to rapid growth of population our country is now facing three major problems. These are: unemployment of large number of population, chronic shortage of food and continuous depletion of natural resources. The consequential growth of this rate of population, which is termed as population explosion has reduced the per capita land, water and other natural resources. This has started shattering the environment and affected the eco-system also. The day to day life of the country people have been deteriorated to a great extent and beyond one's imagination.

India is an agri-based country accomplished with a large number of villages and near about 70 percent of farming population. But reduction in per capita land, vagaries of rain, non availability of irrigation facilities and sudden breaking of unexpected natural calamities have frustrated the cultivators and constrained them to switch over from agriculture to other occupations due to low yields of crops. The above situation has caused shifting of farming population from rural areas to urban areas in search of jobs and the continuous process of these rural masses to urban areas has generated negative pressure on urbanization and caused to sag the morale of the urban authorities. Non supply of land and accommodation facilities for the shifting population has become a headache due to arising of clamour. Besides that, failing to provide desired amount of public utility services and other amenities have become a state and country issue and subject of discussion. All the aforesaid factors mingled up with depletion of natural resources have posed as challenges. As the development phenomena of the country is likely to be jeopardized, steps deemed fit are now being taken for overall development in all sectors.

Current Issues

Keeping abreast of all these issues, first of all, emphasis should be given for improvement over agriculture. Sea change could be possible all over the country by adoption of scientific methods and techniques in this sector. Agriculture has to be made sustainable in the country to have a significant development. Taking into consideration of limited amount of resources, necessary steps are to be taken for maximization of production not only per unit of area but

E-mail: [1]ashutoshpatra25@gmail.com, [2]skmoharana@hotmail.com

[1]Former Joint Director and Engineering Head, Soil Conservation and Agriculture Department, Odisha

[2]Senior Consultant, Berhampur, Ganjam, Odisha

also per unit time and unit quantity of water. This would definitely generate a positive impact on the rural people to restart a settled life in rural areas.

But as productivity of any resource depends upon efficiency of resource use, we must take care of basic elements necessitated in agriculture. Land and water are the utmost needs in case of agriculture. However, we now notice that condition of both these resources have already been deteriorated causing very low yields. The changes in the climate parameters have governed the amount of precipitation and its fluctuations, there by affecting the vegetations. This is because of the reason that while near about 30 percent of total cultivated lands are being irrigated, the balance 70 percent lands are deprived of assured irrigation and these lands are purely dry lands. The life of dry land dwellers has become precarious due to degradation of land followed by degradation of vegetations in a large scale. Since these dry lands are normally exposed to the weathering agencies, the rays of sun has a direct desiccating effect on the naked surface of the lands, resulting in increasing the atmospheric temperature along with increase in the process of evaporation. Tons of desiccated soils moving away from those dry lands by means of various forms making these area unfertile and unproductive. Further, reduction in the number of rainy days and the amount of precipitation brings a drought affecting agriculture production. So also instances of rainy days with higher precipitation and higher velocity washes away huge quantities of productive top soils by converting the dry lands into deserts.

But it is a matter of fact that while a very long time is needed i.e. near about 7 to 8 centuries for formation of one inch layer of soil over the earth's crust on account of resultant of the complex phenomena of interactions of parent materials, slope of area, weathering processes, time and the amount of available moisture there, the desiccated soils are washed away easily by the water and wind by making those area unsuitable for agriculture works.

The continuous displacement of soil from one place to another by various modes is called soil erosion, which eventually leads to low water holding capacity of soil associated with depletion of fertility status of the affected area. In India the rate of soil erosion is beyond one's imagination as 6000 million tons of soil is said to be eroded every year in our country. The National Commission of Agriculture has reported that near about 2.5 million tons of Nitrogen, 1.5 million tons of phosphorous and 2.2 million tons of Potash accomplished with huge quantities of organic manures and micronutrients amounting to millions of rupees are being taken away with these eroded soil particles.

Effects of Soil Erosion

- Degradation of land resources due to loss of its fertility and productivity.
- Loss of bio diversity.
- Affects livelihood of farming community.
- Shatters the environmental securities
- Causes rising of river beds and evokes high flood during the peak period.
- Results siltation of water reservoirs, ports and other water bodies.
- Reduces storage capacity of reservoirs and generates negative impact on them towards production of hydro electric power.

Colossal loss of soil is noticed to be more in undulating and hilly terrains. This is because of the reason that the amount of precipitation after falling over the land surface flows down in mode of runoffs based on the topographical situation. It gathers momentum and attains erosive velocity in its path while flowing down from higher elevation to the lower elevation (Fig. 1).

Soil is generally eroded naturally and also by means of accelerated erosion. The natural erosion is governed by the following environmental factors.

These are:

- Impact of precipitation over the land.
- Texture, type of soil and the gradient of lands
- Wind velocity.
- Tidal waves
- Climatic condition of the area.

Whereas the accelerated or man/animal made erosion is due to the following reasons as mentioned below:

- Adoption of podu or shifting cultivation.
- Cultivation in the untreated and unprotected lands
- Over grazing or frequent grazing of cattles and other such animals in the pasture land.
- Deforestation of forests/ jungles for setting up of industries, housing compleyes, construction of tangible irrigation projects, alignment of new railway tracks, road projects.
- Excavation of mines to harness ore and the allied products and such other structures influencing severe soil erosion followed by land degradation.

Although it seems unbelievable, but absolutely correct to state that near about 120.72 m. ha area of our country has already been degraded by means of various forms. The details of various modes of degradation are presented in Table 1:

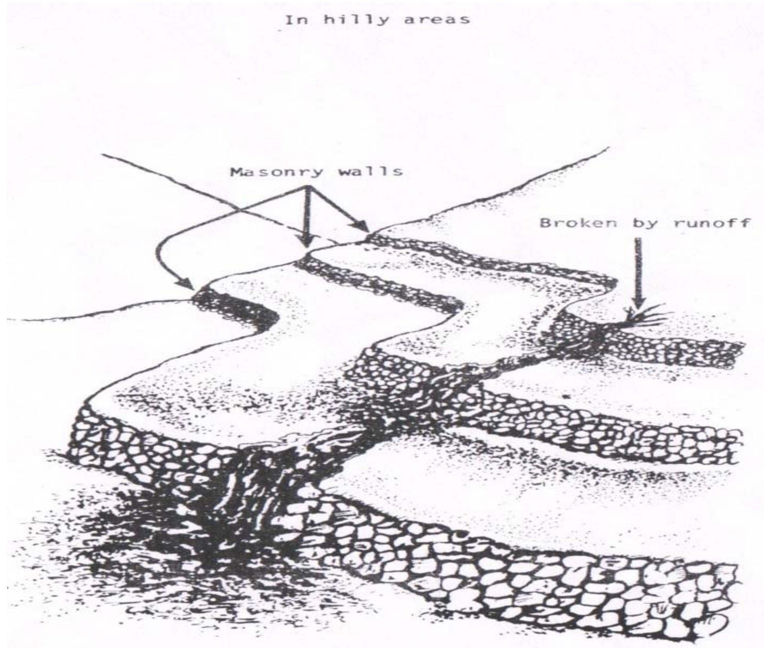

Fig. 1 Loss of soil and nutrients by runoff

Table 1 Statistical representation of degraded lands

Sl. No.	Type of Degradation	Arable Land (in million ha)	Open Forest <40%% Canopy (in million ha)
1.	Water erosion (>10tonnes/ha/year)	73.27	9.30
2	Wind erosion (Acolian)	12.40	-
	Sub total	85.67	9.30
3	Chemical degradation		
	a) Exclusively salt affected soils.	5.44	-
	b) Salt affected and water eroded soils.	1.20	0.10
	c) Exclusively acidic soils (pH<5.5).	5.09	-
	d) Acidic (pH<5.5) and water eroded soils.	5.72	7.13
	Sub total	17.45	7.23
4	Physical degradation		
	a) Mining and industrial waste	0.19	-
	b) Water logging (permanent) (water table within 2mts depth)	0.88	
		1.07	
	Sub total	104.19	16.53
	Grand total (Arable land and Open forest)	120.72	16.53

The Table 1 Shows that major portion of land degradation has been caused due to water only. Hence, in order to increase the productivity of the soil and yield more in agricultural sector first of all the degraded lands are to be reclaimed on priority basis apart from taking care of other lands by means of the following measures blended with indigenous technology.

These measures are cited below:

1. *Agronomical*: This measure is practiced in the comparatively flat lands having slopes up to the extent of 4 percent. Contour cultivation and contour ploughing are taken up to reduce the velocity of runoff, there by completely eradicating its soil carrying capacity. Suitable crop rotation is being practiced in the lands with leguminous crops for supplementation of nitrogen into the soil apart

from retention of soil moisture for a longer time. (Fig. 2).

2. *Afforestation*: This is adopted in the areas which are not fit for agronomical practices Trees are grown in the lands with the vegetative cover over the land surface, aiming to combat over the wind erosion and provide a blanketing material over the naked surface. The tree crowns reduce the impact of wind force and its velocity. (Fig. 3)
3. *Agrostrological*: This is even quite feasible in barren and completely eroded lands where the above mentioned two measures are not at all practicable. The fodder grasses like blue panic, Nappiers, Rhode and Elephanta or such type are raised in the lands to provide a blanketing cover over them and also to cater the feeding need of the grazing animals.
4. *Mechanical*: This is found fit in areas where, all these aforesaid measures are not at all exercised as it should have been. This is mostly also taken up in the lands with steep slopes, where the agronomic practices may not completely help in arresting soil erosion. This commonly includes the engineering works starting from smaller ones to bigger ones. These are consisted of contour bunding, contour trenches, graded bunding, terracing, gully plugs, check dams, loose boulder structures, percolation tanks, drop structures, cross drainage and road crossing structures, sunken structures, land levelling and shaping, dug wells, low cost water harvesting structures of both reservoir type or diversion weir type etc. inclusive of drainage bank stabilization and brush wood check dams in small drainage ways.

One or more of these structures are constructed in the area as per the necessity of site with a view to lengthen the time of concentration and to increase the rate of infiltration of the precipitation.

However, these above four measures should not be taken up haphazardly and scattered manners, but needs to be implemented on “Watershed Basis” for more effective of the agricultural programmes.

Watershed Concept: Watershed is a geohydrological unit or a piece of land which drains out at a common point. In the other words it is a definite area having undulating terrain from which the entire rain water drains out either in form of nallah, stream, small or big river. Thus watershed is either a small or vast area comprised of villages, roads, hills, forests etc. within it. The watershed development a new paradigm is a project based ridge to valley approach for initiating in situ soil and rain water conservation and thereby to maximize the agricultural production. Treatments of the degraded area from the starting point is the prime need of this programme for reclamation of the area and prevent the further deterioration. (Fig. 4).

Fig. 2 Agronomical measure to check soil erosion

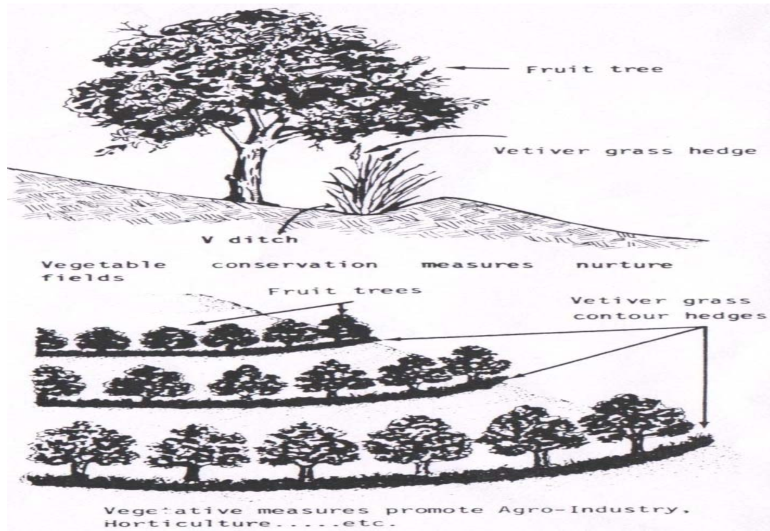

Fig. 3 Checking of wind erosion by means of tree plantations

Fig. 4 Preventing soil erosion by loose bolder structure

Main Objectives

- Conserves soil and rain water.
- Upgrades the depleted status of natural resources in harmonious and integrated manner.
- Increases the agricultural productivity including the production of fodder, fibre, timber, fuel wood, bio mass etc. for use in the industries inclusive of cottage industries on account of diversified land use.
- Generates massive employment of unemployed people, especially the rural youths and land less labourers.
- Mitigates agricultural drought situation during low rain fall and prevents evoking of floods during heavy rain fall period on account of storing of rain water at the upper reach and other feasible sites of the watershed.
- Reduces siltation of storage reservoirs, yields more water in various water bodies, converts dry drainage ways into perennial sources with turbid less flow in them.
- Reduces inequalities between the irrigated tracts and non irrigated tracts due to stable production and setting up of bio mass processing units in the watershed areas.

- Improves the socio-economic condition of the dwellers.
- Checks the migration of rural mass to urban areas in search of jobs and thus prevents the urban areas from getting over crowded.

The above factors of constraints are to be tackled tactfully by adoption of appropriate methods of soil and water conservation measures, failing which agriculture cannot be sustainable and productive as per the need. Since soil erosion and run off from crop lands respond greatly to changes in climate including climatic induced changes in plant biomass, plant residue decomposition rates, evapotranspiration rates, processes of soil surface inclusive of land use etc. agricultural engineering technologies should be implemented in the dry land area in systematic and planned manners to get more production than ever before and thereby preventing desertification of those area.

But in order to achieve all the above benefits and fulfill the objective, the watershed has to be developed with efficient management of land, water and other natural resources. The innovative techniques adopted herein are not only cost effective but also affordable and practicable by all the farming community. Adoption of management practices helps in reorientation of agricultural productivity and provides a new dynamism to both the farmers and users groups as well, due to coordinated development of land, water and other related resources. Watershed development programme enhances socioeconomic status of the people in equitable manner, with no disturbances to the environment.

Since efficient management of rain water is the prerequisite need apart from conservation of soil and soil moisture, action deemed fit must be taken at first to check the colossal losses influxed by the runoffs. Appropriate plan of action for increasing the quantum of utilizable rain water from the existing figure of 1086 cubic K.M. has to be taken in such a manner, so that the balance quantum of the precipitation tantamounting to 2916 cubic K.M. could be supplemented to the source of irrigation and the ground water aquifer. The farmers of watershed area should take efforts for construction and implementation of micro-irrigation system on the basis of killing two birds at one shot i.e. storing of adequate water for a longer period with less expenditure and deriving maximum water use efficiency by choosing suitable cropping pattern and providing irrigation to the additional areas, which are out of reach of irrigation. But emphasis must be given to follow certain principles to make the programme effective in all respect.

These are:

- Plan the soil and water conservation programme systematically on watershed basis but not in a sporadic manner.
- Execute the works as per technical need but not as per the sweet will of farmers.
- Utilize the land on capability basis and field feasibility but do not leave any piece of land unattended and untreated.
- More emphasis should be given for application of organic and green manures and bio-fertilizers also, aiming to build up soil fertility and increase the quality of produces.
- Adoption of green technology in agriculture by use of bio-fuel in farm machineries, water lift pumps etc. should be initiated to prevent furthermore supplementation of green house gases to the environment.
- Utmost importance should also be given for periodical maintenance of soil and conservation structures.

The detailed list of the structures is furnished below for needful action.

1. Construction of mini percolation tanks in the starting point of first and second order streams and a big percolation tank in the third and fourth order stream reduces the erosive velocity of runoffs.
2. Construction of check dams in the second and third order streams with earthen embankment in its centre and surplus weir on one or either sides of it, stores adequate quantity of rainwater for future use.
3. Positioning of sunken pits in the gullies of first and second order streams prevent further deterioration of land.
4. Excavation of continuous contour trenches along the contours along with taking up contour cultivation in sloppy lands conserves soil and water.
5. Excavation of diversion drains around hillock base and collection of the rain water in a dug out sump or dug wells facilitates to provide irrigation to crops in later period.
6. Construction of water harvesting structures of reservoir type in the downstream side of the streams provide irrigation to crops under gravitational flow method as and when needed.
7. Construction of masonry diversion weir or random rubble stone diversion weir with gabion provision in the perennial or semi perennial streams to divert water to higher patches of crops fields which are deprived of getting irrigation facilities earlier.
8. Renovation of existing tanks in dry lands collects and stores of sufficient quantities of rain water and cater the irrigation and personal needs of the villagers. (Fig. 5)

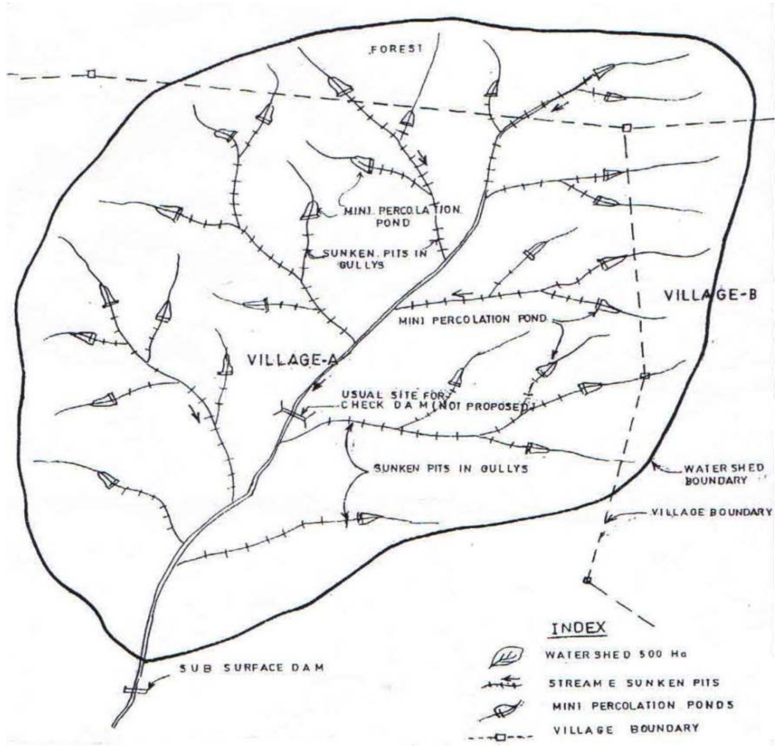

Fig. 5 A typical sketch map of watershed

All these measures are very much essential to prevent the degradation of ground water quality and quantity as they do not exert negative impact on ecological balance. This is in view of the reason that the watershed activities are evolved through the interaction of rain water with land mass.

Conclusion

Now taking into consideration of all the current issues in the urban localities appropriate action needs to be taken too for mitigation of the alarming situation now being generated towards overcrowding, rise in atmospheric temperature, acute shortage of land, drinking water and accommodation facilities. There is necessity of utilization of compressed natural gas in all the automobiles to prevent furthermore supplementation of green house gases in the atmosphere, causing rise in temperature and depletion of fossil fuel reserves. The public should be abided by the rules of construction of roof top harvesting systems over the roof tops of buildings for collection and recharging of the rain water into the wells and underground strata respectively. There is also need of construction of ecofriendly buildings with innovative green technologies with a view to save energies, emerging from conventional sources. So also, all the existing water bodies should be renovated and rejuvenated for storing adequate quantum of rain water in them, thereby creating a cooling conducive atmosphere in the adjoining locality. Furthermore needful action should also be taken up for installation of various plants for effective management of solid wastes, e. wastes and for purification of drainage water, so that the purified water could be reused for gardening, and washing of roads, pavements etc as and when felt necessary. But all this, requires support of the government and participatory involvement of every inhabitant of the area to achieve the goal without any hinderance.

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Effective Removal of Toxic Heavy Metal Ions from Industrial Wastewater using Surface Modified Algal Biomass (Ulva Lactuca)

Saravanan Anbalagan[1], Mathan Muthu[2], Gnanasekar R.[3], Senthil Kumar Ponnusamy[4] and Yaashikaa P.R.[5]

Abstract The application of raw Ulva lactuca (RUL), sulphuric acid modified Ulva lactuca (SMUL) for the removal of Cu(II) ions from the aqueous solution was investigated under various operating conditions. The newly synthesized adsorbent was characterized by FTIR and SEM analysis. Batch adsorption experimental studies were conducted by varying pH, adsorbent dose, initial Cu(II) ion concentration, temperature and contact time. The optimum conditions for the adsorption of Cu(II) ions onto the adsorbent was found to be: pH (6.0), adsorbent dose (1.0 g: RUL and 0.2 g: SMUL), contact time (60 min: RUL and 30 min: SMUL), temperature of 30 °C for an initial Cu(II) ion concentration of 50 mg/L. Adsorption equilibrium data were analyzed by the Langmuir and Freundlich model. Experimental data was successfully fitted with Freundlich model and the maximum monolayer adsorption capacity was found to be 205.1 mg/g for SMUL. Adsorption kinetics was tested with the pseudo-first-order and pseudo- second-order kinetic models. The kinetic results show that present adsorption process was best fitted with pseudo-second-order kinetic model. This work provides that newly synthesized adsorbent has shown superior adsorption capacity and recyclability for removing high-concentration Cu(II) ions in wastewater.

Keywords: Adsorption, Ulva Lactuca, Cu(II) Ions, Isotherm, Kinetics

Introduction

Nowadays, continuous contamination of surface and ground water is a serious environmental problem. Wastewaters containing heavy metals have been leaking into the environment in large quantities. Industrial and municipal wastewaters commonly contain heavy metals (1–3). The rapid development in a diverse range of industries including iron industry, steel industry, mines, quarries, food industry, dyeing industry, oil refinery, petrochemical industry, cement industry, paint industry, pharmaceutical industry, pulp and paper industry (4–6). Apart from much heavy metals, Cu(II) ion is most commonly used as colouring agent in many fields such as leather, silk, jute, wool, cotton and paper. In order to remove the heavy metals from water and wastewater, several conventional methods have been employed like membrane separation, precipitation, ion exchange, electrochemical treatment, electro dialysis, reverse osmosis and evaporation. Each methodology has some drawbacks such as cost effective, sludge disposal problem and lower efficiency at low concentration of metal ions. Adsorption technology is the most promising technology for the removal of organic and inorganic pollutants from the aqueous solution due to its low cost in application, superior potential for the removal of toxic dyes and metal ions at low concentration, sludge reuse, easy availability and large surface area. Different adsorbents have already been used by many researchers such as activated carbon (7,8). Still, there is a requirement to develop the effective adsorbent material for the separation of toxic heavy metals from wastewater effluent. Recently, a surface modified agricultural biomass have been focused as an effective adsorbent due to its large surface area, high thermal stability and large volume of micropores and mesopores structure. In this present research work, a novel effective raw and surface modified agricultural biomass has been used as an adsorbent material, in order to attain rapid and higher removal of toxic heavy metals from aqueous solution. Agricultural waste material plays a vital role in the biosorption process. This biomass material has some major functional groups such as hemicelluloses, lignin, simple sugars, lipids, starch and proteins that facilitate heavy metal ion biosorption. *Ulva lactuca* is rich in simple sugars such as glucose, sucrose and fructose. The use of *Ulva lactuca* for the removal of Cu(II) ion is slight investigated due to its low

[1,2,3]Department of Biotechnology, Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi–600066, Chennai

[4,5]Department of Chemical Engineering, SSN College of Engineering, Kalavakkam–603110, Chennai

surface area, high crystallinity and porosity. The aim of the present investigation is to prepare the biosorbent material from the *Ulva lactuca* and to check its potential to remove the Cu(II) ions from aqueous solutions. The depiction of raw and surface modified adsorbent was carried out by FTIR and SEM analysis. Batch adsorption studies were carried out to optimize the influencing parameters. The adsorption isotherm and kinetics studies have been discussed to explain the adsorption process.

Materials and Methods

Preparation of Aqueous Solution and Adsorbent

A stock solution of 1000 mg/L of Cu(II) ion solution was prepared by dissolving required amount of $CuSO_4.5H_2O$ into the deionized water. Since different concentrations of Cu(II) ion solution were required for adsorption studies namely 50 to 250 mg/L. The required concentrations of Cu(II) ion solutions were attained by diluting the stock solution with double distilled water. The *Ulva lactuca* was collected from Pazhaverkadu beach, Tamilnadu, India. The collected algal biomass were washed thoroughly using pure water to remove the dust particles and other impurities. The air-dried algal biomass were grinded into fine powder using a steel mill and sieved at the particle size of 0.354 mm. This prepared raw material [RUL] was further proceeded to surface modification process. The RUL was treated with concentrated sulphuric acid in the ratio of 1:2 for about 24 h for dehydration process. After that, the dehydrated adsorbent material was washed with double distilled water to remove the acid content, this process continues until the pH value of the supernatant reaches the constant pH value of 7.0. Then, the material was allowed to dry in hot air oven at the temperature of 80 ^oC. The dried material was sieved at the particle size of 0.354 mm. This sulphuric acid treated activated biomass was abbreviated as (SMUL). This effective UACUS were utilized as an adsorbent material for this research work.

Batch Adsorption Experiment

The Batch experimental studies were carried out at different parameters such as initial Cu(II) ion concentration, solution pH, adsorbent dosage, contact time and temperature. In each experiments, required amount of adsorbent was added to 250 mL conical flask containing 100 mL of Cu(II) ion solution and the mixture was agitated in a temperature controlled shaking incubator (Orbitek, India) at 80 rpm. After the prescribed time interval, analysis of the samples were done and the concentration of the supernatant were determined from the absorbance of the solution using atomic absorption spectrophotometer (AAS).

Adsorption Isotherm and Kinetic Experiments

In the estimation of adsorption isotherms, batch adsorption studies were conducted by adding 1.0 g: RUL and 0.2 g: SMUL in 250 mL conical flash containing 100 mL of different concentration of Cu(II) ion solutions (50 to 150 mg/L) and the mixtures were shaken in a shaking incubator 60 min: RUL, 30 min and SMUL 40 min at the initial pH of 6.0. The filtrate was analysed to determine the residual Cu(II) ion concentration by using AAS. Similarly for adsorption kinetics, batch adsorption studies were carried out by adding 1.0 g: RUL and 0.2 g: SMUL in 250 mL conical flash containing 100 mL of fixed concentration of Cu(II) ion solutions (50 mg/L) and the mixtures were shaken in a shaking incubator for different time intervals (5 to 90 min: RUL and 5 to 60 min: SMUL) at the initial pH of 6.0.

Results and Discussion

In the characterization study, the FT-IR studies reported that, the presence of ionic groups is responsible for the formation of covalent bond and electrostatic interaction between the Cu(II) ion and the adsorbent material (RUL and SMUL). The presence of aliphatic group is accountable for the formation of matrix with a cross linked network. The SEM analyses reported that presence of large extent of surface area and different size of pores might be due to the uptake of water molecules and the presence of void volume on the surface of the adsorbent material during sulphuric acid modification process. The size and shapes of the pores are irregular and interconnected. These pores could form the matrix layer with a cross linked network, these characteristics shows that SMUL has the superior adsorption capacity for the removal of Cu(II) ions from the aqueous solution.

In batch adsorption studies, the effect of pH studies reported for the removal of Cu(II) ion is increases with an increase in the solution pH and beyond the pH of 6.0 it reaches almost a constant value. The maximum removal of Cu(II) ion is observed at pH of 6.0. The effect of adsorbent dose illustrated that the removal of Cu(II) ion was increased with the increase in adsorbent dose (1.0 g: RUL and 0.2 g: SMCUS). This observation can be explained that number of active sites on the adsorbent surface increased by increasing adsorbent dose, resulting in the increase of Cu(II) ion removal. The effect of initial Cu(II) ion concentration stated that percentage removal of Cu(II) ion was decreased with an increase of Cu(II) ion concentration from 50 to 250 mg/L. This might be possibly due to the reduction of active sites. The effect of contact time studies reported that adsorption of Cu(II) ion increases with the increasing contact time and it was found that the rapid adsorption of heavy metals in the first 60 min for RUL, 30 min for SMUL as the equilibrium time selected for these materials, thereafter the adsorption rate decreased gradually and the adsorption reached equilibrium in about 90 min. The effect of temperature studies shows that percentage removal of Cu(II) ion was decreased with an increase of temperature from 30 to 60°C which may be due to weakening of adsorptive forces between the Cu(II) ion and the adsorbent.

Adsorption Isotherm

Adsorption equilibrium isotherms are important for the description of, how the adsorbate molecules interact with adsorbents, provide a complete understanding of the nature of interaction and distribution of adsorbate molecules between the liquid and solid phase when the adsorption process reaches an equilibrium state. In this study, Langmuir (9) and Freundlich (10) isotherm models were employed to calculate the adsorption equilibrium between Cu(II) ion and RUL and SMUL. Adsorption isotherm parameters, correlation coefficient values (R^2), sum of squared error (SSE) and root mean squared error (RMSE) values were calculated from the plot of adsorption equilibrium data (C_e vs q_e) was shown in Fig. 1 and the values are summarized in Table 1. From the tabulation, it was found that Freundlich isotherm model had higher correlation coefficients than Langmuir models for RUL and SMUL. The Freundlich adsorption isotherm is an indication of the surface heterogeneity of the adsorbent material and this was applicable for the adsorption of single adsorbate within a fixed range of concentration. This shows that preferential adsorption of Cu(II) ion onto adsorbent may be due to multilayer adsorption capacity.

Table 1 Adsorption isotherm study for the removal of cu(ii) ions onto rul and smul

Isotherm Model	**Parameters R.^{2} SSE RMSE**			
1. RUL Langmuir	q_m = 23.59 (mg/g), K_L=0.2402 (L/mg)	0.928	13.12	2.09
Freundlich	K_F= 6.716 ((mg/g)(L/mg)$^{(1/n)}$), n= 2.834 (g/L)	0.999	0.039	0.11
2. SMUL Langmuir	q_m = 117.4 (mg/g), K_L= 0.4294 (L/mg)	0.945	27.3	9.54
Freundlich	K_F = 34.88 ((mg/g)(L/mg)$^{(1/n)}$), n= 2.549 (g/L)	0.975	124.1	5.57

Table 2 Adsorption kinetic study for the removal of cu(ii) ions onto rul and smul

S. No	**Adsorption Kinetic model**	**Concentration 50 mg/L**	
		RUL	**SMUL**
1	Pseudo first order:	9.742	49.268
	$q_{e, exp}$	10.22	50.29
	$q_{e, cal}$ (mg/g)	0.043	0.099
	k_1 (min^{-1})	0.99	0.9938
	R^2	0.7887	5.091
	SSE	0.267	0.7977
	RMSE		
2	Pseudo second order:	13.07	59.78
	$q_{e, cal}$ (mg/g)	0.0032	0.0019
	k_2 (g/mg.min)	0.9776	0.9607
	R^2	1.776	36.1
	SSE	0.4007	2.124
	RMSE		

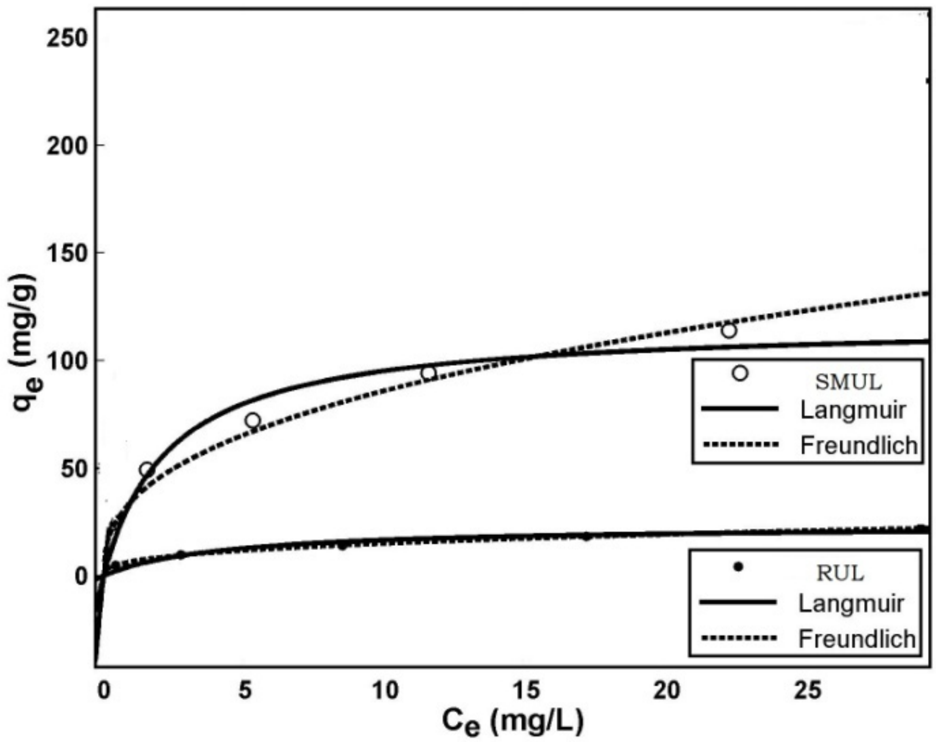

Fig. 1 Adsorption isotherm fit for the removal of Cu(II) ion onto RUL and SMUL

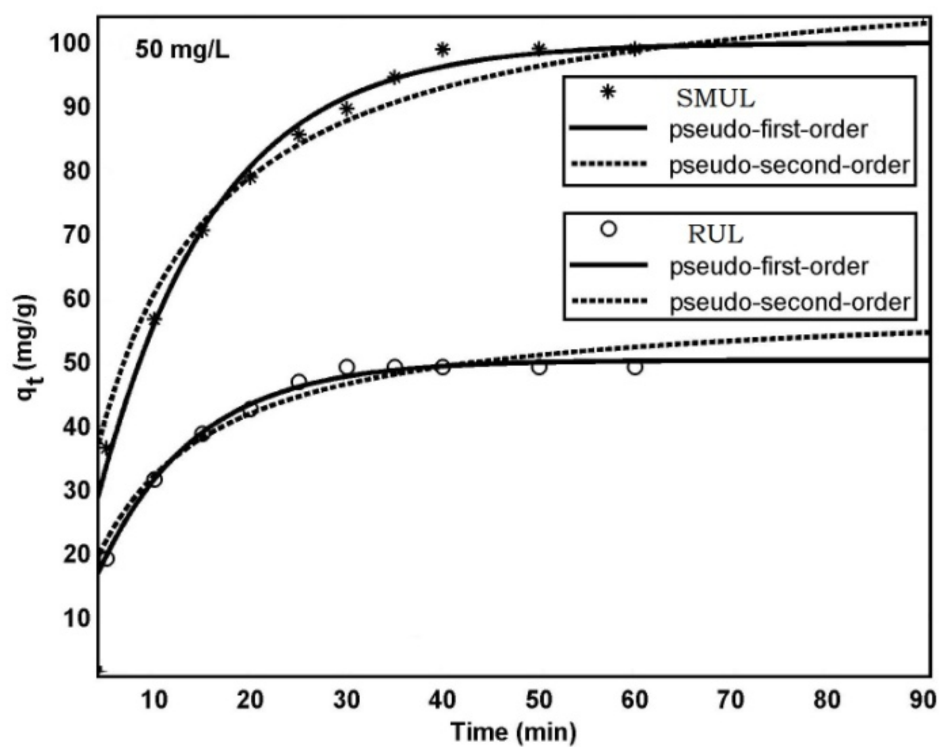

Fig. 2 Adsorption kinetic fit for the removal of Cu(II) ion onto RUL and SMUL

Adsorption Kinetics

Adsorption kinetics can be used for describes the heavy metals adsorption rate, explore the mechanism of adsorption and possible rate-controlling steps. In this study, two adsorption kinetic models were used such as pseudo-first-order (11) and pseudo-second-order (12). The kinetic constants and correlation coefficients, sum of squared error (SSE) and root mean squared error (RMSE) values were calculated from the plot of adsorption kinetic data (q_e vs time), the results were shown in Fig. 2 and values are summarized in Table 2. It can be seen from Table 2, correlation coefficient (R^2) values for the pseudo-first-order was higher than other kinetic models. In addition to this, the calculated values of $q_{e,cal}$ from pseudo-first-order model were in good agreement with the experimentally obtained ($q_{e,exp}$) values which clearly indicated that pseudo-first-order model was best fit with the adsorption kinetic data for the removal of Cu(II) ion. Therefore, the adsorption rate may be controlled by physical adsorption involving the vander walls forces through sharing or exchange of electrons between the adsorbent and the Cu(II) ion.

Conclusion

In the present study, the experimental results concluded that synthesis of adsorbent material-algal bio waste (RCUL and SMUL) has shown superior adsorption capacity and have rapid adsorption rate for the removal of Cu(II) ion from effluent wastewater. Supplementary, it has considered being cheap adsorbent material from the viewpoint of chemical and economic use. The operating parameters for the maximum adsorption were found to be contact time of (60 min: RUL and 30 min: SMUL) initial Cu(II) ion concentration of 50 mg/L, adsorbent dosage of (1.0 g: RUL and 0.2 g: SMUL) and solution pH of 6.0. The adsorption isotherm and kinetics were also studied to determine the adsorption mechanism of present adsorption system. Freundlich isotherm model best fitted with the experimental data, which describes that adsorption of Cu(II) ion using RUL and SMUL was multilayer adsorption. Pseudo-first-order kinetic model was best fitted and more valid to describe the adsorption behavior of Cu(II) ion. The monolayer adsorption capacity was found to be 205.1 mg/L for SMUL. This research highlights that newly synthesized SMUL was new promising adsorbents for the effective removal of Cu(II) ion from contaminant liquid. In addition to that algal biomass has some advantages such as low-cost, high adsorption capacity and its application will be extended to removal of toxic heavy metals from aqueous solution.

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Experimental Investigation on Behaviour of Mesh Confinement Concrete Column

D. Jegatheeswaran[1] and V. Harikumar[2]

Abstract Concrete is a vital material often used in the construction of residential, industrial, high rise buildings and special purpose structures. An experimental investigation is presented in this paper for evaluation of axial compressive strength of M20 grade cement concrete circular columns confined with locally available steel wire mesh. Twenty four full scale circular Column specimens of 180 mm diameter with height of 1000 mm were tested under monotonic compression. In this experiment two methods of specimens were casted. First method is mesh confinement solid column with one, two and three layer of steel wire meshes. Second method is mesh confinement tubular column with one, two, and three layer of steel wire mesh. To compare the axial compressive strength of mesh confinement column with plain cement concrete column. Percentage of steel in concrete column was maintained as prescribed by BIS. The experimental results showed that the most influential parameter on the property of load carrying capacity is the layer of mesh reinforcement of column. The use of wire mesh enhanced the capability of column to resist the axial loads due to confinement role provided by such material. The ultimate load carrying capacity of mesh confinement column was increased 23% to 38% of the conventional plain cement concrete column. The critical path of the failure mode was similar for all of the tested columns and normally began from the top or bottom ends, then, in some cases, passed through the middle zone of the column. A suitable expression was suggested to be used for calculating the modulus of elasticity of the tested column based upon the value of load carrying capacity under compression loads.

E-mail: [1]profdjpillai@gmail.com

[1]Professor, Department of Civil Engineering,
Sona College of Technology, Salem–636005, Tamil Nadu, India

[2]P.G. Student, Department of Civil Engineering,
Sona College of Technology, Salem–636005, Tamil Nadu, India

Keywords: Axial Compressive Strength, Confinement, Steel Wire Mesh, Solid Column, Tubular Column

Introduction

Reinforced concrete (RC) is widely used for construction all over the world. Columns transfer the loads from beams and slabs to foundation. Columns support high compressive forces in mega structures such as long-span structures and tall buildings. Moreover, columns may suffer damage due to over loading and natural disasters such as earthquakes and fires because of the limited strength and ductility of concrete. Failure of one or more columns may lead to the collapse of the structure. Therefore, both longitudinal and lateral reinforcements are essential for RC columns. While the concrete core is subjected to radial compression in the horizontal direction, the confining volume is subjected to hoop tension. However, either the large spacing or close spacing between ties results in lack of confinement of concrete core. The shortage of confinement offered by ties was the motivation for using materials such as Expanded Metal Mesh (EMM), Welded Wire Mesh (WMM) and Fiber Reinforced Polymer (FRP) to confine the concrete core. The more availability, lower cost and less need for advanced installation technique for steel meshes (EMM and WWM) make them predominant in developing countries. In this study, an indigenously available stainless steel wire meshes (SSWM) available in local market has been explored and has been investigated for their tensile strengths, bond strengths and confinement of concrete columns to increase their axial load carrying capacities.

Methodology

In the experimental work, totally 24 Nos. of columns were cast. Among that, two sets of 3 Nos. of column cast with conventional reinforced concrete with and without holes (Solid and Tublar). Another two sets of 9 Nos. of column cast with mesh confinement with and without holes. In the column with mesh confinement, single, double and three layers of steel wire meshes were used. All the columns were tested under universal testing machine. The load carrying capacity and mode of failure of columns were noted. The observed values of tabulated, calculated and compared with obtained results. Finally the conclusion were drafted from the findings.

Material Properties

The cement used in preparing the concrete mix is ordinary Portland cement of grade 53 conforming to IS:8112-1989 with a specific gravity of 3.15.

The used fine aggregate is natural siliceous sand having specific gravity of 2.6 and fineness modulus of 2.7 conforming to zone–II of IS:383-1970.

Coarse aggregate used in the study consist of crushed stone size 10 mm and 12 mm. The specific gravity is 2.66 and bulk density 1383 kg/m^3 conforming to IS:383-1970.

High yield strength deformed bars of 10 mm and 8 mm were used as longitudinal reinforcement and lateral ties. Steel wire mesh having Diameter of 1.25 mm Spacing of 15 mm X 15 mm Square Mesh.

Experimental Programme

Preparation of the Specimens

Steel moulds were used for casting the columns. Before casting, machine oil was applied on all the surfaces of moulds. 6 vertical bars of 10 mm diameter were used for the longitudinal reinforcement and 8 mm diameter were used for ties spaced at 100 mm the clear cover maintained at 20 mm. For mesh confinement concrete the meshes were installed in the mould before casting. Steel wire mesh wrapped 1-layer, 2-layer, 3-layers without reinforcement. To prevent the mesh from loosening the mesh was tied with steel wire at a spacing of 100 mm through the whole length and the concrete was mixed thoroughly and was poured into the moulds in layers. The mix design for M20 grade of concrete was proposed using IS method. The design mix obtained was 1:1.69:2.59:0.50. The mixing of the concrete was done. Each layer of concrete was compacted using a table vibrator. After 24 hours of casting, the specimens were removed from the moulds and cured under water for 28 days. After curing, the cylinders were taken out of the curing tank and air dried for a period of 24 hours in a well-ventilated shed at ambient atmospheric conditions. Fig. 1 and Fig. 2 shows that the casting and after casting of column.

Fig. 1 Casting of column

Fig. 2 Column after cast

Instrumentation and Set Up

Tests were conducted under universal testing machine having 1000 kN capacity. The loading rate was 10 mm per minute. During testing, both end of column was fixed. In order to avoid the movement of columns, the end plates were provided to have a uniform load distribution over the column. Longitudinal deformation was measured by dial gauge deflecto-meter having 50 mm deformation with 0.02 mm least count. Every 50 kN increment of load, the respective deformation was noted. After failure of column, the mode of failure of column was observed. From the observation and noted results, the Load-deformation graph was drafted for each individual column. The experimental set-up of column is illustrated in Fig. 3.

Fig. 3 Experimental set-up of column

Table 1 Test results of column specimens

Column Designation	Ultimate Load, kN	Stiffness, kN/mm	Compressive Strength of Column, N/mm^2	Compressive Strength of Cube, N/mm^2	Compressive Strength Index
SC	429.80	1750	42.98	64.650	0.665
TU	409.80	950	40.98	57.80	0.709
SC3L	532.00	1833.33	53.20	64.65	0.823
TU3L	365.80	900	36.58	57.80	0.632

SC-Solid Column; TU-Tubular Column; 3L-3 Layer

Results and Discussion

The test results obtained for the columns tested in this study are presented in Table 1. Results of companion cube and cylindrical specimens were also reported in the same Table.

Failure occurred by crushing of the concrete at the compression face of the cross section. The failure modes of all the specimens were closely observed and it was evident that the maximum load was attained at solid columns with 3 layer mesh confined compared to solid conventional columns. This is due to the fact the effective confinement achieved is higher in the case of confined columns than conventional columns. The confinement is offered by the only 20 mm gap in meshes used in the columns. The improvement achieved in strength of solid column is higher when compared to strength obtained for corresponding tubular column. Capacity and compression strength of the columns are tabulated in Table 1.

$$\text{Compressive strength index} = \frac{\textit{compressive strength of column}}{\textit{compressive strength of cube}}$$

Conclusions

1. The compressive strength of conventional tubular column is 40.98 kN. This is 12.11% higher compared to the compressive strength of 3-layer mesh confinement tubular column.
2. The compressive strength of solid column with 3-layer mesh confinement is 53.20 kN. This is 23.78% higher compared to the compressive strength of conventional solid column.
3. The compressive strength of solid column with 3-layer mesh confinement is 53.20 kN. This is 29.80% higher compared to the value obtained for 3-layer mesh confinement tubular column.
4. The compressive strength of conventional solid column is 42.98 kN. This is 17.50% higher compared to the value obtained for 3-layer mesh confinement tubular column.
5. Generally, the solid column having 3-layer mesh confinement gives more stiffness compare than all columns. Tubular column is little weak compare than solid columns.

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Exploring the Codial Provision to make Sustainable Pavement Quality Concrete

Shibashish Mukherjee[1]

Abstract Sustainability is important to the well-being of our planet, continued growth, and human development. Concrete is one of the most widely used construction materials in the world. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amount of CO_2, a greenhouse gas (GHG). The production of one tonne of Portland cement produces about one tonne of CO_2 and other GHGs. The environmental issues associated with GHGs, in addition to natural resources issues, will play a leading role in the sustainable development of the cement and concrete industry during this century. For example, as the supply of limestone decreases it will become more difficult to produce adequate amounts of Portland cement for construction. Once there is no more limestone, and thus no Portland cement, all of the employment associated with the concrete industry as well as new construction projects will be terminated. Therefore, it is necessary to look for sustainable solutions for future concrete construction. Sustainable concrete should have a very low inherent energy requirement, be produced with little waste, be made from some of the most plentiful resources on earth, produce durable structures, have a very high thermal mass, and be made with recycled materials. Sustainable constructions have a small impact on the environment. They use "green" materials, which have low energy costs, high durability, low maintenance requirements, and contain a large proportion of recycled or recyclable materials. Green materials also use less energy, resources, and can lead to high-performance cements and concrete. Concrete must keep evolving to satisfy the increasing demands of all of its users. Designing for sustainability means accounting for the short-term and long-term environmental consequences in the design.

A large amount of theoretical and experimental research programs were carried out by many universities and research institution in various countries. As a result, a great deal of useful information has been disseminated, and fruitful results have been put into practice. Yet, there is a need for developing a comprehensive understanding about the detailed contribution of Aggregates sizes, shape, gradation, towards minimizing the Cement Content. Different Codial Provisions for Concrete Mix Design, use of chemical & mineral admixture, for Pavement concrete.

Keywords: GGBS, Sustainability, PQC, Flexural Strength, Mix Design

Introduction

The stresses induced in concrete pavements are mainly flexural. Therefore flexural strength is more often specified than compressive strength in the design of concrete mixes for pavement construction. A simple method of concrete mix design based on flexural strength for normal weight concrete mixes is described in the paper. This paper presents a simple method to produce concrete having a 28-day Flexural strength 40 MPa at different percentages of slag as a replacement to cement. Concrete mixes are designed for three Cement replacement conditions as per MORTH Vth Revision, IRC-44: 2008, satisfying the durability requirements. Their flexural strength, compressive strength and its characteristics are reported in this paper. Mix design procedure suggested in the draft IRC: 44 (2008) is adopted.

As per guidelines laid by new government all new Highway Projects supported by NHAI of India will use Cement Concrete.

The entire 28 KM stretch for Satara-Kolhapur section of NH4 has been constructed with 40%age Fly-ash as replacement of Cementitious material for PQC & DLC, duration May 2002 to February 2005. As per IRC: SP: 84-2014 & IRC:SP:73-2015, provides guidelines for design & construction the proposed alternative conforms to any one of the international standards, code of practice, specifications, guidelines etc.[24]

IRC revised codes or new codes or amendments to existing codes

American Association of State Highway and Transportation Officials (AASHTO)

American Society for Testing of Materials (ASTM)

Euro Codes

E-mail: [1]shiva_muk2002@yahoo.co.in

[1]General Manager (Roads) Welspun Enterprise Ltd., Mumbai

National Standards of any of the following countries: United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, Netherlands, Spain, Australia, New Zealand, Japan and South Africa. [20,21]

Proportioning on Basis of Strength

The cement concrete pavement work shall consist of construction of unreinforced, dowel jointed, plain cement concrete pavement in accordance with the requirement of M40 grade of concrete (flexural strength 4.5 Mpa) for construction of normal concrete pavements. For rural roads minimum M30 grade of concrete (flexural strength 3.8 Mpa) is recommended to be used. For M45 flexural strength 5 MPa.

The stresses induced in concrete pavements are mainly flexural, it is required that their design is based on the flexural strength of concrete in all major projects. The mix shall be so designed in the laboratory as to ensure the minimum flexural strength in the field with the desired tolerance level as per IS 516. To achieve the desired minimum strength in the field, the mix in the laboratory shall be designed for somewhat higher strength, making due allowance for the type and extent of quality control likely to obtained in the field as to ensure the minimum strength is achieved in the field for this purpose.

$f' = f_{cr} + Z \times \sigma$

Where,

f_{cr} = Flexural strength (modulus of rupture), N/mm^2

f_{ck} = Characteristic compressive cube strength of concrete, N/mm^2

f' = Design Flexural Strength in N/mm

f_{cr} = Target Mean Flexural Strength at 28 days,

Z = Usually 1.65 as per is 456-2000 (as per Table 4 of IRC-15:2011)

σ = standard deviation. (as per Table 5 of IRC-15:2011)

Standard Normal Variate, Z: The value of Z shall depend upon the importance of the road. It may be chosen from Table 4 of IRC-15:2011. It is recommended that for National Highway/State Highways work, it may be kept as 1.96, for expressways, it may be kept as 2.33 and for lesser important road like urban streets, rural roads etc. it may be kept as 1.65. The above are minimum recommended values. Higher values of variate may be adopted as per the quality requirement by the agencies concerned.[2]

Fair to Good means construction with semi-mechanized methods and site mixed/semi automatic batching plant, insertion of tie bar/dowel bars and joint cutting by manual method/joint cutting by machine (usually for low traffic roads).

Good to Very Good means construction with semi-mechanized/ fixed form paving machines and batch mixed concrete with semi-automatic batching plant insertion of tie bars and dowel bars by manual method usually for medium traffic roads.

Very Good to Excellent means construction with fixed form/slip form paving machines and batch mixed concrete with automatic batching plant insertion of tie bars and dowel bars by manual/ automatic dowel/tie bar insertion mechanism method usually for heavy traffic roads/ expressway.

The Standard Deviation, σ For concrete roads, flexural strength of concrete is the design criteria. For all major projects, flexural strength of the mix shall be determined by third point loading of flexural beams (150 mm X 150 mm X 700 mm) as per IS-516. Determination of flexural strength by correlating with cube strength (compressive strength) shall not be allowed for major projects, as the correlation is not established.

As standard deviations is the measure of variation and will depend upon the degree of quality control, exercised during production of aggregates and concrete mix. For major projects using batch type mixing plant with modern aggregates crushing plants, standard deviation will be relatively much less as compared to the locations where mix is prepared using semi mechanized production process. The standard deviation (σ used in equation) for major projects shall accordingly be used corresponding to the deviation in the flexural strength actually obtaining in the field. For the purpose of initial mix design major projects value of σ shall, however, be taken as per Table 5 of IRC-15:2011. This may be subsequently suitably adjusted as per the actual test results observed on at least 30 flexural beams during construction.[2]

Table 1 Values of normal variate for different values of tolerance

Accepted Tolerance	Standard Normal Variate, Z	Degree of Control	Type of Road
1 in 20	1.65	Fair to Good	Urban streets, rural roads
1 in 40	1.96	Good to Very Good	National Highway/State Highway
1 in 100	2.33	Very Good to Excellent	Expressway

Values of Normal Variate for Different Values of Tolerance

Table 2 Expected values of standard deviation σ of flexural strength

Grade of Concrete (Characteristics Flexural Strength in MPa)	Standard Deviation for Different Degrees of Control, MPa Flexural Strength		
	Very Good	**Good**	**Fair**
3.0	0.38	0.55	0.60
3.5	0.35	0.50	0.55
4.0	0.32	0.45	0.50
4.5	0.29	0.40	0.45
5.0	0.26	0.35	0.40

Cement Concrete Pavement ON FIELD Requirement & Methodology

The Cement Concrete Pavement work shall consist of construction of unreinforced, dowel jointed, plain cement concrete pavement in accordance with the requirement of M40 grade of concrete (Flexural Strength 4.5 Mpa) for construction of Normal Concrete Pavements.

Materials

The following material shall be used for cement concrete pavement.

Cement

Any of the following cement capable of achieving the design strength may be used with prior approval of the Engineer and approved mix design

Ordinary Portland Cement, 43 Grade, IS: 8112
Ordinary Portland Cement, 53 Grade, IS: 12269
Portland Pozzolana Cement IS: 1489 (Part1)
Portland Slag Cement, IS: 455
Note:

As Per IRC:44-2008 Minimum cementitious material content shall be 325kg/m^3. This is irrespective of the grade of cement and is inclusive of mineral admixture additions such as fly-ash, or ground granulated blast furnace sag. These mineral admixtures may be taken into account in the concrete composition with respect to the minimum cement content if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolana and slag specified in IS:1489 (Part1) and IS: 455 respectively and stipulated in these guidelines. The maximum cement content shall be 425 Kg/m^3 and is exclusive of mineral admixtures such as flyash, silica fume or ground granulated blast furnace slag.

As per IS 1489 (Part 1) :2015 The standard specifies that the fly ash constituent shall not be less than 15 percent and not more than 35 percent by mass of Portland pozzolana cement.

As per IS 455: 1989 The standard specifies that the Slag constituent shall not be less than 25 percent and not more than 65 percent by mass of Portland Slag cement.[2]

Admixture

Chemical Admixtures

Admixtures confirming to IS 9103 may be used to improve workability of the concrete or extension of setting time. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in trial paving works. If air entraining admixture is used, the total quantity of air in air-entrained concrete as a percentage of the volume of the concrete shall have 4.5± 1.5 percent entrained air for 31.5mm maximum size of aggregate. The maximum quantity of chemical admixture shall be 2 percent by weight of cementitious material

Mineral Admixture

Fly ash up to 20 percent by weight of cement may be used in Ordinary Portland Cement 53/43 Grade. The fly ash shall conform to IS: 3812 (part-1). Fly ash of no other grade shall be used.

Granulated Blast Furnace slag (as per IS:12089) up to 50 percent

Silica fume (as per IS:15388-2003 and IS:456-2000, IRC:SP:70): if specified by the Engineer may be used. up to 10 percent by weight of cementitious material.

Meta-kaolin (as per IS 16354-2015) up to 10 percent by weight of cementitious material.

Coarse Aggregate

Aggregate for pavement concrete shall be from natural sources complying with IS: 383:2016, but with Los Angeles Abrasion value not more than 35 %age. The limits of deleterious materials shall not exceed the requirements set out in Table 1 of IS: 383. The grading of zone of coarse aggregates as per IS 383:2016 shall be within the limits as given in Table 7.

The combined flakiness and elongation index shall not be more than 35 percent. Lime stone aggregates may be used conforming to IS:383. The maximum size of coarse aggregates shall not exceed 31.5 mm.

Fine Aggregate

The fine aggregate shall consist of clean natural sand or crushed stone or a combination of the two and shall conform to IS: 383:2016.The fine aggregates shall not contain substances more than the following as mentioned in the below Table 2 of I.S 383:2016.

Although IS: 383 permits the fines passing 75 microns up to 15 %age in case of stone crusher dust, this provisions should be used with caution only when crushed stone dust is used as a fine aggregates and the mix produced in the laboratory and the field should be satisfactory in all respects and shall comply with specifications.

The grading of zone of fine aggregates as per IS 383:2016 shall be within the limits as given in Table 9.

For crushed stone sands, the permissible limit on 150 micron IS: Sieve is increased to 20 %age. The use of crushed stone sand is permitted in PQC. However, its percentage of fines passing 75 micron sieve shall not exceed 8 percent.

Combined Grading as per MORTH Vth

Table 4 is recommended for combined gradation of fine and coarse aggregate in PQC (Paving Quality Concrete)

The above grading is applicable both for natural river sand and crushed stone aggregate.[25]

Water

Water used for mixing and curing of concrete shall be from the bore wells. The water shall be tested and approved for use. The water should be free from injurious amount of oil, salt, acid vegetable matter or other substance harmful to the finished concrete. It shall meet the requirement stipulated in IS 456. Portable water is generally considered satisfactory for mixing and curing.

Steel

These shall conform to the requirement of IS 432, and IS 1786 as relevant. The dowel bars shall conform to Grade S 240 (with yield strength 240 MPa) and tie bars (deformed/plain) to Grade Fe 500 deformed steel bars as per IS 1786/IS 432. Tie steel shall be coated with epoxy paint for protection against corrosion, wherever required.

Concrete Strength

While designing the mix in the laboratory, correlations between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on samples.

The ratio between the 7 and 28 day strength shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at least six batches of trial mix. The average of the 7 day cured specimens for each batch, and the ratio ‘R’ shall be determined. The ratio ‘R’ shall be expressed to three decimal places.

If during construction of the trial length or during normal working or during normal working, the average value of any four consecutive 7 day test results fails below the required 7 day strength as derived from the value of ‘R’, then the cement content of the concrete shall, without extra payment, be increased by 5 %age by weight.[2]

As per IRC 58:2015 clause no 5.8.2 the 90's strength of can be worked out by multiplying the 28's day flexural strength of PQC by 1.10.[3]

Design Mix

The mix design is prepared as per IRC: 44 2008 "Guidelines for Cement Concrete Mix Design for Pavements (Second Revision)" in reference to IRC:15 2011 "Standard Specifications and Code of Practice for construction of Concrete Road". The criteria of design mix are it is based on characteristics Flexural strength

Various Mix Design Calculations

Here in this literature Three different Mix Design combinations are used to determine the optimum cement content corresponding to the required characteristic flexure strength. After carrying out all the necessary calculations; Cubes & Beams are casted after verification of fresh concrete properties to determine the require design criteria of hardened concrete.

Table 3

Sieve Designation	Percentage by Weight Passing the Sieve
31.50 mm	100
26.50 mm	85–95
19.0 mm	68–88
9.50 mm	45–65
4.75 mm	30–55
600 micron	8–30
150 micron	5–15
75 micron	0–5

Table 4

The Following Data are Used to Determine the Concrete Mix Proportion of M40 Grade Concrete to be Used as PQC (Pavement Quality Concrete) in Rigid Pavement

Grade Designation (required flexural strength)	M40 (4.5 N/mm^2)		
Type of cement	53 Grade Cement		
Maximum nominal size of aggregate	31.5 mm Aggregates		
Mix Design Notification	M1	M2	M3
Minimum Cementitious Content	As Per Morth Vth Revision	As Per IS 10262-2009	As per IRC :44-2008
	Not Provided	Not Provided	325 Kg/Cm
Maximum Cementitious Content	As Per Morth Vth Revision	As Per IS 10262-2009	As per IRC :44-2008
	Not Provided (Only Maximum Cement Content as per IS 456 2000)		
Maximum water-cement ratio	0.5 for mineral admixture is added		
Workability	30±5mm		
Method of transporting and placement of concrete	Tipper		
Types of aggregates	Angular		
Whether a chemical and mineral admixture used	Yes		
Whether fibers shall used	No		
In view of above design criteria The Mix proportions comes out to be as follows			
Cement in Kg/Cum	310	190	173
Cementitious material GGBS	155	190	173
Water in Litres/Cum	122	131	131
Admixture Dosage kg/Cum	3.33	3.81	3.11
Fine Aggregates in Kg/Cum	791	763	523
Coarse Aggregates in Kg/cum	1193	1324	1532
Water cement ratio	0.33	0.33	0.38
Slump in mm after one hour	30	30	26
Required Characteristic Flexural Strength in n/mm^2	5.068		
Required Characteristic Flexural Strength in n/mm^2 for 90 days strength as per IRC 58 2015 (1.10 times of 28 days strength)	5.575		
Average 7's days Beam Strength in n/mm^2	5.52	4.18	4.33
Average 7's days Cube Strength in n/mm^2	33	30	33
Average 28's days Beam Strength	6.7	5.01	5.26
Average 28's days Cube Strength	53	48	51
Average 90's days Beam Strength	6.9	6	6.1

Conclusion

From the above three example as per Indian code and as per Guidelines of IRC:SP:84-2014 & IRC:SP:73-2014 any alternative material, technology/ method, that is not covered in the Indian or International standards but the use of which has been permitted on similar projects, as the project Highway such as NH-4 from Satara-kolhapur, Kagal section completed in the year 2005, its continued successful performance of materials for at-least 5 years which is a supportive for its critical performance can be a very good support for design of sustainable green Pavement concrete.

This work can be used as a base for construction of State highways, Rural Roads, Urban Roads, Highways, Express way in contributing to the creation, implementation environment-friendly construction, reduced Green House emissions, saving of fuel consumption by Constructing Durable road connectivity.

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Green Walls in High Rise Buildings

Suresh Sahu[1]

Abstract The reason for presenting this technical paper to give the highlights about the advanced technology and the benefits of Green Walls in High Rise Buildings. All the metro and other bigger Indian cities are facing unpredictable expansion through population growth and urbanization in the coming decades, and the horizontal-suburban model of urban development is increasingly being discredited on sustainability grounds. As the land is available very less to build on as per the demand and hence, the logical solution for this issue is to build upwards. However, a major human need—access to greenery—must be addressed by any viable plan for increased height and density. This guide thus sets out recommendations for selecting, implementing and maintaining green walls in high-rise buildings, including local Indian climatic factors that need to be taken into account.Green buildings will play a major role in implementation of the better climate. It is necessary that action has to be taken for better climate, utilization of space, modern life style, etc. by implementing technology of “Green Walls in High Rise Buildings”.

Keywords: The Vertical Garden, planting media, Eco Skyscraper, Bio facades, Cantilevering Tree facades

What is Green Walls in High Rise Buildings

Green walls in high rise buildings is the systems where plants are growing on plane surface like walls of the building, in a very controlled manner with the help of different type of irrigation system and plantation media subject to the maintenance at time to time basis are termed as a green or vegetated wall in high rise building.

Email: [1]sahu@supremeengicons.com

[1]Supreme Engicons (india) Pvt. Ltd.,
Andheri (W), Mumbai-400058

Construction of Different Types of Green Buildings

As current scenario and Based on the variation of materials used in the construction of green building, out of wide range and types of green buildings some example for the same are as mentioned below:

Facade Supported Green Walls

In this type of green building the system of walls for holding the plants are supported off the areas where the medium of planting is not necessary to the external surface. In this system Plant materials can be rooted at the ground level of the building structures or on rooftops, which can also be attached to existing walls of the structure with specially designed supporting system. Figure-1 is an example of the exterior surface supported green wall.

Plants on Trellis

This type of green wall systems contains of steel, wood or plastic trellises with simple lightweight materials, which will fixed on the external surface of the building without increase in load to the structure. The climbing plants and the scrapers are supported with the help of horizontal, vertical or the diagonal trellis members with simple framework of vertical supports and horizontal crosspieces that is flat and can train plants—like shrubs, small or young trees, or vines—to grow up. Figure-2 shows the real example of trellis.

Plants on Cantilever Balconies

Few builders place large number of plants in the front area of building, which are achieved by the construction of Cantilever Balconies with sufficient depth to hold the plantation media along with the quantity and weight of soil as per requirement, where soil can go up to the level of the safety railing.

The structure is required to construct with required high grade of reinforced concrete to take high weight of the soil and the tree. After all those required supporting system the structures are integrated as primary structure of the green building. Figure-4 shows an example of high-rise buildings with Plants in cantilevered balconies.

Fig. 1 Facade supported green walls

Fig. 2 Trellis with simple framework

Fig. 3 Plants in cantilever balcony

Fig. 4 Plants on stepped designed terrace

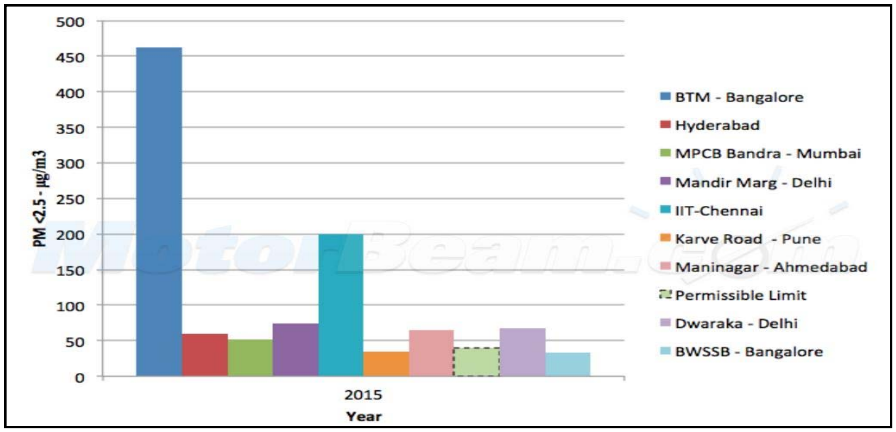

Fig. 5 Increase in air pollutions

This system is used for those areas where plants grow in different type, large in numbers and that require large soil is used. This can call as a green roof building and a green wall building.

Plants on Terraces in Step Design

We can also make building green by using another system of "plants on the stepped designed terrace". During the construction of stepped terrace, the concrete floors should be able to hold the weight of planting media which are arranged in trays made with lightweight materials supported with the infill walls and advances in steps design in the upward direction and would finally seem matched with the structure of the terrace. This type of green building method, plants in large variety as well as large quantity will be used and which requires large quantity of soil. This type of building can call as a green roof building. Figure – 3 shows the example of Plants on terrace in step design.

Benefits of Green Buildings

The cities like Mumbai & Delhi seems to be getting less livable due to consistently increase in air pollutions. Figure-5 shows the example of increase in air pollutions. Looking in all the aspects, Now days Architects and construction companies had started to use latest technology to make buildings as green as possible. The examples of green wall high rise buildings can be seen in many foreign countries.

By using this type of concept of green buildings containing thousands types of plants on exterior façade, terraces, balconies will able to preserve most of the natural environment all around the area. This type of construction and operation will also play a leading role in promoting the healthy environment for human being without disrupting the natural resources like the land, water and energy in and around the building. This green wall high rise buildings will helpful to us in controlling the different type of pollutions as well. Figure-6 Shows the Decrease in pollution due to green Building.

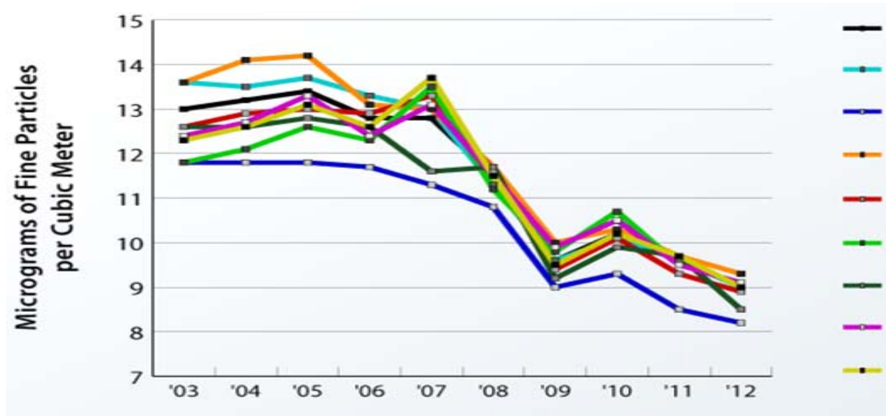

Fig. 6 Decrease in air pollutions

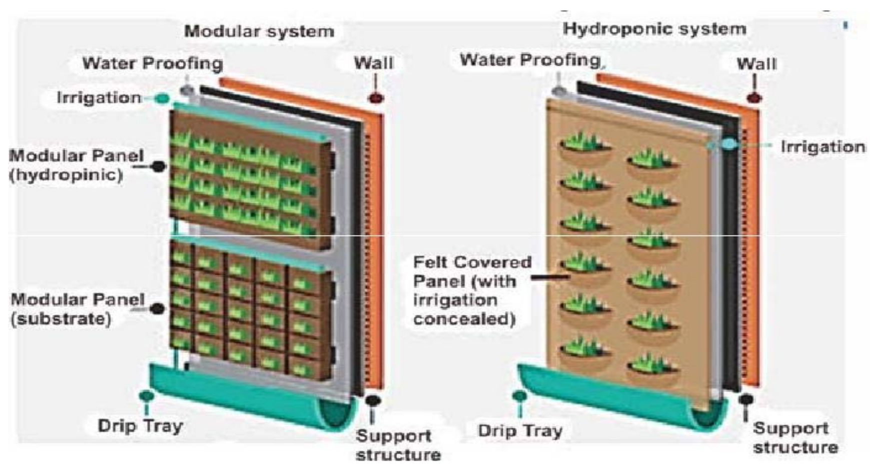

Fig. 7 Construction model and scheme of framing

By the construction of the green building OR Green Wall in The high Rise Building will also raise the aesthetic looks. Various plans with different type of texture and colours can be arranged in skillful manner to make the decorative look of the building facade. Constructing this type of building will play an important part in recreating the complementary spaces.

Green wall can also protect the human being from the harmful effects of ultraviolet rays. This direct effect will cause the complete deterioration of the structure. The internal stresses within the wall are decreased by creating the temperature fluctuations and also by this type of green wall Building.

Green live walls OR vertical greenery in entire building facade will able to formed a binding among the greenery in vertical design and the surfaces of structure. The binding between both are helpful in creation of microclimatic conditions. The changes like air temperature, surface temperature and humidity changes are mainly based on the condition of outdoor climate and also on the performance of the installed greenery on vertical walls. This type of microclimates will make difference directly in affected indoor conditions. In the case of vertical greenery the direct heat from the sun will absorbed by the greenery installed on outer surface of the structure and is transferred to inside surfaces, thus affecting indoor air conditions. In this process indoor temperatures will increases and thermal comfort of the residents will also strongly affected by indoor conditions.

Apart from all other benefits of this type of buildings, the live building with green walls will also gives us major relief from high sun radiation which radiated from the RCC/Concrete surfaces like buildings and roads. This would give a calming effect to the human being as well as surrounding environment.

In current situation of the negative climatic conditions and individual psychological health issues of not only of human being but also of all the leaving things are affected by the positive effects of green walls and also help in bringing a visual connection for all with the exterior vegetation growth. Breathing diseases suffering people are greatly benefited by the air filtering and the oxygenating abilities.

Construction of Green Wall

By construction of green façade building, Green Walls are covering all the types and methods of growing different type of plants in large numbers. Covering vertical surfaces of a buildings, structures or any kind of walls by growing plants/climbers from ground or from roof or from the wall itself by using different type of irrigation system supported with various plantation media like planters, modules, pots, fabrics, or by mechanically holding growth mediums of any kind, using whatever way & holding plants firmly, with provision of drain system. Therefore implementation for this type of planting media containing very broad definition to understand.

1. Green high Rise Building containing green walls are comprises of different type of plants grown in supported vertical systems like trellis made by light weight materials which are in general attached to an internal or external wall, although in some cases can also be freestanding structure such as green columns or canopy tree forms made of rigid panels. The construction model and scheme of framing are as shown in Figure-7
2. This type of Green walls can also be constructed by using different type of "Pre-molded blocks" available and which is manufactured into various sizes, shapes and thicknesses. The advantages of construction by using this type of pre molded blocks are that it do not break down for 10 to 15 years and also can be manufactured considering the higher or lower water holding capacity depending on the selection of plant for the walls, balconies and terraces, and are easily handled for maintenance and replacement as and when required.

Recommendations

Looking in all the aspects like current scenario of increasing in pollution, heat, etc., it is necessary to build the High rise building containing vertical garden called "GREEN WALL" , which will surly solve the many type of current as well future issues.

Most of the Indian cities are facing problems by the population growth, which may become horrible in the coming decades and to solve this type of issues it is the logical solution is to build upwards, the HIGH RISE BUILDING.

Major human need of clean surrounding can be taken care by selecting, implementing and maintaining green walls in high-rise buildings considering the local Indian climatic factors as green buildings will play a major role in implementation of the better climate. It is our recommendation as well as requirement of the time that action has to be taken for better climate, utilization of space, modern life style, and etc.by implementing technology of "Green Walls in High Rise Buildings".

Discussion

Apart from all above facts, some discussions are need to be done for the GREEN WALLS. A green wall actively pulls or forces air through the plants leaves, roots and growth medium of the wall and then into the building's "heating, ventilation and air conditioning" system to be re circulated throughout the building.

Major point of discussions is to equate the people about all the positives and negatives of the green wall/roof/balconies in the high rise buildings and its benefits in future on climate, human being and other living things in our surroundings.

With further research and after educating the people to support the green wall high rise, building may one day allow for our buildings to avoid polluted air, negative climatic conditions and individual psychological health by this type of green wall building.

Conclusion

Green Wall in High rise buildings OR Green Building is basically concept of growing your plants upwards on vertical surfaces OR on terraces OR on balconies of a building. As space is a constraint for many urban areas these days, having a vertical/terrace garden is certainly an option to still include some greenery in the vicinity. Green wall/Building is not only increase the aesthetic looks of the building but also can help to cool and insulate buildings by reducing the need and cost for air-conditioning. Growing plants on any type of surface in the building will also play a major role in filtration of polluted air particulates and improve air quality as well as add some humidity to centrally cooled offices at the same time. Vertical gardening requires little maintenance/trimming and mostly does not use soil. It also helps to save water by reducing the need for irrigation and watering. It also helps to soften the grey, hard and cold look of concrete especially in the jungle of concrete.

Some Gist is as below:

- Green Wall building is helpful in Reducing pollution and land development impacts from automobile use
- Helpful in restoring natural resources like water by Limiting the disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration and managing storm water run-off.
- Encourage and recognize increasing levels of self supply through renewable technologies to reduce environmental impacts associated with fossil fuel energy use

- To provide Personal Control on ventilation and lighting system for good health and pleasant environment.
- Provide proper connectivity between outdoor as well as indoor atmospheric conditions through the fresh air, sunlight and aesthetic looks into the possessed areas of the structure.
- To protect good Health of occupants.
- To use resources like energy, water, etc efficiently
- Reducing overall impact to the environment by implementing technology of "Green Walls in High Rise Buildings

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Improving Welder's Health through Local Exhaust Ventilation at Construction Sites

Krishna Nirmalya Sen[1] and Vimal Raj[2]

Abstract Welding is a metallurgical process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. In construction work involving structural steel and pipelines, welding is an important process such as pipe welding, structural steel fabrication, structural steel welding etc. Exposure to welding fumes can cause numerous health problems. Many welders who work in factories or in the construction, ironworks, manufacturing, mining, metallurgy, petrochemical, railroad, shipbuilding or steel industries, most suffer from some sort of respiratory illness or pulmonary infection. In construction industry many a times such welding operations are carried in a covered booth like set ups which results in buildup of welding smoke in the working zone which poses serious health hazards to the welders. Whether in outdoor or indoor situation, natural air circulation is ideally restricted in the interest of weld quality, thereby exposing the welder to health hazards of welding fumes. This gets further aggravated in a confined space like situation.

Since the location of welding job in construction sites keep on changing, implementing effective engineering controls to handle the welding fumes is a challenge. On the other hand, usage of "Personal Protective Equipment (PPE)" have limited effectiveness in reducing the likelihood and the consequence of risks and harm associated with exposure to welding fumes. As per hierarchy of controls, engineering control is one of the effective options after elimination and substitution. However additional administrative controls such as periodic medical examination of welders, regular supervision/ surveillance of welding operation is also very important for an effective and safe welding operation.

To proceed with effective engineering controls, existing ventilation conditions were studied for various welding applications in construction. Illness patterns of large number of welders deployed at various project sites were studied. Based on the findings suitable engineering intervention possibilities were explored. A simple, easy-to-fix, forced ventilation system can be very helpful in mitigating the hazards of welding fumes at site. This equipment can easily be fixed at various typical work-spots based on the specific requirements. Reduction of harm potential is achieved through reduction of concentration of hazardous fumes/ gases in the breathing zone of the operator. This is determined by measuring concentration of relevant hazardous fumes/gases before and after the intervention. The new ventilation system helps in diluting and removing the welding fumes that get generated at the workplace. Implementation of the above-mentioned engineering control measures are effective for reducing the concentration of harmful substance at the breathing zone of workers exposed during manual metal arc welding process at construction sites.

Keywords: Construction, Welder, Health, Engineering Control, Ventilation

Introduction

Welding is a metallurgical process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld.

In construction work involving structural steel and pipelines, welding is an important process such as pipe welding, structural steel fabrication, structural steel welding etc.

E-mail: [1] knsen@lntecc.com, [2]vimalkailasom@lntecc.com

[1]Head EHS, L&T Construction,
Metallurgical and Material Handling SBG, Kolkata, India

[2]Senior Engineer, L&T Construction,
Metallurgical and Material Handling SBG, Kolkata, India

The electric arc is struck between the electrode and the work piece, or between two electrodes. It is usually necessary to add some molten metal to the joint and this is done either by,

- Melting the electrode itself, consumable electrode processes; or
- Melting a separate filler rod which is not carrying current, non-consumable electrode processes

Welding operation adopted is hazardous in nature and classified as hot work. Hot work activities, such as welding and gas cutting, involve the use of heat. Besides health hazards due to exposure to welding products including fumes, sparks etc. The flames, sparks and heat produced during the hot work are ignition sources which can cause fires and explosions in many different situations. Welders who ignore healthy work practices today are putting their long-term health in jeopardy. Being aware of some of the less obvious health hazards can help to ensure healthy living later in life.

One organization that has collated studies and research results is the American Society of Safety Engineers (ASSE) that lists both short-term and long-term effects of exposure to welding fumes. Common short-term effects range from eye, nose, ear, throat and chest irritations to coughing and shortness of breath, bronchitis, pneumonitis (the inflammation of the lungs), encephalopathy (a syndrome that results in brain dysfunction) and nausea. Another short-term effect is known as metal fume fever that has flu-type symptoms that last between 24 and 48 hours.

But some welding fumes are more deadly than others, and the Society warns that work involving metal that contains cadmium can result in death.

The National Institute for Occupational Safety and Health (NIOSH) is actively involved in studies involving fumes that contain manganese (commonly added to carbon steel to make it strong and hard), and these studies have found that Parkinson’s (or something with the same symptoms) is caused by exposure to manganese fumes.

According to the ASSE, other common long-term health effects of welding exposure include pulmonary infection and heart disease, respiratory illness, lung and throat cancer, stomach problems, kidney disease, and a variety of neurological problems.

Welders may not develop cancer, but many experience chronic lung problems including asthma, bronchitis, decreased lung capacity, emphysema, pneumonia, as well as pneumoconiosis (a dust-related disease), siderosis (also dust-related but specifically caused by iron oxide dust), and silicosis (which often develops when welders have been exposed to silica).

Fig. 1 Examples of some on-site welding

Welding in Trench

Welding at Height

Table 1 Examples of potential exposure associated with the various welding process

Process	Potential Exposure
SMAW	Excessive fume concentration and fluoride (MS);chromium and nickel (SS)
FCAW	Excessive fume levels
Air carbon arc/ Plasma arc cutting	Excessive fume; noise
Oxy-gas cutting	Production of carbon monoxide or oxides of nitrogen
Thermal spraying	Excessive fume levels of sprayed metal, e.g. zinc.
Confined spaces	Oxides of nitrogen

(*Source:* Sen K N *et al*., Pulmonary Health Hazards in Manual Welding Operation in Construction: A study on Engineering Control Measures)

Contents of the welding fumes depend on the components of the base metal, coatings and/or filler materials and the temperatures used in the welding process. Types of metals commonly found in welding fumes include aluminum, beryllium, cadmium oxides, chromium, copper, fluorides, iron oxide, lead, manganese, molybdenum, nickel, vanadium and zinc oxides. Types of gases, includes carbon monoxide, fluorine, hydrogen fluoride, nitrogen oxide, ozone etc.

Since such fumes and gases could be hazardous to worker health. It is necessary to study the chemical characteristics of these chemicals suitably to find out suitable mitigation measures Exposure to welding fumes can cause numerous health problems. When inhaled, welding fumes can enter the lungs, bloodstream, brain nerve cells, spinal cord and other organs and can cause both short- and long-term health effects.

Methodology

Illness patterns of large number of welders deployed at various project sites were studied. Based on the findings suitable engineering intervention possibilities were explored. Details are given below:

Study on Illness Pattern of Welders

A study on 870 minor illness cases reported at medical centre at five major construction projects were analyzed and it was found that 73% of the welders have reported eye irritation followed by eye irritation as well body pain by 16% of the welders. Details highlighted in Chart 1

Ventilation arrangements were studied for various welding applications. In outdoor or semi-outdoor situations, natural air circulation can be sufficient to provide enough ventilation. Its effectiveness, however, depends on whether the day is windy or calm and in wind direction upwind or downwind. Using welding curtains, spark enclosures or hoardings when working outside prevents exposure to natural air movement and therefore prevents effective ventilation.

Interventions

General Ventilation

In indoor locations and confined spaces, draft fans or air-movers provide general or dilution ventilation. A well-designed and well-maintained ventilation system is usually effective for most situations involving clean, uncoated, mild steels. However, the only means of judging if the system is doing its job is to take regular airflow measurements and to sample for exposure.

For example, in the U.S.A, Occupational Safety and Health Administration (OSHA) require that a minimum of 65 cubic meters (2000 cubic feet) of air be moved per minute for each welder in a room. These figures might vary if, for example, a plasma-arc machine is being used inside a room.

Local Exhaust Systems

Vent hoods or gun-mounted exhausts can provide local exhaust ventilation. Local exhausts are the most effective ventilation systems for all situations that generate fumes containing heavy metals and, particularly, for stainless steel or plasma-arc welding. In field locations portable hoods may be explored. The effectiveness of local exhaust ventilation depends on the distance the hood is from the source of gases and fumes, on the air velocity and on the hood placement.

Local Exhaust Ventilation

Hazardous atmospheric contaminants can often be controlled effectively at their source by means of a local exhaust system. This system comprises:

- A hood which captures the contaminant at its point of generation;
- A duct system with appropriate airflow;
- An air cleaning system to prevent pollution of the general atmosphere;
- An exhaust fan; and
- A stack or other means of dispersing the decontaminated air into the atmosphere.

Fig. 2 Examples of local exhaust ventilation for welding in shop-floor

Fig. 3 Onsite local exhaust ventilation system developed

Results

Reduction of harm potential is achieved through reduction of concentration of hazardous fumes/ gases in the breathing zone of the operator. Accordingly, concentrations of relevant common hazardous fumes/ gases are measured in before and after the intervention.

As per hierarchy of controls, engineering control is one of the effective options after elimination and substitution. However additional controls such as regular medical examination of welders, regular supervision/ surveillance of welding operation is also very important aspect of consideration for an effective and safe welding operation.

A simple, easy-to-fix, forced ventilation equipment to handle welding fumes was fabricated. This equipment can easily be fixed at various typical work-spots based on the specific requirements. The new ventilation system has the following components:

- *Divergent Portion*: The place through which the welding fumes are taken inward through the battery operated fan fixed inside the body of the equipment.
- *Body*: It is the central portion through which fumes are transferred to the filtration process; the filter is generally a honey comb metallic filter.
- *Filter*: This is simple metallic honey comb structured metallic filter. This will facilitate the filtration process of welding fumes.
- *Convergent*: The convergent portion enables venting of welding fumes that are generated from the filtration process
- *Leveler & Fixing Arm*: The ventilation system has a leveler and a fixed arm, the leveler arm helps in projecting the divergent portion towards the welding fumes and fixing arm helps in fixing the same to the any structure. Hence this arm enables the quick fix arrangements

The new ventilation system helps in handling welding fumes that get generated and removed from workplace. Since filtration is a part of the ventilation process, generated welding fumes get filtered before emanating to atmosphere.

The applications of the ventilations systems are being utilized for various types of applications as given below:

- Ventilation system for welding pipes
- Ventilation system for welding structural steel
- Ventilation system inside confined space (Inside Pipes, Equipment etc.)

Table 2 Variation of average percentage of dilution of fume concentration at various angles of the portable head.

Angle of the Portable Hood (Degree) with Horizontal	Average % Dilution of Fume Concentration n = 30
0	12
15	20.3
30	34.7
45	56.5
60	63.9
75	72.2
90	79.6

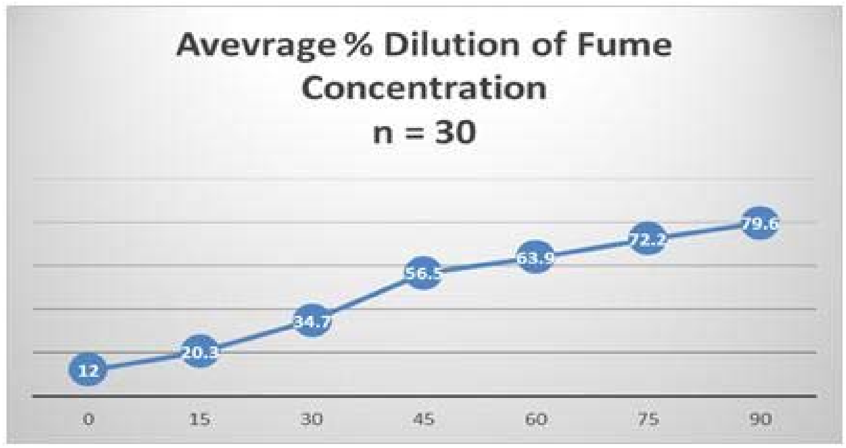

Fig. 4 Average percentage dilution of fume-analysis of effectiveness at various angles

Conclusions

Reduction of concentration to potentially harmful welding fumes can be conveniently achieved at construction sites through usage of local exhaust ventilation (LEV) system. Such LEVs can be locally developed using easily available materials. Due to reduction of concentration of the fumes, the harmful effect of the same on human subjects also gets enormously reduced. This study asserts that exhaust ventilation systems could be useful in reduction of concentration of hazardous fumes and gases in the breathing zone of the operator which also got confirmed through measurement of concentrations of relevant common hazardous fumes/ gases before and after the intervention.

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Installation of Solar/ Grid Powered Micro Irrigation Infrastructure in the Canal Commands

Rajeev Bansal[1], Neeraj Sharma[2], Shiv Narayan Singh[3] and Barjinder Singh[4]

Abstract The water use efficiency in irrigation sector will be achieved by adopting integrated approach in water management by increasing the available supply with reduction in conveyance losses and by increasing the field application efficiency with use of water in Drip & Sprinkler Irrigation technology. This purpose will be served by Installation of Solar/ Grid Powered Micro Irrigation Infrastructure in the Canal Commands by providing common infrastructure with components Community based water storage tank near outlet head, Pumping Unit (Grid/ Solar Powered), Filtration units, HDPE pipe network/ Hydrant/ Outlet assembly, Valves etc with Drip/ Sprinkler irrigation sets will serve this purpose. The Solar Power System is proposed to be connected with the utility power grid so that the energy generated by the solar modules, whenever not required for operation of the pumping system or is in excess of requirement, can be sent to the Utility Grid through bidirectional meter.

Keywords: Solar/ Grid, Micro Irrigation, Canal Command, Irrigation Efficiency

Introduction

Haryana State, with geographical area of 4.4 Million Hectares, is mostly arid or semi arid with limited rain fall ranging from 300 mm in the south-west to 1100 mm in the north-east. There are no perennial rivers running through the state and about 2/3rd of the area is underlain with brackish water facing problems of rising water table and inadequate natural drainage. 80% of the cultivable area of the State stands covered by the various canal commands including the lift canal commands, but the actual average annual intensity of canal irrigation in the State is only about 70% (combined for both the crops of Rabi & Kharif) which clearly reflects the limited availability of canal water. Large dependence of the State's agricultural sector on the ground water has led to overexploitation of this source of water and consequently the water table has registered a steep fall in the fresh water belts and rise in saline ground water areas leading to the problems of water logging and soil salinity. Growing water crisis and need to produce more food per drop of water, requires adoption of water efficient irrigation methods instead of the conventional flood irrigation to increase the field application water use efficiency and to enhance crop productivity. Micro Irrigation systems have matured to their significance not only in water saving but also in efficient energy, labour and fertilizer management system for more crop production. Micro Irrigation Systems will be helpful in Uniformity of water application, Higher water use efficiency, No land acquisition and levelling, Assured Irrigation to the agricultural fields, Improving cropping Intensity, Increasing efficiency through judicious use of irrigation water, Saving farm land, appreciating land use and Improving socio economic condition of the farmers.

Methodology

Solar/ Grid Powered Micro Irrigation Infrastructure in the Canal Commands has been installed by providing Community based water storage tank near outlet head, Pumping Unit (Grid/ Solar Powered), Filtration units, HDPE pipe network/ Hydrant/ Outlet assembly, Valves etc. in the command area of canal outlet, as shown in layout plan Fig. 1. Drip/ Sprinkler irrigation sets will be installed by the individual farmers in their farm holdings by availing the benefits of subsidy. It is proposed to take water from canal outlet through underground pipeline with gravity and to store the same in the tank of appropriate size for construction of which the land shall be made available by the WUA of the shareholders of the canal outlet. Solar/ Grid powered pumping system connected through net metering has been installed nearby the tank with proper filtration systems to avoid any chocking. Water has been carried to entire area of the chak of the outlet through HDPE pipe line network under pressure. The entire pipe network has been buried under ground at 3 feet deep to avoid land acquisition. Water with the requisite pressure for running of the drip/ sprinkler set has been made available to each shareholder at his farm holding through the common infrastructure to be operated & maintained by the Water User's Associations.

E-mail: [1]chiefengineercada@gmail.com, xenkurukshetracad@gmail.com

[1,2,4]Command Area Development Authority (CADA), Haryana

[3]Project Co-ordinator, Jain Irrigation Systems Ltd., Jalgaon, Maharashtra

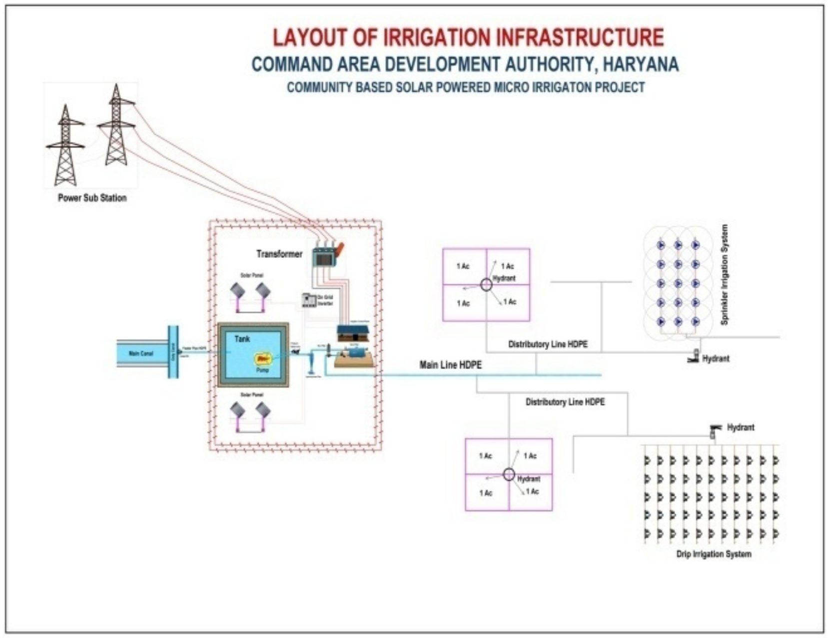

Fig. 1 Layout plan

Design Parameters

Modified penman method has been used to find out crop water requirement and computed the peak water requirement in rabi & kharif season. In this scheme average water requirement of 2 mm/ day has been considered. Design of this scheme is based on actual culturable command area (CCA), approved discharge normally 2.4 cusecs/ 000 acres and schedule of running of canal outlet by collecting the authenticated data from the Canal Authorities. Each component of this scheme shall be designed in such a manner that minimum operating pressure of 2.5 Kg/cm^2 available to the farmers on their farm gate. Size of the storage tank has been designed by considering discharge of the outlet and volume of water accumulated in 24 hours. A feeder pipe of required size in appropriate length has been provided from canal outlet to the storage tank by gravitational flow. Solar pumping system is a vital part of this scheme and in this scheme grid connected solar powered pump has been considered to reduce the cost of electricity of appropriate size. At least one pump is provided in a block of area 40 to 50 Hactare. Solar pumps of the capacity up to 10 to 20 HP is preferred with average working of 14 hours/ day. The HP of pump set required is based upon design discharge and total operating head. The total operating head is sum of total static head, friction loses worked out with hazen-williams equation in pipeline network and losses in filtration unit. Pipes in main line and sub-main shall not be below 110 mm (OD) and the size shall be decided based on the criteria to limit the friction loss in the main & sub main keeping the minimum flow velocity in the pipeline as 0.6 m/sec.

HP of pump set = (QxH)/ 75e

Q = discharge, LPS

H = head, m

e = pumping efficiency

Solar PV array of at least 1100 wp capacities has been installed per HP rating of pumping sets and total capacity of the Solar pv array for operation of solar pumping sets has been worked out in such a manner that total annual solar energy generation from the PV power system in no case be lesser than the total energy requirement to run the Micro Irrigation System and there is no net import of energy from the utility grid on annual basis. For working out the total annual energy requirement of the Micro Irrigation System likely days of running of canal outlet in a year has been considered based on the actual schedule of canal running, but total running days of the canal in year shall not be any case be less than 180.

The output power of SPV would be fed to the inverters for conversion of the DC produced by SPV array to AC for operation of the motor pump sets and feeding the same into the nearest electricity grid through 11 KV, 24 hours energised HT independent line after synchronisation when in excess of requirement. A hydrant assembly has been provided with minimum 110 size for the land holding of every share holder with provision of at least one hydrant for every 04 acres or less.

Conclusion

Significant irrigation from tube wells are being done in various districts of Haryana, canal water use efficiency is very poor and ground water wastage in shape of flood irrigation is being over exploited. It also causes wastage of electricity. Use of micro irrigation infrastructure will reduce the use of tube wells by which ground water will be saved. In areas where ground water is saline causes less yield and soil degradation conjunctive use of ground water with canal water improvement of soil quality and electric power will be saved. More area can be brought under canal command, which was otherwise either rain fed or irrigated by tube wells. In the areas where canal irrigation is less and farmers depends upon rain water and ground water which is very low and saline with no scope of ground water development, the only solution is creating of Micro Irrigation infrastructure on canal outlets. Where the ground water table is very high with brackish water, there are chances of creating the situation of water logging, which is harmful for soil properties. In this area, it is essentially required to minimize the flood irrigation by replacing with micro irrigation. There is also a possibility of solar based community tube well for conjunctive use of water. Hence, by installation of Solar/ Grid Powered Micro Irrigation Infrastructure in the Canal Commands through integrated approach of supply management and demand management, yield & net sown area will increase, dependency of tube well & overexploitation of ground water will decrease, saving of highly subsidised electricity and above all change of mind set of the farmers towards the use of available water judiciously.

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Krishna River Basin-Water Management: A Green & Social Perspective

Gangaraju Mallampalli[1]

Abstract Krishna River originating in Maharashtra flows through Karnataka, Telangana and Andhra Pradesh before joining Bay of Bengal at Hamsala Deevi (Andhra Pradesh). The water management in the basin is entrusted to Krishna River Management Board (KRMB) by a Gazette Notification dated 28th May,2014 by Government of India. The administration, Regulation, Maintenance and operation of the water resource in the basin in accordance with the judicial awards in force is the responsibility of KRMB under the supervision of an Apex Council. Balancing the needs of the four states on an equitable basis in tune with the judicial awards and on a sustainable basis is a challenge for KRMB.

This paper attempts to present the challenges before the Board in the management of the Krishna River basin yield on a sustainable basis. The present scenario as also the roles of Central Water Commission (CWC), National Institute of Hydrology, Roorkee in providing forecasts of water availability are presented.

Research Report 83 of International Water Management Institute, Colombo (2005) on "Spatial Variation in Water Supply and Demand across River Basins of India" is discussed.

The practices and processes in Murray – Darling Basin Authority, Australia, California Water Action Plan 2016 Update, California State, USA and services of Bureau of Reclamation(USBR), National Oceanic and Atmospheric Administration (NOAA), USA for sustainable water management in the river basins are discussed. to propose as to what can be adapted in Krishna River Basin Management.

Keywords: Krishna River Basin, Water Management, Equitable and Sustainable use, Contemporary Practices

E-mail: [1]gangaraju.mallampalli2014@gmail.com

[1]In Individual Capacity, Hyderabad, India

Preamble

The Krishna River, from its origin near Mahabaleshwar, Maharashtra is flowing through Karnataka, Telangana and Andhra Pradesh and joins Bay of Bengal at Hamsala Deevi (Andhra Pradesh) in the east coast. The River traverses a total length of about 1400 kms and has basin area of 2,58,948 Sq. Km as per the Integrated Hydrological Data Book (Non Classified River Basins), Central Water Commission (CWC), New Delhi[1]. Major Tributaries are Bhima and Tungabhadra. Malaprabha, Musi & Munneru tributaries also contribute significantly to Krishna River catchment. As per Table 1 of the Data Book[1] average annual flow as on 31.3.2016 is 78.10 BCM of which Live Storage Capacities of completed Projects is 50.651 BCM and under construction is about 4.156 BCM. Predominant use of this River water is for Irrigation.

Water Management

In the Basin: As per the Krishna Water Disputes Tribunal-1 (Justice R.S. Bachawat) award (popularly known as Bachawat award) notified in Extraordinary Gazette dated 31-5-1976, water share, allocated on 75% dependability, is Maharashtra – 560 TMC, Karnataka 700 TMC and Andhra Pradesh (combined Telangana and Andhra Pradesh at present) is 800 TMC. When Justice Bachawat Award has become due for review, Krishna Water Disputes Tribunal-2 (Justice Brijesh Kumar Tribunal) was constituted. Justice Brijesh Kumar Tribunal gave the verdict on 29.11.2013. Consequent to bifurcation of Telangana and Andhra Pradesh, the term of Justice Brijesh Kumar Tribunal was extended for 2 years from 1.8.2014. Krishna River Management Board (KRMB) was notified on 28.5.2014 for Administration, Regulation, Maintenance and Operation of waters of Krishna River Basin. An apex council was also notified to supervise KRMB.

The primary challenge for KRMB in the Water Management of the basin is to regulate and maintain adequate water supply on equitablebasis for Drinking Water needs and Irrigation purposes against competing needs of the states in the basin and within the contours of judicial awards. Vagaries of nature and uneven precipitation in the basin are also challenges. Ensuring adequate flows in lean season to maintain water quality, ground water recharge and out flow into the sea are the challenges for a sustainable river ecosystem. Management of flood flows by monitoring, regulation and storage in the completed projects and planning for the future storage is the task for the engineering community.

Krishna River Management Board (KRMB)

KRMB is the notified agency for the water management by monitoring flows, regulating flow and storage in the completed projects on the river to meet competing needs of the four states in the basin. Compliance with the judicial awards is another responsibility.

Green and Social Perspective

The Authors Daniel P. Loucks and Eelco van Beek in their book "Water Resource Systems Planning and Management –An Introduction to Methods, Models and Application" (2017)[2] observed that the goal of sustainable water management is to promote water use in such a way that society's needs are both met to the extent possible now and in the future. They also observed that surface water flows and aquifer storage volumes vary over space and time. They are finite. In the present scenario of Climate Change the rain fall intensity and precipitation in any particular area or river basin is erratic and increasingly unpredictable. International Water Management Institute (IWMI), Colombo in its Research Report 83–"Spatial Variation in water supply and demand across river basins of India" (2005)[3] classified Krishna River Basin as "Economically Water Scarce, Food Deficit Basin". It also identified Krishna River basin as a water stressed basin with increase in ground water irrigation. From Green and Social perspective, the issues/challenges identified in the report are

- Growth in Population and Urbanisation
- Irrigation expansion
- Environmental flow requirement
- Reallocation of agricultural withdrawals.

The report suggested to consider contribution of water transfers or interlinking of river basins to augment supplies in water stressed basins. Water Management in the Krishna River Basin (a water stressed one with predominant use for agriculture) on a sustainable basis is all the more challenging. UNESCO–International Hydrological Programme (IHP) identified that Water Resource Systems Planning and Management as a multidisciplinary activity.

Present Scenario

Central Water Commission (CWC)

As per Annual Report 2015-16[4], is charged with the general responsibility of initiating, coordinating and furthering, in consultation with the State Governments concerned, schemes for the control, conservation and utilization of water resources in the respective State for the purpose of flood management, irrigation, drinking water supply and water power generation. For river management, CWC makes hydrological observations and provides Flood Forecasting Service. Integrated Hydrological Data Book (Non classified River Basins), CWC, New Delhi (2017)[1] is one of its publications to assist planners and designers of Water Management Projects. As per Para 3.1.2, Online Surface Water Information System (eSWIS) is already operational in CWC. Mathematical modelling is being used for Flood Forecasting. Rain fall-Run off module coupled with Hydro dynamic routing Module has been taken up. Under National Hydrological Project, tools and facilities for better forecasting and real time management of Rivers are in the pipe line. Probable Maximum Precipitation (PMP) Values at grid points, patterns of key storms, temporal distribution of patterns of rainfall etc (PMP Module) is under development in association with National Remote Sensing Centre (NRSC), Government of India.

Basin Planning

The National Action Plan on Climate Change (NAPCC) adopted by the Government of India envisaged the need for review of National Water Policy. It inter-alia stated that the National Water Policy would be revised in consultation with states to ensure basin level management strategies to deal with variability in rainfall and river flows due to climate change. Accordingly the National Water Policy 2002 was reviewed and revised. The 2012 policy was adopted by the National Water Resources Council in December 2012. (Para 4.4 of Annual Report 2015-16)[4], National Water Policy-2012 envisages to adopt River Basin as a basic Hydrological Unit for planning under Integrated Water Resources Management (IWRM). Development of IWRM Plan for Brahmani-Baitarni under Indo Australian Cooperation is already taken up and computer modelling under various scenarios is in progress. National Water Development Agency (NWDA) is entrusted with feasibility studies for Inter Basin Transfer of Water and Link Canals which is outside the scope of this article.

Hydrological Modelling

National Institute of Hydrology, Roorkee. Ministry of Water Resources, River Development & Ganga Rejuvenation, GOI is involved in the National Hydrology Project through the Centre of Excellence for Hydrological Modelling. They provide solutions and training in Hydrological modelling.

Contemporary Practices

Operations in the River Murray System, Australia

Murray Darling Basin Authority, Australian Government (MDBA) is the authority for the Water Management in the River Murray system (Australia's largest river system) as also the assets in the Basin. MDBA publication No. 06/2016[5], Title: Objectives and outcomes for river operations in the River Murray system, 28th April, 2016 is reviewed in this article. The general objectives and outcomes are documented in Clause 4 of the document in the areas of:

- Water storage and Delivery and accounting
- River Murray Operations (RMO) Assets
- People and communities
- Environment
- Communication and information Management.

The authority have a Basin Plan and a dynamic Annual operating Plan. Managing water is done taking into consideration, Water for the environment, Hydrological modelling, Salinity, Water in Storages, Water markets & Trade, and Water Quality. In computer based Hydrological modelling, 24 individual river systems models are linked together using rainfall-runoff models for creating continuous stream flow records and use eFLOW predictor tool. The specific objectives and outcomes are also determined on annual basis which are not available in the public domain. As per the publication, the present practices are evolved over a period of four decades.

Bureau of Reclamation, USA

The Bureau is a USA federal agency with the mission to manage, develop and protect water and related resources in an environmentally and economically sound manner in the interest of American Public. AGRIMET is a co-operative agricultural weather network. Real time water management services are provided under HYDROMET. The Hydromet data is then integrated with other sources of information to provide stream flow forecasting and current runoff conditions for river and reservoir operations.

Water SMART (Sustain and Manage America's Resources for Tomorrow) Program provides Basin studies to evaluate the impacts of climate change and help ensure sustainable water supplies by identifying strategies to address imbalances in water supply and demand.

National Oceanic and Atmospheric Administration, USA (NOAA)

NOAA provides National weather service and Advanced Hydrologic Prediction Service. Colorado Basin River Forecast Centre (CBRFC), NOAA is making water supply and demand studies and providing forecast services for Water Management in the Colorado river basin. They use both statistical and dynamical models.

California Water Action Plan 2016 Update–Actions for Reliability, Restoration and Resilience[6]

California State (USA) identified the challenges of management of scarce resource of water and the effect of Physical Infrastructure developed in the state to have resulted in unintended consequences. It also identified the effects of climate change for having eight consecutive drought years, decline in ground water supply, poor water quality and Floods. To achieve the Goals of Reliability, Restoration and Resilience the state declared that Working Together and Continued collaboration is essential. They identified ten Action areas of which the following are considered as more relevant in respect of Krishna River Basin.

- Integrated Water Management across all levels of Government
- Achieve the co-equal goals for the Delta
- Increase operational and regulatory efficiency
- Manage and prepare for dry periods.

Summary

The key learnings of this study are:

- Integrated Water Management of the river basin (IWRM) is essential to ensure equitable and sustainable use. It is a multidisciplinary activity.
- Co-operative approach byall the stake holders in the basin is essential in drawing action plans and prioritize competing needs.
- Adequate planning for management of drought, normal and flood conditions is to be done.
- It is a good practice to draw up general Objectives and Outcomes keeping the River Basin as a Hydrological unit and draw up specific objectives and outcomes on yearly basis.
- Hydrological modelling tool is extensively used by the Murray Darling Basin Authority, Australia in IWRM.
- Both Statistical and Dynamical models can be used effectively, in combination, for Water Management in River Basins.

Suggestions

The need of the hour is Integrated River water Management in the Basin for sustainable use meeting the present and future community needs. What is to be done now, What can be done in the short term, What can be the long term plans are proposed as under.

- Overall utilization to be limited to the Tribunal awards
- To regulate flows and storages to meet drinking water needs of the community and ensure timely supplies for irrigation
- Maintain water quality, ground water levels and adequate outflows into the sea to avoid ingress of salinity
- General objectives to be laid down on a cooperative basis in consultation with all the stake holders and Resource Management Plan guidelines to be prepared
- Basin plans are to be prepared on annual basis at the beginning of crop years on an equitable basis
- Midterm review and revision of basin plans in consonance with weather forecasts and actual spread and precipitation
- Multidisciplinary approach to develop Real Time Water Management capability like "HYDROMET" in USA is required
- Both statistical and dynamical models, in combination, may be used for forecasting
- Development of Probable Maximum Precipitation (PMP) modules for the main river and major tributaries to be made on priority
- A legalised and statutory structure like Murray Darling Basin Authority, Australia (MDBA) would be beneficial for integrated management.

Engineering community both from service institutions and academic institutions can contribute for integrated water management needs of the country.

Limitations

Legal and statutory aspects are outside the scope of this article. The study is limited to examine as to how engineering community can contribute for equitable and sustainable management of water resources in Krishna River Basin.

Acknowledgements

Nationwide Campaign "Rally for Rivers" by Sadguru Jaggi Vasudev was the inspiration to look for the role engineering community can play in the water management of our rivers, particularly Krishna River. During the quest, the author stumbled upon the eBook "Water Resource Systems Planning and Management – An Introduction to Methods, Models and Application" by Authors Daniel P. Loucks and Eelco van Beek (2017) jointly published with Deltares and UNESCO-IHE and available in open access through Springer link. When it is seen that "Green and Social Perspective" is one of the sub themes for Indian Engineering Congress 2017, it was felt that Water Management in Krishna River Basin on sustainable basis is a challenge for the community to work on this and delve upon. The author acknowledges the opportunity provided by the Organizers of IEC 2017 to submit this article for the Congress.

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Multi-phase Structural Steel Release for Pipe Rack

Ruchi Dikshit[1], Saivivek Mandava[2] and Rushikesh Trivedi[3]

Abstract Design of pipe racks in petrochemical projects is often very challenging and requires a lot of interfaces between several engineering disciplines, procurement and construction. With the advent of construction and fabrication driven project schedules, pipe rack design usually ends up being on critical path. At the same time, during early phase of detail engineering, structural and piping stress engineers do not have definite inputs to proceed with final design to feed fabrication and construction teams. In addition, as project advances, changes occur due to design development in process, mechanical and piping engineering.

There seems to be an industry wide need for innovative engineering and project execution strategies to meet shorter project schedules along with providing the most cost effective solution.

This paper is an attempt to provide guidelines for structural engineers to design steel pipe racks for schedule critical projects based on authors' recent experiences. Additionally, important steps in design coordination required among engineering disciplines are also addressed. Structural group may need to initiate & continue progressing structural design of pipe rack before matured information is available including fireproofing requirements, equipment data and pipe stress loads. A structural engineer should work very closely with piping and mechanical team to control over/under design of racks and achieve required schedule objective to contain overall cost.

Methods and sequence of engineering, procurement and construction followed on a recently executed refinery project in Middle East region are presented. Construction schedule required steel for racks to be installed at site to start piping installation much earlier than conventional projects. There was also a long lead time to have the engineered steel procured and fabricated prior to shipping it to construction site.

To mitigate schedule challenge, pipe rack steel was issued to fabricator in multiple phases. Although it took slightly more engineering effort hours, this approach not only helped in meeting construction milestones and effectively managing late stage design developments/ changes but also controlling overall project cost.

Keywords: Pipe Rack, Petrochemical, Design, Interface

Introduction

Multi-phase design is an approach in which the structural steel is issued for construction in different phases.

With project schedules getting shorter (read Lump sum execution) there is an industry wide need for innovative engineering to meet the shorter project schedules. Pipe rack construction schedule can be reduced if pipe installation starts earlier than its typical schedule. For pipe installation to start early, the pipe rack steel should be installed at site before that (refer Fig. 1).

On conventional projects, foundation is released for construction after 30% client model review and steel is issued for construction after 60% client model review. But for schedule critical projects, it is beneficial to issue pipe rack foundation and steel immediately after the 30% client model review. Hence, to mitigate the schedule challenge the pipe rack steel is proposed to be issued in multiple phases (refer Fig. 2).

Methodology

Phase one structural steel release-After successful 30% client model review, pipe rack foundations are issued for construction immediately followed by phase one structural steel release for fabrication and construction. Phase one structural steel release will include issue of structural steel

[1] E-mail: [1]ruchi.m.dikshit@fluor.com, [2]saivivek.mandava@fluor.com, [3]rushikesh.trivedi@fluor.com

[1,2,3]Fluor Daniel India Pvt. Ltd., Gurgaon, India

that houses all the major piping for the pipe rack that is required at the construction site early to gain schedule advantage. Thus, phase one steel will include all the major steel below column splice level (refer Fig. 2, Fig. 3 & Fig. 4).

Phase two structural steel release-After successful 60% client model review, pipe rack phase two steel is issued for fabrication and construction. Phase two steel release includes issue of structural steel above splice level (refer Fig. 2, Fig. 3 & Fig. 4). Phase two steel includes all the main steel that supported piping and equipments that are vendor (third party) dependent and therefore not finalized during the phase one steel release. It mainly includes structural steel related to battery limit platform area, air cooler and walkway steel, header pipe supporting steel, steel supporting the control valve and pressure safety valve (refer Fig. 1 for clarity on listed items).

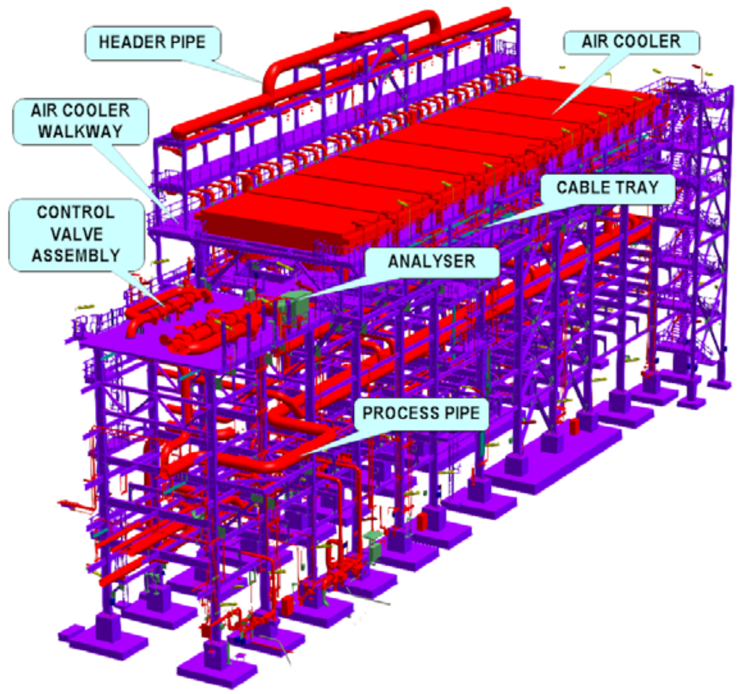

Fig. 1 3D view of typical process unit pipe rack

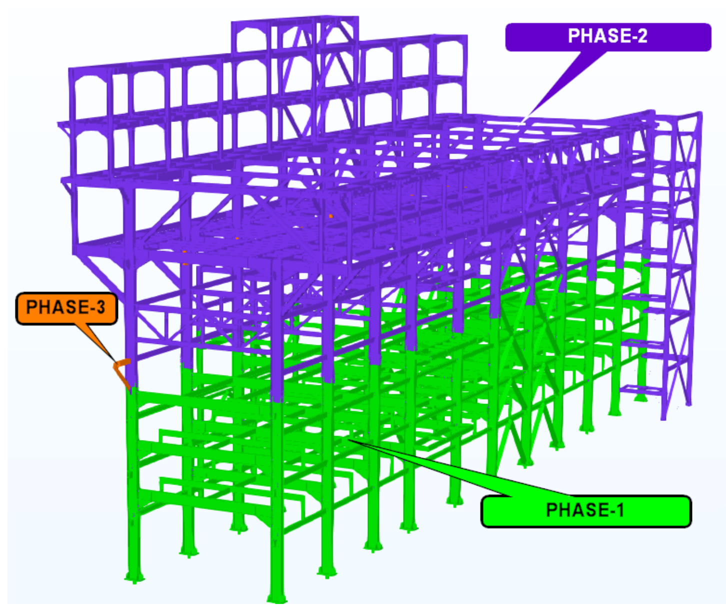

Fig. 2 Pipe rack 3D view

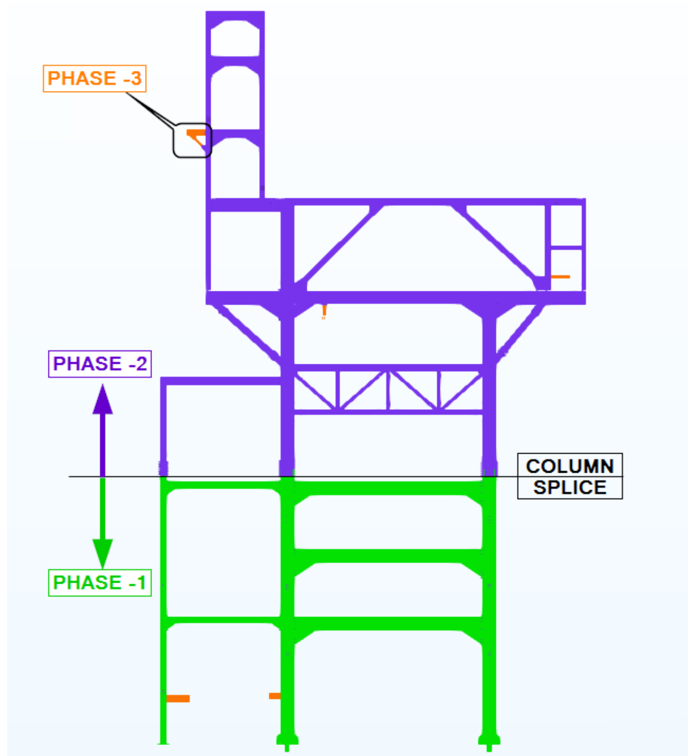

Fig. 3 Pipe rack transverse view

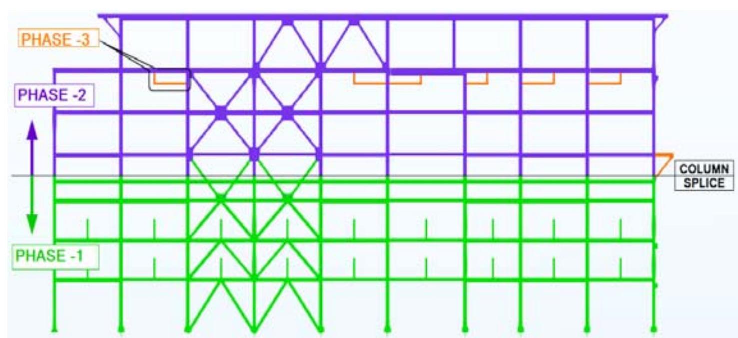

Fig. 4 Pipe rack longitudinal view

Phase three structural steel release - Phase three steel release includes issue of miscellaneous structural steel (refer Fig. 2, Fig. 3 & Fig. 4) for small bore pipe supports, cable tray supports, manifold supports, etc. It includes the structural steel normally related to the last vendor (third party) items received during project execution. Phase three steel is issued for fabrication and construction post 90% client model review. Depending on project location and involved cost, these steel supports can be pre-fabricated & shipped to site or fabricated at site by installation contractor. However, steel support for miscellaneous items finalized around 30% and 60% project progress is preferred be issued in phase one and two respectively. Main aim of phase three steel release is to avoid rework in already issued steel in phase one and two.

Interfaces

Interface within various engineering disciplines, construction and fabrication group play a vital role for success of this approach. Structural group must work very closely with piping, electrical and mechanical group to control the design and achieve required schedule objective to contain overall cost. Structural group must also involve construction and fabrication teams while deciding the phase one and two release split.

For Phase one release, it is best to include all the major big bore plant piping. The exact location of column splice must be agreed with piping and construction teams. The location of air coolers should be final and agreed with mechanical and piping. Requirement of all major platforms for operation and access should be addressed. While providing platforms, the platform extent should be such that the future space requirement for miscellaneous items like utility stations, manifold, instrument supports, analyzer cabinets, etc. is addressed. Miscellaneous support for small bore pipes, cable trays that are finalized during phase one is preferred to be incorporated. All the grating and handrail cutouts finalized should be addressed in phase one steel release. The cutouts that are likely to be modified should not be included as rework at site due to modification in cutouts is very costly and time consuming; such cutouts can be prepared at site during construction. Before the release of structural steel, a thorough internal review with all engineering disciplines and project management must be performed. The design margins in main steel should be discussed and agreed upon with project management beforehand. All the risk items should be highlighted and agreed upon with project management team prior to release. All the major client model review comments impacting the phase one steel release should be resolved.

All major plant piping should be supported by the end of phase two structural steel release. The supporting arrangement and vendor data for all major equipments like air cooler, silencer, analyzer etc. and valves like control valve, pressure safety valve etc. supported on pipe rack should be available. With final vendor and stress data available, the phase one steel should also be re-validated. Any concerns should be discussed with respective discipline for probable solution. Main aim for phase two steel release is to capture all design developments post release of phase one in correct manner. Like in phase one release, miscellaneous support for small bore pipes, cable trays that are finalized during phase two is preferred to be incorporated. All the grating and handrail cutouts finalized during phase two should be incorporated in design and those that are not final should not be included. Before the release of structural steel, a thorough internal review with all engineering disciplines and project management must be performed. All the risk items should be highlighted and agreed upon with project management team prior to release. All the major client model review comments impacting the phase two steel release should be resolved.

Prior to phase three structural steel release all piping including small bore should be supported. All cable trays that are to be supported by structural group should be addressed. Any minor modification in phase one and two steel due to design development should also be addressed in phase three release. All the model review tags impacting steel should be resolved.

There is also a critical Interface with construction and fabrication teams. Structural group should involve construction and fabrication teams to convey the priorities for steel fabrication release and shipping. Strength and type of connections designed by fabrication team and the design margin in connection must be communicated and agreed beforehand. Structural group should understand the method and sequence of construction and address the constraints at site, if any, in design.

Results

The key benefit of multi-phase steel release is the definitive schedule advantage, releasing phase one steel for fabrication and construction around 30% model review instead of 60% model review. The schedule advantage means higher probability of completing the construction work and handling over the plant to client within schedule avoiding the late handover penalty charge by Client. Reduced overall schedule also means reduced overall project cost considering timely procurement of materials and start of construction. Other important benefits include, providing flexibility to piping and mechanical disciplines in developing design and a lesser chance of rework due to late design development.

However, it is noted that more engineering efforts are required as verification of phase one steel is often necessary after more detailed information becomes available. If not executed properly in close coordination with piping and mechanical teams, a structural engineer may end up over designing or under designing of phase one steel. Over design may result in cost overrun and under design may require reinforcement of phase one steel during subsequent release of steel or some site modification.

However, this risk can be mitigated in alignment with project management and engineering teams by frequent reviews and discussions. As applicable, client too can be involved in decision making prior to finalizing multi-phase release execution approach.

Conclusion

This approach was successfully implemented in a process unit of a recently executed Petrochemical Project. As pipe rack construction was on unit's critical path, early release of phase one structural steel resulted in generation of early work fronts at construction site. This helped in generating a float for construction. This approach helped achieve an overall schedule gain of eight weeks for construction.

Definitions, Abbreviations and Acronyms

Pipe rack-A pipe rack is the main artery of a process unit. Pipe racks consist of a series of transverse bents that run along the length of the pipe system; spaced at uniform intervals typically around 6 m. Transverse bents are typically connected with longitudinal struts. Pipe racks mainly support pipes, cable trays and mechanical equipment in petrochemical plants.

Model review-Model Reviews are conducted by Client for the purpose of verifying that the plant design adheres to project requirements including operation and maintenance. They are the primary means of reviewing the plant layout, project scope validation, and design. These reviews typically happen during 30%, 60% and 90% project progress.

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Nano Enhanced Technique for Textile Dyeing Wastewater

Chandra Devi Raman[1] and S. Kanmani[2]

Abstract Textile dyeing industry wastewater threatens environment, due to its color and mixture of chemicals. Water soluble unfixed dyes and inorganic salts are the major pollutants in textile dyeing industry wastewater. The conventional and available treatment methods have limitations in treating textile dyeing wastewater such as low biodegradability of dyes (biodegradation), massive sludge generation and disposal concern (flocculation, membrane filtration, fenton process), removing pollutants from one phase and transferring to another phase (adsorption, phytoremediation), formation of toxic intermediates, products (photochemical process), only suitable for specific dyes (ion exchange method), costly (electrochemical oxidation), requirement of long contact time (electrolytic precipitation) and short life of the process (ozonation). The existing treatment methods discharge partially treated or untreated textile dyeing industry wastewater into environment thereby causing severe pollution. Immediate urge of the current research is to explore an efficient, economic and environment-friendly technique to treat the textile dyeing wastewater. The application of nanotechnology in treating toxic environmental pollutants has been evolving in recent years.

This article investigates the potential of nano iron particles on textile dye degradation and textile dyeing wastewater treatment. The nano sized iron particles are highly reactive towards textile dye molecules and synthesized using sodium borohydride chemical method. The synthesized particles were characterized for size, zeta potential, crystal structure, morphology, elemental composition and specific surface area. The oxidized surface and aggregated structure pattern in aged nano iron particles could reduce the reactivity. The recovery and reusability of nano particles are possible due to its magnetic property. This research outcome support efficient and environmental friendly technique to handle toxic textile dye and treat textile dyeing wastewater.

Keywords: Textile dyeing wastewater, Nano iron particles, environmental sustainability

Introduction

The environmental pollution due to industrial activities has been increasing in recent years. One such industry is textile dyeing. The textile dyeing industry effluents are complex and inconsistent mixture of many pollutants ranging from dyes, alkalis, salts of organic and inorganic, acids to heavy metals [1]. The conventional treatment methods are ineffective to mineralize water soluble dyes [2] and further discharge the untreated or partially treated colored wastewater into nearby environment [3]. Disposal of textile industry effluent into nearby water source and land for longer period accumulates pollutant in the environment [4, 5].

Photocatalytic oxidation is the emerging technique since last decade, utilizes titanium dioxide (TiO_2) and ultra violet (UV) illumination, and generates low waste to degrade textile dyes. TiO_2 is considered as an efficient semiconductor catalyst due to the formation of an electron-hole pair in the presence of UV light [6]. The photocatalytic degradation of textile dye using TiO_2/UV system was successfully reported [7–9]. Kanmani and Thanasekaran, (2004) and Bizani et al. (2006) noticed that the dye degradation is possible by TiO_2 catalyst only in the presence of UV light. Although there are numerous benefits in utilizing TiO_2, there are some limitations for the pure one, as the bandgap larger than 3.2 eV causes low efficiency. In addition the electron-hole recombination rate is too high, resulting in low photocatalytic efficiency [10–14]. Hence TiO_2 doped with another metal could enhance the dye degradation efficiency. The performance of doped TiO_2 showed effective dye degradation [15]. The photocatalytic degradation of dye pollutant is improved if the catalyst excited by UV light or catalyst doped or integrated with other process like ozonation, fenton-oxidation. The equipment and operating costs of the integrated advanced

E-mail: [1]kavya1811@gmail.com, [2]skanmani@annauniv.edu

[1]Research Scholar, Centre for Environmental Studies, Anna University, Chennai, India

[2]Professor and Director, Centre for Environmental Studies, Anna University, Chennai, India

oxidation processes are high and also, the treatment is effective only for the low dye initial concentration. In reality, a high production of hydroxyl radicals also reduces reaction rate, because the radicals prone to recombined [16]. The photocatalytic degradation of textile dyes using TiO_2 catalyst produced toxic intermediates and products due to partial mineralisation [17–20]. Moreover, the metal doped TiO_2 or other metal catalyst could introduce toxicity in the treated solution [21–23]. This photocatalytic degradation is efficient only for pumping and treating strategy and not suitable for field application, remediating contaminated sites.

Iron metal has the history of degrading organic pollutants in contaminated site. The microstructure, physical characteristics, corrosion behavior and reactivity of micro and nano sized iron particles were studied [24]. The study also confirmed that decreasing the size of the iron particles and dispersing them on a support increases the specific surface area of the iron. Zhang, 2003 reviewed the field injection of nano sized iron particles, reduced 99% of trichloroethylene (TCE), but the potential of the technology was not well understood and this initiated the investigations on iron particles in the domain of reactivity, stability, mobility. The higher performance of nano iron over micro iron was also observed [25–27]. Tan *et al*., 2015 identified nano iron is less toxic compared to carbon nano tubes, nano diamond, nano TiO_2, nano ZnO and also confirmed that no toxicity is reported to date for humans.

This article studies the potential of nano sized iron particles on dyeing wastewater treatment, since the particles are highly reactive, non-toxic and economical. The particles were synthesized using chemical method and characterized for size, zeta potential, crystal structure, shape, elemental composition and specific surface area. The behaviour of aged nano sized iron particles was also monitored and discussed.

Methodology

The nano iron particles were synthesized using sodium borohydride chemical method [28]. The particle size and zeta potential were determined using nano particle analyzer SZ-100 (Horiba, Japan). Ultima-IV X-ray diffractometer (XRD) with Cu Kα radiation (Rigaku, Japan) was utilized to identify the crystal structure. Transmission electron microscopy (TEM) with Energy-dispersive X-ray spectroscopy (EDS) of Tecnai G2 Spirit (FEI, Netherlands) was used to observe morphology and elemental composition of synthesized nano iron particles. Micromeritics ASAP 2020 (Micromeritics, USA) was operated to measure the specific surface area based on Brunauer–Emmett–Teller (BET)-N2 adsorption method. The UV-Vis spectrophotometer (Jasco Inc., Japan) was operated to monitor changes in dye concentration.

Textile dyeing wastewater was collected from a common effluent treatment plant at Tiruppur, Tamil Nadu. The physical and chemical characterization of the wastewater before and after the treatment was done. The experiments were conducted for 30mL volume of textile dyeing wastewater and an optimized dose of 1.0 g/L of synthesized nano iron particles were added to the dye solution. At every 5, 10, 20, 30, 60, 120 and 180 minutes of contact time, the supernatant was collected and centrifuged. The efficiency of nano iron particles on dye color removal was determined using the following equation.

Dye color removal efficiency (%) $= \left(1 \quad \frac{c_t}{c_o}\right) \times 100$

where c_o is the initial dye concentration and c_t is the dye concentration after contact time t (min). All the experiments were repeated at least three times in order to obtain the results with an error < 3%.

Results and Discussion

The addition of 0.18 M of ferric chloride to the 0.94 M of sodium borohydride synthesized iron nano particles, presented in Fig. 1. The mean size of synthesized particles was 60 nm and the zeta potential of +45.2 showed their tendency to aggregate. The large peaks observed at 35˚ and 63˚of XRD spectrum demonstrated the signal of oxidation of iron particles and miller indices demonstrated the particles were cubic crystals. The TEM image showed the morphology of particles was spherical and they arranged chain-like pattern due to its magnetic property. Traces of oxygen were observed in addition to iron content in the EDS analysis. This showed the particles were exposed to atmospheric oxygen. The specific surface area of iron particles 25.12 m^2/g was measured. The collected textile dyeing wastewater was characterized for pH, chemical oxygen demand (COD), chlorides and sulphates. The initial absorbance of the textile dyeing wastewater was monitored at 340 nm, 385 nm, 436 nm, 525 nm, 620 nm, 700 nm, 740 nm of wavelength in UV-Vis spectrophotometer. The addition of nano iron particles to the textile dyeing wastewater reduced initial pH 8.97 to 7.6. The change in absorbance was monitored till 180 min but the reaction attained its equilibrium in 10 min. The absorbance of textile dyeing wastewater before and after treatment with nano iron particles is presented in Fig. 2. The nano iron particles removed 74% of textile dyeing wastewater color and 40% of COD, presented in Table 1. The physical observation showed the formation of thin layer sludge in the treated solution (Fig. 3). Hence, textile dyeing wastewater was characterized for chlorides and sulphates in addition to COD. The results showed that the chlorides, sulphates were removed 37%, 25% respectively. The nano iron particles dissociated water molecules, generated hydrogen ions and involved them in reduction process, hence the decolorization of the dyeing wastewater. The nano iron particles with large amount of hydroxide ions formed iron oxides and hydroxides, induced adsorption process. The factor needs to be considered to achieve maximum efficiency of the nano iron particles is to maintain the stability of nano iron particles until they reach the pollutant. Further study on two months aged nano iron particles showed instability and thereby decreased their reactivity towards dye molecules. The behaviour of the two months aged nano iron particles was monitored, those particles showed aggregation towards each other due to magnetic property and formed cluster of particles, size more than 200 nm, presented in Fig. 4. Furthermore, the direct exposure of iron particles to atmospheric oxygen formed oxide layers over the surface reduced their reactivity. Addition of supports may reduce the aggregation as well oxidation of nano iron particles until they reach the pollutants. The green supports using plant extracts could be a better option to maintain environmental sustainability in the treatment of textile dyeing wastewater.

Fig. 1 Nano iron particles synthesize

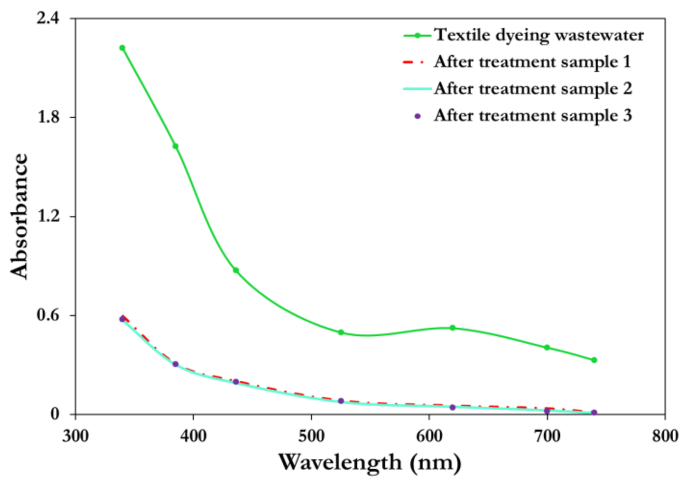

Fig. 2 UV-Vis spectra of textile dyeing wastewater before and after treatment with nano iron particles

Table 1 Characterization of textile dyeing wastewater

Parameters Monitored	Before Treatment	After Treatment
pH	8.97	7.6
Color removal (%)	-	74
COD (mg/L)	1640	984
Chlorides (mg/L)	6613	4146
Sulphates (mg/L)	580	436

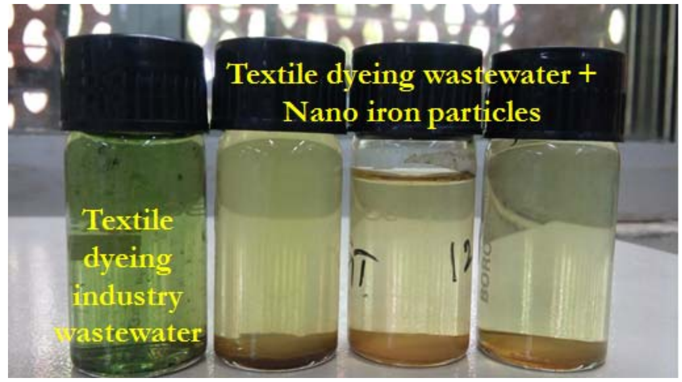

Fig. 3 Thin layer sludge formation in the treated solution

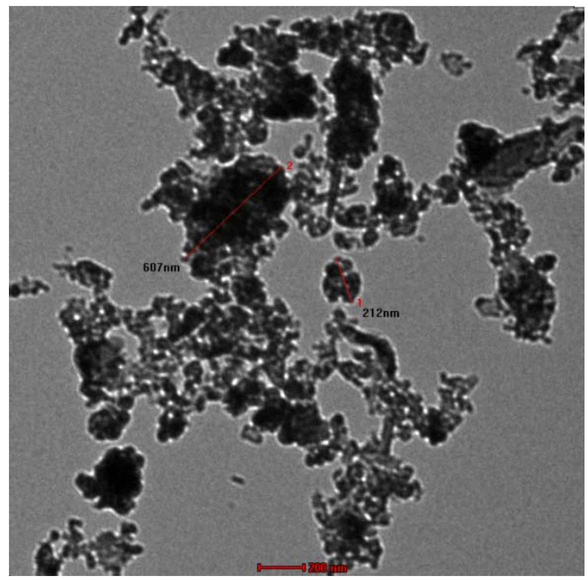

Fig. 4 TEM image of two months aged nano iron particles [29]

Conclusion

The nano iron particles were synthesized using sodium borohydride chemical method. The particles were characterized for size, zeta potential, morphology, crystal structure, elemental composition and specific surface area. The results showed that the formation of nano sized iron particles. With respect to time, the surface was prone to oxidation and particles were aggregated due to their magnetic property. This reduced the reactivity of nano iron particles; hence, the textile dye decolorization efficiency was only 74% with 40% reduction in COD. Moreover, the results demonstrated the possibility of chlorides and sulphates removal using nano iron particles. Further study is recommended to understand the mechanism of chlorides and sulphates removal in addition to textile dyeing wastewater treatment. The reuse and recovery of particles might be possible using magnetic separation and this could be studied in future. The study using two months aged nano iron particles, showed instability and reduction in reactivity. The addition of supports to nano iron particles could improve the stability and reactivity. Hence, green supports using plant extracts are highly recommended to achieve environmental sustainable treatment to textile dyeing wastewater.

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Non-linear Behaviour of Short and Long Reinforced Concrete Column: Finite Element Studies

K. Senthil[1], S. Rupali[2], M.A. Iqbal[3] and K.S. Satyanarayanan[4]

Abstract The finite element studies were carried out on column under an axial load using ABAQUS/ CAE, and the response of column studied for loss of cover (as would happen if the reinforcement corroded and started to spall) from one face. The inelastic behaviour of concrete and reinforcing steel bar was defined to the model by using Concrete Damaged Plasticity model (CDP) and Johnson-Cook model respectively which is available in ABAQUS/CAE. The size of column was considered as 0.23×0.23 m, 0.3×0.3 m, 0.4×0.4 m and 0.5×0.5 m, whereas the length of the column considered was 3000 mm. The length to depth ratio was considered between 6 and 13. The effect of changing shapes such as square, circular and rectangular have also been studied against axial loading. The simulations have been carried out against eccentric loading to study the response of column in terms of displacement, reaction forces and von-Mises stresses.

Keywords: Short and Long Column, Non-linear Behavior, Shape of Column, Finite Element Studies

Introduction

A large number of existing RC columns may exist having inadequate concrete cover, area of reinforcement and area of concrete when compared with the current codal provisions. Also, a large number of existing reinforced concrete buildings may present with less cover concrete or loss in stiffness by longevity or it may be due to minor earthquake or accidental loads or frequent loads. The behavior of reinforced concrete columns under static monotonic loading has been studied through experiments as well as simulations by many researchers [1-5]. However the non-linear behavior of column against increasing loading using finite element analysis is limited. The present study focuses on non-linear behavior of short and long column against static loading using finite element analysis. The simultaneous occurrence of spalling of concrete and correction of reinforcement, the load distribution no longer be axial and the strains may also vary across the breadth of the section. Therefore, the numerical investigation have been carried out for studying the behaviour of reinforced concrete column subjected to static monotonic loading using ABAQUS/CAE. The parameters such as shape, size of column and removal of cover have been studied against axial loading. The results were compared in terms of displacement, *von-Mises* stresses and load carrying capacity of the column member.

Constitutive Modelling

The finite element model of the reinforced concrete frame is made using ABAQUS/CAE [6]. In order to define the material behavior of concrete, the Concrete Damaged Plasticity model available in ABAQUS finite element code was employed. The model is based upon the concept of isotropic damaged elasticity in conjunction with isotropic tensile and compressive plasticity to represent the inelastic behaviour of concrete. The compressive strength of concrete is 20 MPa. The Poisson's ratio of the concrete is assumed equal to 0.2. The parameters for CDP model other than damage variables were discussed in [7-8].

The material behavior of the steel reinforcement is incorporated using the well known Johnson–Cook [9] elasto-visco plastic material model that is capable of predicting the flow and fracture behavior of the ductile materials. It includes the effect of linear thermo-elasticity, yielding, plastic flow, isotropic strain hardening, strain rate hardening, softening due to adiabatic heating and damage. The Johnson-Cook properties of Fe 415 steel grade has been employed for predicting the material behavior of steel reinforcement [10].

E-mail: [1]urssenthil85@yahoo.co.in, [2]satavalekarrs@gmail.com, [3]iqbal_ashraf@rediffmail.com, [4]srm.kssn@gmail.com

[1,2]Assistant Professor, Department of Civil Engineering, National Institute of Technology Jalandhar, Punjab

[3]Associate Professor, Department of Civil Engineering, Indian Institute of Technology Roorkee

[4]Professor, Department of Civil Engineering, SRM University, Kattankulathur, Tamilnadu

Numerical Modelling

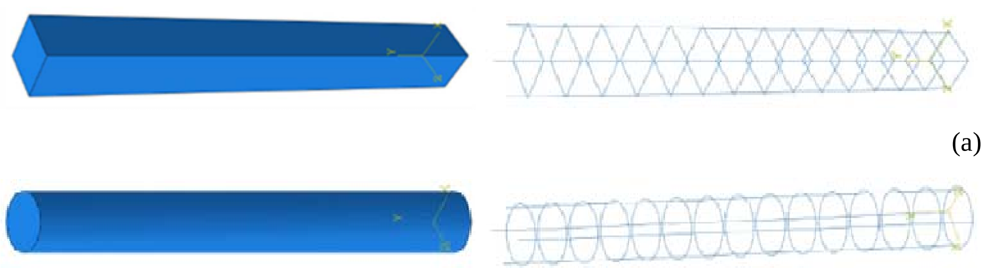
The numerical simulation is performed by using commercial finite element tool ABAQUS/Explicit. The columns with main reinforcement and stirrups have been modelled and the constitutive behaviour is employed to predict the material behaviour of concrete and steel bar and discussed in the present section. The mesh convergence study is also carried out and discussed below.

In the present study, the steel reinforcement considered four numbers of 16 mm deformed steel bars as main reinforcement and 8 mm diameter deformed bars as stirrups placed at 200 mm centre to centre. The simulations are carried out on column and the results are compared in terms of displacement, von-Mises stresses and load carrying capacity. The total length of the test specimen is 3 m with a square cross section of 0.3 × 0.3 m considered. Both the concrete and reinforcement in the column was modelled as deformable body [Fig. 1(a), (b)].

The arbitrary loading was applied in the form of pressure for 160 seconds at equally spaced intervals. The magnitude of the loading is assigned in the form of pressure varied from 0 to 10000 kN/m^2 and corresponding load was 0 to 900 kN respectively. For example, at 160 Seconds, the pressure assigned 10000 kN/m^2 and corresponding load is (10000000 × 0.3 × 0.3)/ 1000 = 900 kN. Similarly the load at 60 seconds, the pressure assigned 4500000 N/m^2 and corresponding load is (4500000 × 0.3 × 0.3)/ 1000 = 405 kN. The beam boundaries of two ends were restrained with respect to all the degree of freedom. The interaction between concrete and steel was modelled using the tie constraint option available in ABAQUS/CAE wherein the concrete was assumed as host region and the steel as embedded region. The element types used in finite element model for concrete are 8-noded bricks and reinforcement steel was a 2-noded linear three dimensional truss.

The mesh sensitivity in the reinforced concrete column was studied by varying the element size in the entire region of the column. The element size of concrete have been considered as 20, 30, 40, 50, 60 and 70 mm, whereas the element size in steel reinforcing bar was kept constant, 0.15 m for entire simulations. Typical finite element model of concrete and reinforcement bar element is shown in Fig. 2. The displacement of column was found to be almost same, i.e. 1.72 mm when the mesh size varied from 70 mm to 20 mm. However, the reaction forces offered by the column were found to be sensitive against varying the mesh size. The load carrying capacity of column with mesh size of 60, 50, 40, 30 and 20 mm is found to be 888, 887, 875, 934 and 1007 kN, respectively. The load carrying capacity of column is obtained theoretically i.e. 936 kN and is found matching with the predicted load of 934 kN corresponding to mesh size of 30 mm. Therefore, it is concluded that the mesh size of 30 mm having 100 (10 × 10) number of elements across cross section of the column was considered for conducting remaining simulations. Total number of elements in concrete, main reinforcement bar and stirrups are 10000, 232 and 315 respectively.

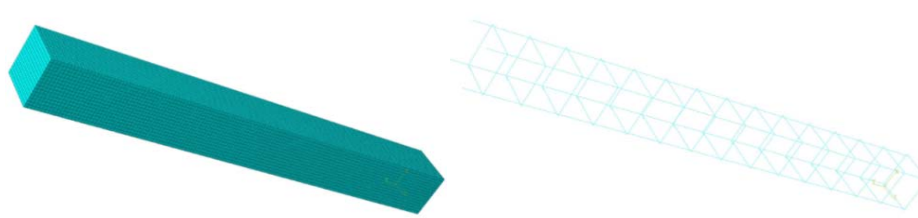
Fig. 1 Modelling of (a) concrete and (b) reinforcing steel bar in typical square and circular column



(a)

(b)

Fig. 2 Finite element of model of (a) concrete and (b) reinforcement bar



(a) (b)

Results and Discussion

The extensive numerical simulation is performed on reinforced cement concrete columns against static monotonic loading. The parameters such as shape, size of column and removal of cover have been studied against axial loading. The results in terms of displacement, reaction forces and von-Mises stress on the reinforcing bar as well as concrete have been compared and presented in detail.

Effect of Varying Size of Column

The size of the column is varied as 0.23 × 0.23, 0.3 × 0.3, 0.4 × 0.4 and 0.5 × 0.5 m was considered in the present study. The vertical downward displacements of column with varying diameter of reinforcement bar were shown in Fig. 3. The displacement of column with 0.23, 0.3, 0.4 and 0.5 m sides square column was found increased almost linearly as 1.65, 1.72, 1.78, and 1.81 mm respectively. In general, the displacement of the column may decrease with increase in area however in the present study the displacement is increased may be due to the large area of application of vertical loading. The concentration of displacement was found decreased linearly towards bottom of the column and highest displacement was found at top of the column.

The stress in the concrete element of the column of varying sizes of 0.23, 0.3, 0.4 and 0.5 m were found almost same as 11, 13, 11 and 11 MPa respectively, see Fig. 4. The concrete grade *M20* is considered and the ultimate failure strength of the concrete is 20 MPa, however the results obtained through numerical simulations is under the permissible values. The stresses in the reinforcement bar in the column with 230, 300, 400 and 500 mm sides were found increased almost linearly as 111, 118, 123 and 126 MPa respectively.

The stresses in the lateral ties near top are observed significantly however the stresses found insignificant against the given section. The resistance offered by the column with varying sides such as 0.23, 0.3, 0.4 and 0.5 m diameter reinforcing bar was found increased almost linearly as (9110×8×8/1000 = 583) 583 kN, (9340×10×10/1000 = 934) 934 kN, (7814×13×13/1000 = 1319) 1319 kN and (8032×17×17/1000 = 2321) 2321 kN respectively. The maximum load carrying capacity of the short axially loaded column was calculated as per IS 456 [11], Clause 39. [$P_u = 0.4 f_{ck} A_c + 0.67 f_y\ A_{sc}$], where f_{ck} is 20MPa, A_c is area of concrete (230×230, 300×300, 400×400 and 500×500 mm), f_y is yield strength of reinforcing bar, 415 MPa and A_{sc} is area of steel reinforcing bar 803 mm^2. The load carrying capacity of the column measured theoretically was 646, 943, 1503 and 2223 kN however the results obtained through numerical simulations is under the permissible values.

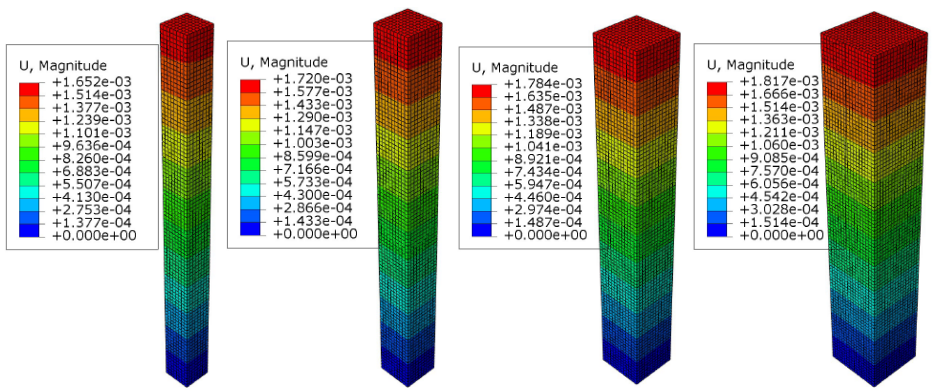


Fig. 3 Displacement (m) of square column with (a) 230 (b) 300 (c) 400 and (d) 500 mm sides

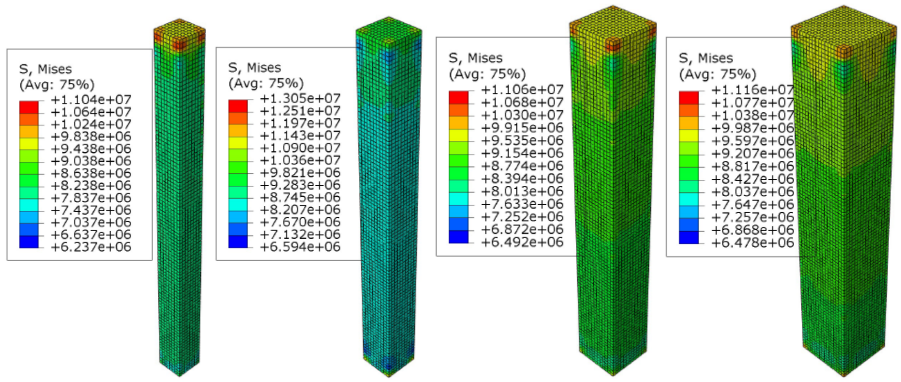


Fig. 4 Von-Mises stress (N/m^2) in concrete of square column with (a) 230 (b) 300 (c) 400 and (d) 500 mm sides

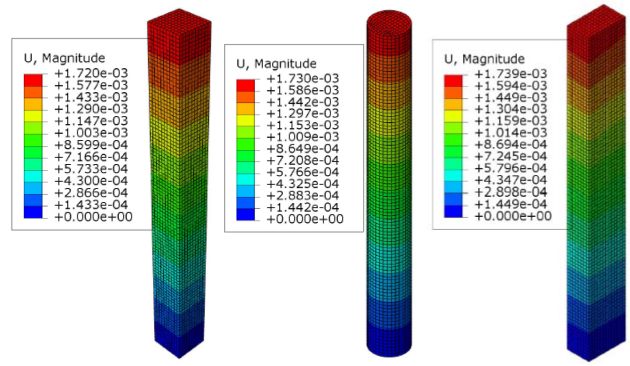


Fig. 5 Displacement (m) of (a) square (b) circular and (c) rectangular column of equivalent area

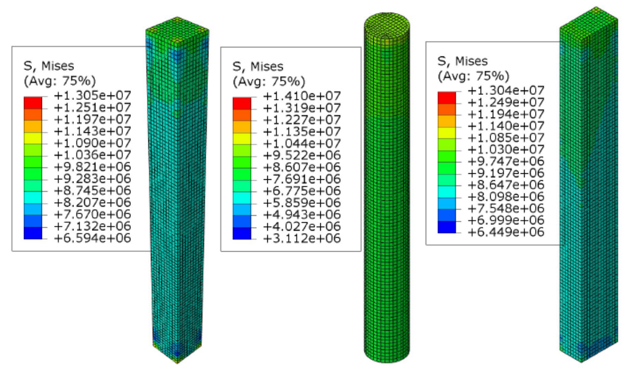


Fig. 6 Von-mises stress (N/m^2) of concrete having (a) square (b) circular and (c) rectangular column of equivalent area

Effect of Varying Shapes of Column

The shape of the column is varied as square, circular and rectangular is considered to study the influence of shapes against axial loading considering equivalent area. The equivalent size of square, circular and rectangular column is 0.3×0.3m, 0.34 m and 0.23×0.39 m respectively. The vertical downward displacements of column of different shapes were shown in Fig. 5. The displacement of square, circular and rectangular column is found almost same as 1.72, 1.73 and 1.74 mm respectively.

The stresses in the concrete element of the column of square and rectangular shapes are found almost same as 13 MPa whereas the stress in circular column is 14 MPa, see Fig. 6. The important observation is the distribution of *von-Mises* stresses in the concrete is uniform however the trend was reverse while simulating square and rectangular column. The stress in the main reinforcement as well as stirrups of the column of square, circular and rectangular shapes were found almost same as 118 MPa. The important observation is the distribution of von-Mises stresses in the concrete is uniform however the trend is reverse while simulating square and rectangular column. The resistance offered by the column with varying shapes such as square, circular and rectangular shape is (7084×128/1000 = 906), (9340×100/1000 = 934) 934 and (8805×104/1000 =) 915 kN respectively.

Effect of Removal of Cover Concrete

The non-linear behaviour of reinforced concrete square column with and without cover was studied. The loss of cover considered in the present study as one side (Fig. 7(b)) and two side (Fig. 7(c)) of the square column. The results thus obtained in terms of displacement, reaction forces and stresses are compared with the conventional case, Fig. 7(a). The vertical downward displacement of square column with and without cover were shown in Fig. 6. The displacement of column with and without cover is found increased almost linearly as 1.72, 1.759 and 1.79 mm. The displacement of column with full cover is found decreased to 2.3 and 4.1 % as compared to the column with one sided and two sided cover, respectively.

The *von-Mises* stresses in concrete of square column with and without clear cover were shown in Fig. 8. The stress in the concrete element of the column with four sided, three sided and two sided cover is 13.05, 13.81 and 17.03 MPa respectively. The important observation is the stress in the column with full cover and three sided cover is found almost same whereas the column with two side, the stress increased significantly. Therefore, it was concluded that when the square column lost their cover concrete of two sides, the loss in strength is almost 30% as compared to the column with full cover concrete.

The von-Mises stresses in steel reinforcing bar of square column with and without clear cover were shown in Fig. 9. The stress in the steel bar element of the column with full cover, three sided cover and two sided cover was 118, 119 and 122 MPa respectively. The maximum deviation of stress in the column with and without cover is insignificant however it is very important to cover the reinforcement against atmosphere.

Fig. 7 Displacement (m) of column with cover concrete at (a) four (b) three and (c) two side

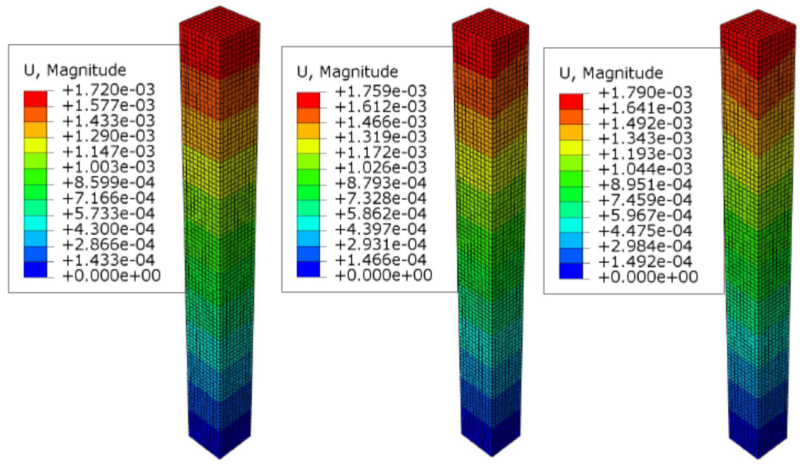


Fig. 8 Von-mises stress (N/m^2) in concrete having cover concrete at (a) four (b) three and (c) two side

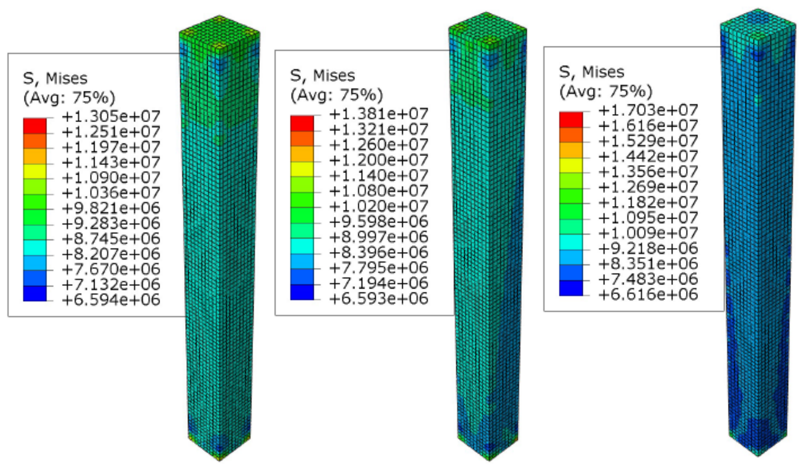
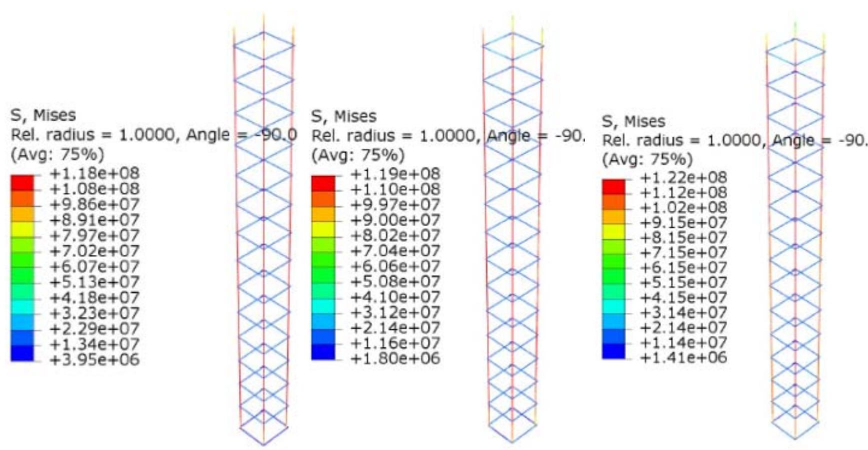


Fig. 9 Von-mises stress (N/m^2) in steel bar of column having cover concrete at (a) four (b) three and (c) two side



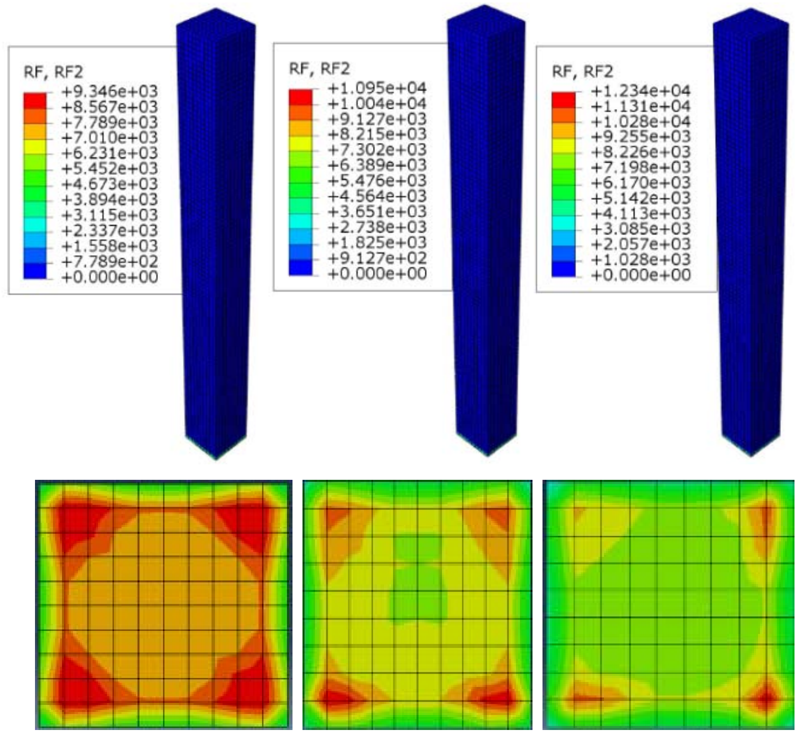


Fig. 10 Reaction forces (N) of column with (a) four (b) three and (c) two sided cover concrete

The maximum load carrying capacity of the given column has been obtained numerically at a specified load, see Fig. 10. The resistance offered by the column with full cover, three sided cover and two sided cover was (9340×100/1000 = 934) 934, (9127×10x9/1000 = 821) 821 and (9255×9×9/1000 = 749) 749 kN respectively. The maximum load carrying capacity of the short axially loaded column is calculated as per IS 456 [11]. [$P_u = 0.4f_{ck}A_c + 0.67f_y A_{sc}$], where f_{ck} is 20MPa, A_c is area of concrete (90000, 81000 and 72900 mm^2), f_y is yield strength of reinforcing bar, 415 MPa and A_{sc} is area of steel reinforcing bar 803 mm^2. The load carrying capacity of the column measured theoretically is 943, 871 and 806 kN however the results obtained through numerical simulations is under the permissible values. Therefore, it was concluded that when the column lost their cover concrete with two side and one side, the loss in carrying capacity almost 19 and 12% as compared to the column with full cover concrete.

Conclusion

The present numerical study describes the non-linear behavior of reinforced concrete column subjected to axial and eccentric loading. The simulation has been carried out using ABAQUS finite element code. The response of columns with varying shapes, sizes, and area of reinforcement, were studied and compared. The influence vertical downward displacement, *von-Mises* stresses and reaction forces of the column is studied. The results thus obtained through finite element investigations led to the following conclusions;

The displacement of column with sides varied from 230 to 500 mm (l/d ratio between 13 and 6) was found increased almost linearly from 1.65 to 1.81 mm, whereas the stresses in the concrete element of the column are found almost same 11 MPa. The stresses in the reinforcement bar in the column with 0.23, 0.3, 0.4 and 0.5 m sides were found increased almost linearly as 111, 118, 123 and 126 MPa respectively.

The displacement of square, circular and rectangular column is found almost same. The stresses in the concrete element of the column of square and rectangular shapes are found almost same as 13 MPa whereas the stress in circular column is 14 MPa. The important observation is the distribution of *von-Mises* stresses in the concrete is uniform however the trend is reverse while simulating square and rectangular column.

The influence of loss of cover concrete was studied and it is concluded that when the square column lost their cover concrete of two side, the loss in strength is almost 30% as compared to the column with full cover concrete.

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Pseudo-Dynamic Analysis of Seismic Active Earth Pressure Behind Inclined Retaining Wall Supporting the Inclined Soil Backfill Considering Soil Amplification

Ashish Gupta[1] and Vishwas A. Sawant[2]

Abstract In the current practice of designing retaining wall in earthquake prone region, pseudo-static and pseudo-dynamic approaches are widely used for cohessionless soil backfill without taking the effect of soil amplification. Soil amplification is very important and necessary factor for the calculation of seismic active earth pressure analyzing the retaining walls, which should not be ignored during the designing by the designer in the earthquake prone regions. In this paper, a detailed formulation has been obtained to calculate the seismic active earth pressure distribution along with the calculations of seismic active thrust for the inclined retaining wall supporting the inclined cohessionless soil backfill considering the soil amplification, horizontal and vertical seismic coefficients, the effect of time and phase difference in both the shear waves and the primary waves using the pseudo-dynamic approach. The seismic earth pressure distribution equation is clearly showing the non-linear behaviour behind the inclined retaining wall in the pseudo-dynamic analysis. From the design values of the seismic active earth pressure coefficient shown in the tabular form, it is observed to be increase with increase in the horizontal and vertical seismic coefficients along with the soil amplification.

Keywords: Seismic active earth pressure distribution, Soil amplification, Pseudo-dynamic approach, Inclined soil backfill

Introduction

The study of seismic earth pressure is very much essential during the design of retaining wall in the seismic prone regions. In this regard, various researchers have been analyze the retaining walls using different methods. Using the pseudo-static method, the pioneer work for determining seismic earth pressure for the design of retaining walls had been reported by Mononobe and Okabe and then known as Mononobe and Okabe method. The time dependent effect during the earthquake loading was completely missing in the pseudo-static method. In pseudo-static method, magnitude and phase of seismic accelerations were also taken uniform throughout the soil backfill.

For analyzing the real seismic problems during the design of retaining walls, Steedman and Zeng [4] had proposed the pseudo-dynamic approach considering the finite shear waves in the backfiill. Pseudo-dynamic method had been used to overcome the deficiencies of pseudo-static method. Choudhury and Nimbalkar [2,3] had extended that pseudo-dynamic approach for determining the seismic passive and seismic active earth pressure behind vertical retaining wall. The propagation of shear and primary waves had been considered in their studies. The effect of seismic coefficients in horizontal and vertical directions had been also considered. Nimbalkar and Choudhury [5] introduced the soil amplification effect in the pseudo-dynamic approach for determining the earth pressure coefficients and earth pressure distribution for vertical retaining wall. In the present work, a detailed formulation incorporating the soil amplification effect has been obtained for computing the seismic active earth pressure distribution. The retaining wall is inclined supporting inclined cohessionless soil backfill.

Detailed Formulation

The rigid inclined retaining wall AB of height H inclined at an angle θ with vertical and wall friction angle δ as shown in Fig. 1. It is retaining cohessionless soil backfill of unit weight γ inclined at an angle i with horizontal. Effect of propagation of both shear waves and the primary waves is also considered along with the effect of soil amplification. Linear variation in input ground acceleration along depth is taken for showing the effect of soil amplification, within the soil media due to the seismic loading. Amplitude of horizontal and vertical seismic acceleration of base of the retaining wall assumed as $a_h = k_h g$ and $a_v = k_v g$.

E-mail: [1]shi_g2000@rediffmail.com, [2]sawntfce@iitr.ac.in

[1]Research Scholar, Department of Civil Engineering, IIT Roorkee, India

[2]Associate Professor, Department of Civil Engineering, IIT Roorkee, India

The horizontal and vertical seismic acceleration at the top has been assumed, higher than the value of horizontal and vertical seismic acceleration at the base. In the present work, horizontal and vertical seismic acceleration at the top of the retaining wall is taken as $k_{h@z=0} = f_a k_{h@z=H}$ and $k_{v@z=0} = f_a k_{v@z=H}$, where f_a is the soil amplification factor. The present analysis induces a period of lateral shaking $T = 2\pi/\omega$, where ω is the angular frequency. A failure wedge, makes an angle α with horizontal ABE is assumed.

From Fig. (1), the mass of the strip of thickness dz at depth z can be obtained as;

$$m(z) = \frac{\gamma}{g}\frac{(H-z)(1+\tan\alpha\tan\theta)\sin\alpha}{\tan\alpha\sin(\alpha-i)}dz \tag{1}$$

The weight of the failure wedge can be obtained as;

$$W = \frac{1}{2}\gamma H^2\left(\frac{1+\tan\theta\tan\alpha}{\tan\alpha}\right)\frac{\sin\alpha}{\sin(\alpha-i)}\frac{\cos(\theta-i)}{\cos\theta} \tag{2}$$

At any depth z below the top of the wall, the horizontal and the vertical acceleration can be expressed as;

$$a_h(z,t) = \left\{1+\frac{H-z}{H}(f_a-1)\right\}k_h\, g\sin\omega\left(t-\frac{H-z}{V_S}\right) \tag{3a}$$

$$a_v(z,t) = \left\{1+\frac{H-z}{H}(f_a-1)\right\}k_v\, g\sin\omega\left(t-\frac{H-z}{V_P}\right) \tag{3b}$$

The total horizontal inertia force $Q_h(t)$ acting in the failure wedge is given by;

$$Q_h(t) = \int_0^H m(z)\, a_h(z,t) = \gamma\, k_h\, m(\alpha)(I_1+I_2) \tag{4}$$

where,

$$m(\alpha) = \frac{(1+\tan\alpha\tan\theta)\sin\alpha}{\tan\alpha\sin(\alpha-i)} \tag{5a}$$

$$I_1 = \frac{\lambda}{4\pi^2}\left[2\pi H\cos\omega\zeta + \lambda(\sin\omega\zeta - \sin\omega t)\right] \tag{5b}$$

$$I_2 = \frac{(f_a-1)\lambda}{4\pi^3 H}\begin{bmatrix}2\pi H(\pi H\cos\omega\zeta + \lambda\sin\omega\zeta)\\ +\lambda^2(\cos\omega t - \cos\omega\zeta)\end{bmatrix} \tag{5c}$$

$$Q_h(t) = \frac{\lambda\gamma k_h m(\alpha)}{4\pi^2}\begin{bmatrix}2\pi H\cos\omega\zeta + \lambda(\sin\omega\zeta - \sin\omega t)\\ +\frac{(f_a-1)}{\pi H}\left\{\begin{matrix}2\pi H\begin{pmatrix}\pi H\cos\omega\zeta\\ +\lambda\sin\omega\zeta\end{pmatrix}\\ +\lambda^2(\cos\omega t-\cos\omega\zeta)\end{matrix}\right\}\end{bmatrix} \tag{6}$$

Using the same procedure for calculating the total vertical inertia force $Q_v(t)$ acting in the failure wedge is given by;

$$Q_v(t) = \frac{\eta\gamma k_v m(\alpha)}{4\pi^2}\begin{bmatrix}2\pi H\cos\omega\psi + \eta(\sin\omega\psi - \sin\omega t)\\ +\frac{(f_a-1)}{\pi H}\left\{\begin{matrix}2\pi H\begin{pmatrix}\pi H\cos\omega\psi\\ +\eta\sin\omega\psi\end{pmatrix}\\ +\eta^2(\cos\omega t-\cos\omega\psi)\end{matrix}\right\}\end{bmatrix} \tag{7}$$

where, $\lambda = TV_S; \eta = TV_P; \zeta = \left(t-\frac{H}{V_S}\right)$ and $\psi = \left(t-\frac{H}{V_P}\right)$

Resolving the forces in the horizontal and vertical direction on the failure wedge, the total active thrust $P_{ae}(t)$ can be obtained.

$$P_{ae}(t) = \frac{\{W-Q_v(t)\}\sin(\alpha-\phi)+Q_h(t)\cos(\alpha-\phi)}{\cos(\delta+\theta-\alpha+\phi)} \tag{8}$$

Using (8), the seismic active earth pressure coefficient, $K_{ae}(t)$ can be obtained as;

$$K_{ae}(t) = \frac{2\{W-Q_v(t)\}\sin(\alpha-\phi)+2Q_h(t)\cos(\alpha-\phi)}{\gamma H^2\cos(\delta+\theta-\alpha+\phi)} \tag{9}$$

Substituting the values of W, $Q_h(t)$ and $Q_v(t)$ in (9), an expression for $K_{ae}(t)$ can be derived as;

$$K_{ae}(t) = \begin{bmatrix}\frac{\sin(\alpha-\phi)\cos(\theta-i)m(\alpha)}{\cos(\delta+\theta-\alpha+\phi)\cos\theta}\\ +\frac{k_h\lambda\cos(\alpha-\phi)m(\alpha)}{2\pi^3 H\cos(\delta+\theta-\alpha+\phi)}\left\{\begin{matrix}m_1\pi\\ +m_3(f_a-1)\end{matrix}\right\}\\ +\frac{k_v\eta\sin(\alpha-\phi)m(\alpha)}{2\pi^3 H\cos(\delta+\theta-\alpha+\phi)}\left\{\begin{matrix}m_2\pi\\ +m_4(f_a-1)\end{matrix}\right\}\end{bmatrix} \tag{10}$$

Where,

$$m_1 = 2\pi\cos\theta_{\lambda H} + \frac{\lambda}{H}\{\sin\theta_{\lambda H} - \sin\theta_t\}$$

$$m_2 = 2\pi\cos\theta_{\eta H} + \frac{\eta}{H}\{\sin\theta_{\eta H} - \sin\theta_t\}$$

$$m_3 = 2\pi\left(\pi\cos\theta_{\lambda H} + \frac{\lambda}{H}\sin\theta_{\lambda H}\right) + \frac{\lambda^2}{H^2}\begin{pmatrix}\cos\theta_t\\ -\cos\theta_{\lambda H}\end{pmatrix}$$

$$m_4 = 2\pi\left(\pi\cos\theta_{\eta H} + \frac{\eta}{H}\sin\theta_{\eta H}\right) + \frac{\eta^2}{H^2}\begin{pmatrix}\cos\theta_t\\ -\cos\theta_{\eta H}\end{pmatrix}$$

$$\theta_{\lambda H} = 2\pi\left(\frac{t}{T}-\frac{H}{\lambda}\right);\ \theta_{\eta H} = 2\pi\left(\frac{t}{T}-\frac{H}{\eta}\right) \text{ and } \theta_t = 2\pi\frac{t}{T}$$

On taking the partial derivative of $P_{ae}(t)$ with respect to z, seismic active earth pressure distribution behind the retaining wall can be determined and expressed as;

$$p_{ae}(z,t) = \frac{\partial P_{ae}(z,t)}{\partial z} = D_1+D_2+D_3+D_4+D_5 \tag{11}$$

$$D_1 = m(\alpha)\frac{\gamma\, z\sin(\alpha-\phi)}{\tan\alpha\cos(\delta+\theta-\alpha+\phi)}\frac{\cos(\theta-i)}{\cos\theta}$$

$$D_2 = m(\alpha)\frac{k_h\,\gamma\, z\cos(\alpha-\phi)}{\tan\alpha\cos(\delta+\theta-\alpha+\phi)}\sin\theta_{\lambda z}$$

$$D_4 = -m(\alpha)\frac{k_v\,\gamma\, z\sin(\alpha-\phi)}{\tan\alpha\cos(\delta+\theta-\alpha+\phi)}\sin\theta_{\eta z}$$

$$D_3 = \left[\begin{array}{l} \left\{ m(\alpha) \dfrac{k_h\,\gamma\,(f_a - 1)\cos(\alpha - \phi)}{\tan\alpha \cos(\delta + \theta - \alpha + \phi)} \dfrac{\lambda}{2\pi} \right\} \\ \left\{ \begin{array}{l} -\cos\theta_{\lambda z} - \dfrac{\lambda}{\pi z}\sin\theta_{\lambda z} \\ + \dfrac{\lambda^2}{2\pi^2 z^2}\left\{\cos\theta_{\lambda z} - \cos\theta_t\right\} + \dfrac{2\pi z}{\lambda}\sin\theta_{\lambda z} \end{array} \right\} \end{array} \right]$$

$$D_5 = -\left[\begin{array}{l} \left\{ m(\alpha) \dfrac{k_v\,\gamma\,(f_a - 1)\sin(\alpha - \phi)}{\tan\alpha \cos(\delta + \theta - \alpha + \phi)} \dfrac{\eta}{2\pi} \right\} \\ \left\{ \begin{array}{l} -\cos\theta_{\eta z} - \dfrac{\eta}{\pi z}\sin\theta_{\eta z} \\ + \dfrac{\eta^2}{2\pi^2 z^2}\left\{\cos\theta_{\eta z} - \cos\theta_t\right\} + \dfrac{2\pi z}{\eta}\sin\theta_{\eta z} \end{array} \right\} \end{array} \right]$$

$$\theta_{\lambda z} = 2\pi\left(\frac{t}{T} - \frac{H}{\lambda}\right);\ \text{and}\ \theta_{\eta z} = 2\pi\left(\frac{t}{T} - \frac{H}{\eta}\right)$$

On optimizing (10) with respect to α and t/T, it can be obtain the maximum value of $K_{ae}(t)$. Then with these optimized values we can get D_1, D_2, D_3, D_4 and D_5. On putting D_1, D_2, D_3, D_4 and D_5 in (11), it provides a general expression of seismic active earth pressure distribution behind the inclined wall.

Sarkar [1] presented an equation for the seismic active earth pressure distribution behind the inclined wall supporting inclined soil backfill considering the soil amplification but without describing the derivation steps in detail, also includes some discrepancy in the formulation. As we know that, it is a common practice for the retaining wall designer to present the detailed expressions for the dynamic active thrusts defining earth pressure coefficients, which is showing the importance of this detailed formulation.

Results and Discussion

Seismic active earth pressure distribution is presented in the non-dimensional ($p_{ae}/\gamma H$) using (11). In the present study, a parametric study has been done to quantify the value of $p_{ae}/\gamma H$ along entire depth. Seismic active earth pressure coefficient (K_{ae}) for different values of soil amplification factors has been shown in Table 1 and Table 2.

Figure 2 is showing the variation of $p_{ae}/\gamma H$ at each and every level of z for the soil amplification factor (f_a) varying from 1.0 to 1.8. On increasing the value of f_a from 1.0 to 1.8, it can be clearly observed that the value of $p_{ae}/\gamma H$ increases significantly. The variation shown in Fig. 2 is non-linear in nature. From Fig. 2, it can be also observed that the value of $p_{ae}/\gamma H$ increases with considerably faster when f_a increases from 1.4 to 1.8 as compare to f_a increases from 1.0 to 1.4. For example, for z/H = 1.0, $p_{ae}/\gamma H$ increases approximately 33.4% when f_a increases from 1.0 to 1.4 and approximately 37.5% when f_a increases from 1.4 to 1.8.

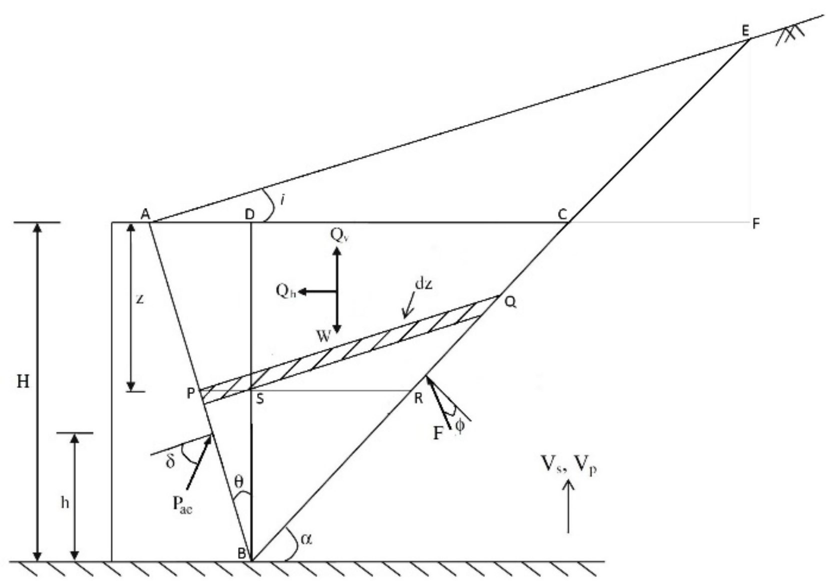

Fig. 1 Forces acting on retaining wall in active state

Table 1 Seismic active earth pressure coefficient (K_{ae}) for k_h = 0.1; k_v = 0.5 k_h

γ = 20 kN/m^3; c = 0; H = 10 m; V_s = 100 m/s; V_p = 187 m/s; T = 0.3 s; H/λ = 0.333; H/η = 0.178; k_h = 0.1; k_v = 0.5 k_h; ϕ = 30^0; i = 10^0

f_a	δ=0			$\delta=\varphi/2$			$\delta=\varphi$		
	ϑ = -30^0	ϑ = 0^0	ϑ = 30^0	ϑ = -30^0	ϑ = 0^0	ϑ = 30^0	ϑ = -30^0	ϑ = 0^0	ϑ = 30^0
1.0	0.255	0.462	0.835	0.217	0.436	0.876	0.201	0.447	1.037
1.2	0.269	0.476	0.852	0.229	0.450	0.898	0.213	0.464	1.071
1.4	0.283	0.489	0.869	0.242	0.465	0.921	0.226	0.481	1.107
1.6	0.297	0.503	0.887	0.255	0.480	0.945	0.239	0.499	1.145
1.8	0.312	0.518	0.905	0.270	0.496	0.970	0.253	0.518	1.185

Table 2 Seismic active earth pressure coefficient (K_{ae}) for k_h = 0.2; k_v = 0.5 k_h

γ = 20 kN/m^3; c = 0; H = 10 m; V_s = 100 m/s; V_p = 187 m/s; T = 0.3 s; H/λ = 0.333; H/η = 0.178; k_h = 0.2; k_v = 0.5k_h; ϕ = 30^0; i = 10^0

f_a	δ=0			$\delta=\phi/2$			$\delta=\phi$		
	ϑ = -30^0	ϑ = 0^0	ϑ = 30^0	ϑ = -30^0	ϑ = 0^0	ϑ = 30^0	ϑ = -30^0	ϑ = 0^0	ϑ = 30^0
1.0	0.366	0.569	0.970	0.320	0.553	1.060	0.305	0.585	1.333
1.2	0.403	0.603	1.013	0.355	0.591	1.120	0.341	0.631	1.437
1.4	0.443	0.639	1.058	0.394	0.632	1.187	0.381	0.682	1.556
1.6	0.487	0.678	1.108	0.438	0.677	1.260	0.426	0.738	1.693
1.8	0.536	0.720	1.162	0.487	0.727	1.342	0.479	0.802	1.852

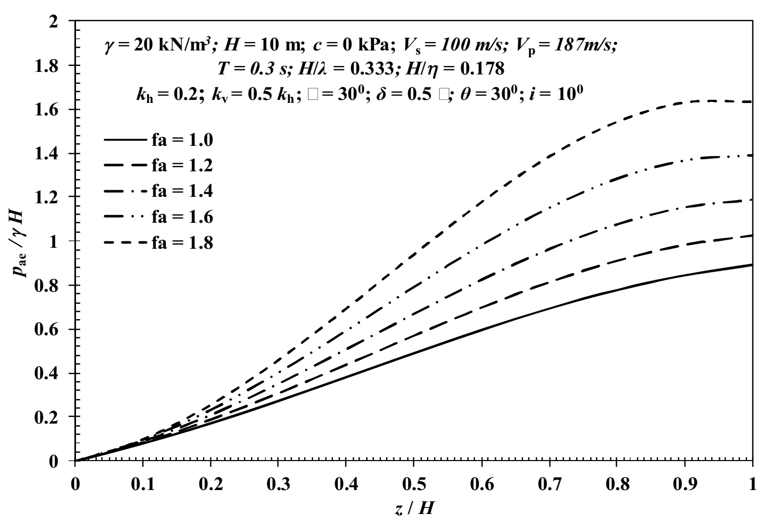

Fig. 2 Non-dimensional seismic active earth pressure distribution for different values of f_a

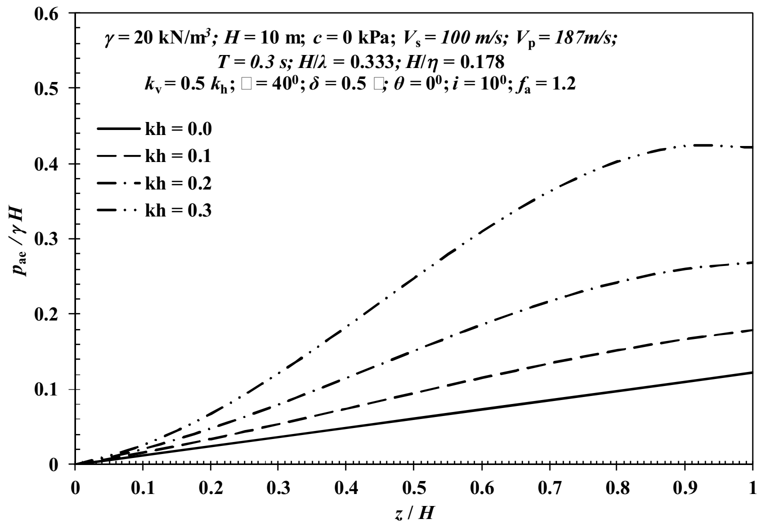

Fig. 3 Non-dimensional seismic active earth pressure distribution for different values of k_h

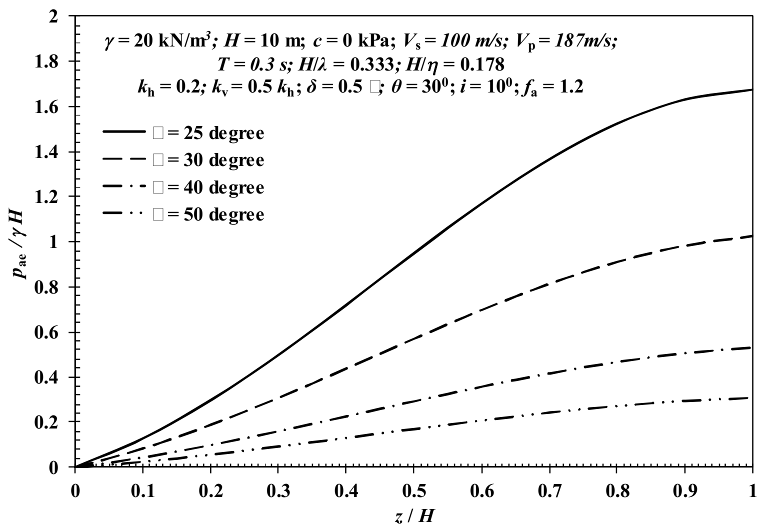

Fig. 4 Non-dimensional seismic active earth pressure distribution for different values of ϕ

The variation of $p_{ae}/\gamma H$ with depth for different values of k_h, varying from 0.0 to 0.3 is shown in Fig. 3. Effect of soil amplification is also taken in the variation. It can be noticed from Fig. 3, that the value of $p_{ae}/\gamma H$ increases continuously, when the value of k_h increases from 0.0 to 0.3. On increasing the values of k_h, pattern of $p_{ae}/\gamma H$ from linear to non-linear. The considerable increase of $p_{ae}/\gamma H$ can be also observed when k_h increases from 0.2 to 0.3. For example, for z/H = 0.5, $p_{ae}/\gamma H$ increases approximately 56.4% when k_h increases from 0.0 to 0.1 and approximately 160.7% when k_h increases from 0.1 to 0.3.

The effect of soil friction angle ϕ on the value of $p_{ae}/\gamma H$ at each and every level of z is shown in Fig. 4 for ϕ increases from 25^0 to 50^0. On increasing the value of ϕ, $p_{ae}/\gamma H$ decreases, showing clearly the non-linear behaviour. The value of $p_{ae}/\gamma H$ decreases faster when ϕ increases from 25^0 to 30^0 and from 30^0 to 40^0. For example, for z/H = 0.8, $p_{ae}/\gamma H$ decreases approximately 224.7% when ϕ increases from 25^0 to 40^0 and approximately 71.0% when ϕ increases from 40^0 to 50^0.

Table 1 and Table 2 are showing the effect of horizontal seismic coefficients on the values of seismic active earth pressure for soil amplification factor increases up to 1.8. Table 1 and Table 2 considers also the effect of vertical seismic coefficient, wall inclination and the wall friction angle.

On comparing in between Table 1 & Table 2, it can be observed that the soil amplification plays a significant role for seismic condition. For a set of various parameters and $\delta = 0^0$ and $\theta = 0^0$, K_{ae} increases about 8.8% and 26.5%, when f_a increases from 1.0 to 1.8 for $k_h = 0.1$ & 0.2 respectively.

For a set of various parameters and $\theta = 30^0$ & $f_a = 1.6$, K_{ae} increases about 29.1% and 52.8%, when δ increases from 0^0 to ϕ value for $k_h = 0.1$ & 0.2 respectively; which are showing the effect of wall friction angle. The value of K_{ae} increases when δ increases from 0^0 to ϕ value for θ value more than 0^0.

For a set of various parameters and $\delta = \phi$ & $f_a = 1.4$, K_{ae} increases considerably approximately 390% and 308%, when θ increases from -30^0 to 30^0 for $k_h = 0.1$ & 0.2 respectively; which are showing the effect of wall inclination.

Conclusion

The detailed formulations are obtained for calculating the seismic earth pressure distribution and the total active thrust behind the inclined retaining wall. These formulations are obtained for the inclined cohessionless soil backfill including the effect of soil amplification. From the equation of seismic earth pressure distribution, it can be clearly observed the non-linear behaviour behind the inclined retaining wall in the pseudo-dynamic analysis, which is very important for designing the retaining walls in the earthquake prone regions. The conclusions drawn from the present study are as follows:

- Non-dimensional value of seismic active earth pressure distribution increases when soil amplification factor increases for increasing depth. The effect is more significant for soil amplification factor more than 1.4.
- Non-dimensional value of seismic active earth pressure distribution increases considerably when horizontal seismic coefficient increases for increasing depth. For horizontal seismic coefficient value more than 0.1, the effect is very high. The behaviour is also changing from linear to non-linear for horizontal seismic coefficient value more than 0.1, which is showing the actual earthquake effect.
- Non-dimensional value of seismic active earth pressure distribution decreases when soil friction angle increases for increasing depth. For soil friction angle more than 25^0 and less than 40^0, the effect is faster.
- Seismic active earth pressure coefficient increases significantly when soil amplification factor and horizontal seismic coefficient increases.
- The value of seismic earth pressure coefficient increases when wall friction angle increases from 0^0 to the value of soil friction angle for wall inclination more than 0^0.
- On increasing the wall inclination from -30^0 to 30^0, seismic earth pressure coefficient increases effectively when horizontal seismic earth pressure coefficient increases from lower value to higher value.

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Reduction in Water Consumption from 135 to 90 LPCD

Rajendra Kumar V. Saraf[1]

Abstract After independence there is a shift of population from rural to urban area. After 1990 urban population of India is increasing beyond assimilative & supportive capacity of municipal authorities. The townships & residential complexes coming in & around fringe area are demanding water supply, sewerage system & sewage disposal. The local authorities are not in position to achieve adequacy. Water is most important input for survival & sustainable growth. As per National Building Code water demand for urban area is 135 LPCD. However the figure varies 135 to 250 LPCD. The way urbanization is growing the demand for water is going to rise. Very soon, Urban India's demand for water is expected to exceed the water available in current water sources. This ultimately puts limit to the growth of Urban area or invite the alternatives to bring water may be from 100 Km away. The inevitable outputs are problem of sewage collection & disposal, municipal Solid Waste Management etc. Urban people are accustomed to get water all the time from the Tap. Besides Drinking, cooking, washing & cleaning, water is required for car washing, air cooler, pet washing etc. The question is whether 135 LPCD includes these activities. Therefore to have water for sustainable development there is urgent need of reduction in Water Foot Print. Assigning the bench mark for water demand, optimum usage of water, reduction in water consumption, multiple use of water by reuse & recycling etc are must to reduce water consumption from 135 to 90 LPCD. The water saved will be available to serve more population & for irrigation. The success stories are given in the paper.

Keywords: Water demand, Conservation, Reduction, Reuse, water foot print

Introduction

Urban population was 17% in 1951. It had shot up to 31% by 2011. Demographers predict that by 2025, 42.5 percent of the country's population will be urban dwellers. [1] Urban India continues to grow in a haphazard fashion without availability of basic amenities like water supply & sewerage system. There is need to consider water availability & sewage disposal before sanctioning the new township or residential complex by Local authority or Town planning department. There is a switch over from water store in drum to the flowing water from the taps provided in the urban houses. Water supply for urban area is from ground water, surface water. Agriculture & Industries also have their claim on these water resources. The water resources are annually recharged with rains. If the rains are scanty the water crisis began. Urban area where water demand exceeds water availability within their geographical boundary has to import water from distant place e.g. Solapur, Hyderabad & Bangalore. Increasing import of water for ever growing urbanization needs critical evaluation. In calculating total water demand for the defined boundaries of urban area water consumption for biotic life & evapo-transpiration is to be considered. Water also goes out of boundary as surface run off, evaporation, evapo-transpiration & moisture in farm produce & products exported out of the boundary. Total water Input & Output can be calculated for the given geographical boundary. If Input > output-System is comfortable, Input = output-System is manageable & Input < output-System is water deficient.

As per National Building Code water demand for urban dweller is 135 LPCD. [2]. It account for water required for drinking, cooking, cleaning (personal hygiene), bathing, washing (clothes & utensils), WC flush. Watering the plants, car and pet washing are additional requirement. Depending on the climatic condition water is also required in summer for Air Coolers. For residential complex water is required for swimming pool & irrigation of lawn and plant. Water demand is soon going to exceed water available in the designated resources for Urban Area. The Municipal authority is unable to cope up with growing demand of drinking water. In summer water supply reduces to one hour in a day to a day in a week. Residents have to search for ground water or Tanker water. Efforts can be made to reduce water consumption from 135 LPCD to 90 or less

E-mail: [1]sarafrv@virajenvirozing.com

[1]Viraj Envirozing India Pvt. Ltd Pune, India

than 90 LPCD. This can be easily achieved by reduction in water consumption by using efficient water gadgets, elimination of leakages & multiple reuse of water. Activity that does not require Drinking water can be identified to replace it with non potable water e.g. use of Recycle water for WC flush. The direct use of rain water will increase Green water footprint & reduce Blue water footprint. Reuse & recycle will decrease Blue & gray water footprint.

All efforts are made to reduce water consumption in 52 Residential Complexes in & around Pune. For studies three Complexes RC-B, RC-B & RC-C are referred. The RC-B, RC-B & RC-C are respectively 9, 6 & 5 years old.

Table 1 Water foot print of urban dweller

Details	Values
Green Water Footprint, (Direct rain water is not used), LPCD	0
Water supply as per National Building Code, LPCD	135
Water Footprint of Water, l / l of water	1.25
Blue Water Footprint, LPCD	168.75
Sewage Generated, l/d, 85% of water supplied	114.75
Gray Water Foot Print Blue water to dilute BOD of raw sewage from 200 to 5 mg/l, LPCD	4475.3
Total Water Footprint, LPCD	4644.05

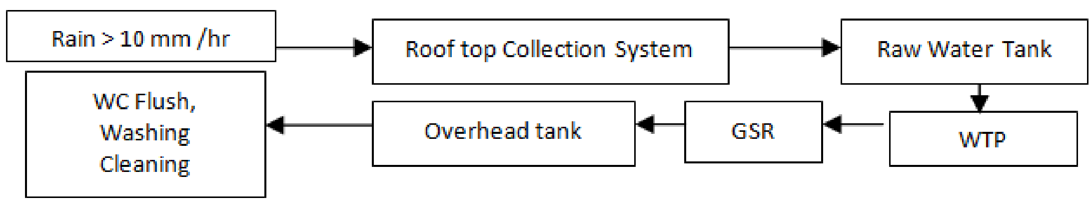

Fig. 1 Model for direct use of rain water at RC-B

Table 2 Calculation for area roof top area required

Details	Values
Total Population	2080
Total terrace Area, m2	2407
Roof top water collected & 780 mm rain fall & 0.85% surface run of rate, m3	1598
Total rain water used per person m3	0.77
No of days rain water collected, max	40
Green Water Foot Print, LPCD	19.02

Table 3 Water quality requirements

Sr. No.	Activity	Water Quality
1	Water Treatment Plant	Well / Raw water
2	Drinking & Cooking	Potable water
3	Personal Hygiene & Bathing,	Soft (Utility) water
4	Washing Utensils & cloths	Soft (Utility) water
5	WC Flushing	Recycle water
6	Irrigation	Recycle water
7	Make up water for Firefighting	Recycle water
8	Car washing & Road washing	Recycle water

Integrated Approach to reduce Water Foot Print

Direct use of Rain Water

Roof Top rain water is collected stored in raw water storage tank along with well water. It is treated in water treatment plant and used as Utility water for bathing, washing & cleaning. Untreated Rain water can be used for WC Flushing, washing & Cleaning etc. This will increase the Green Water Footprint & reduce the Blue Water Footprint. Model of rain water usage is implemented in Residential complex is given in Figure – 1. Table No. –2 give calculation of rain water usage being practiced at Residential Complex A (RC-B). On average it saved 19.02 l fresh water per person per day & Blue Water Foot Print will be reduced by 19 l/person/day.

The biggest advantage of increasing Green Water Foot Print is the saving of Blue water & increase in Blue water storage at resource. As per census 2011 population of Pune is 3,124,458 [4]. Assuming 25% population (78115) practice direct use of Rain water the equivalent amount of Blue water remain in the Reservoir will be 600117 m^3.

Water Quality

Studies are carried out to find the tolerance for different quality of water required for the activities in house. The findings are given in Table – 3

It means three quality of water Drinking (Drinking & Cooking), Utility (Personal hygiene, Bathing, washing) & Recycle (WC Flushing, Car washing & irrigation) are required.

Process to make Utility water is as below

Raw Water -> Pump -> Pressure Sand Filter -> Activated Carbon Filter -> Softener -> Blending -> Softened water storage Tank -> Pump -> On line Chlorination -> Overhead Tank -> Distribution

Hardness of water is adjusted between 40 to 50 mg/l as $CaCO_3$ by the blending unit

Process to make Drinking water is as below

Softened water storage Tank -> Pump -> RO Plant -> RO Water Storage Tank -> Pump -> Overhead Tank -> Distribution system

Residents of RC-B, RC-B & RC-C accepted three water qualities. This has saved fresh water & reduced Blue Water Foot Print.

Reduction in Blue Water Foot Print

Water from underground & surface before & after treatment is account for Blue Water Foot Print. Followings are the measure to reduce Blue Water Foot Print

Use of Water Efficient Gadgets

Water efficient Eco fittings available in market are selected to reduce water consumption. For drinking water supply O ring of 8 mm opening was fitted behind the Tap to reduce water flow. Similar O ring is fitted behind taps of wash basin. This has brought down water consumption by 15 to 20%. It is proposed to install Eco365 aerators to further reduce water consumption.

Elimination of Water Losses & Leakages

Leakages start write from pumping station to the receiving point i.e. Cascade aerator or raw water storage tank in Water Treatment Plant. There is loss of water along with sludge drain from clarifiers, Backwash & rinse of the filters. Around 2% of water is simply drain out. Waste water from Water Treatment Plant is collected and sent to sewage treatment plant to reuse.

All water tanks at ground level are water proofed and tested for water leakage prior to its usage. Once in a year inlet and outlet are closed after complete filling of tank. Drop in water level is observed to check any leakages. RC-B, RC-B & RC-C has not yet shown any leakages. Overhead tank are also tested in the similar manner.

Water distribution line is of U PVC and was tested for leakages before commissioning. Drawing of Water Distribution net work is kept in the office of Society for reference for carrying out the repairs. There is ongoing monitoring of leakages and any leakage observed is immediately stopped.

The manual system that operates the pump to fill water from UG tank to Overhead tank continue to run till is overflows. To eliminate the automatic system with level control switch is provided to all the pumps transferring water from GSR to OHT.

Awareness Program

The awareness program made the flat owner to immediately rectify the leakages avoids the water wastage & conserves water.

Conservative Practices

Study is carried out to develop simple practices to reduce consumption of fresh water. Some of the practices are given in Table No. 4. Individual can make few more addition as per his/her attitude, magnitude of awareness & temperament. It saves 10 to 30% of fresh water consumption.

Table 4 Activities & water conservation measures

Activity	Conservation Measures
Drinking & Cooking	Reduce wastage-Practice Jar & glass to take required drinking water. Reuse water left over after boiling.
Washing vegetables	Practice multiple use of water. After washing tomatoes with tap water use wash water for first wash of leafy vegetable. Second wash of leafy vegetable will be with tap water and wash water from second wash will be used for first wash of potatoes. Discarded wash water will be used for watering plants.
Washing Utensils	Practice counter current washing. Use 3 Tubs (Soap water, First Rinse & Second Rinse) instead of flowing water from tap. Use tap water only in third tub. Water from 3rd tub will be used in 2nd tub and from second tub in 1st tub.
Washing Cloths	Select clothes which absorb less water. Avoid use of Turkish water. Reuse of Rinse & spin water for wash water in manual & machine wash.
Bathing	Better practices. Use of bucket & mug, use of both palms and valve control use of shower drastically reduce water consumption.
Personal Hygiene	Replacing flowing tap with mug reduces water consumption. Direct use of wash water from wash basin for irrigation in bungalows is possible.
WC Flush	Precisely using dual flush after urination & defecation.
Floor wash	Dry sweeping followed by wet mopping requires less water.
Gardening	The better system like drip irrigation or use of mug & putting tray below the pot can reduces water consumption. Wash water left after vegetable & fruit washing is used for watering the plant.
Car wash	Using the bucket & mop per instead of flowing tap water.

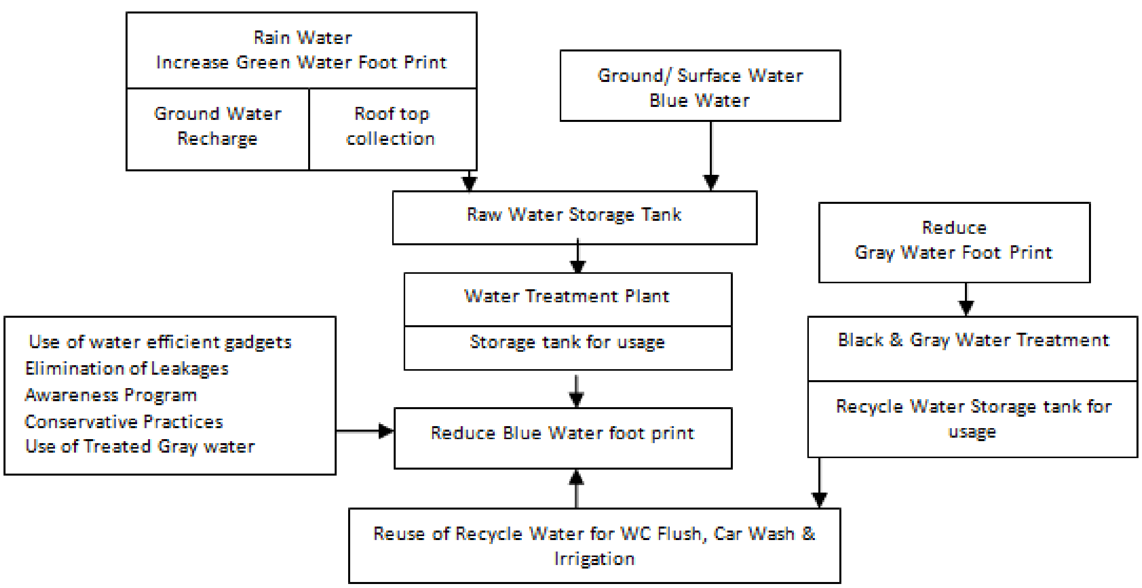

Fig. 2 Integrated approaches for reduction in water footprint

Reduction in Gray Water Foot Print

Aerobic biological treatment from natural to mechanical is available to efficiently treat sewage. [3] Low cost user's friendly technologies having lower energy foot print will be preferred for Residential complex. Black water and Gray water are segregated and treated separately or together. Deep Tank Aeration System having low energy and area foot print is used for Biological process. Biologically treated waste water is further treated by Tertiary treatment. It is observed that Reuse of Gray water has more acceptance than of black water. Fully treated Gray water (Recycle Water) is reused for WC Flushing, car wash & irrigation. This saves 30 to 40 liter of fresh water per person per day. Process Flow chart for Gray & Black water is given below.

Treatment for gray water

Gray water -> Screen Chamber -> Aeration Zone of Deep tank Aeration System (DTAS) -> Biological Treated Sullage tank -> Pump -> DTAS on line Flocculator -> Pressure Sand Filter -> Activated Carbon Filter -> Cascade Aerator -> Chlorination -> Recycle Water Storage Tank -> Pump -> Overhead Tank -> Distribution

Recycle water is supplied through taps for WC Flush, Irrigation and Car Wash

Treatment of Black Water

Black Water -> Anaerobic Bioreactor -> Anaerobic Fixed Media Up flow Bioreactor -> Deep Tank Aeration System -> Chlorination -> Treated Black water Storage Tank -> Irrigation, Excess for Disposal

BOD of Fully treated Black & Gray water is all the time less than 5 mg/l. Therefore Gray Water Foot Print almost brought to zero. Reuse of Treated Gray & Black water has further reduced the Blue Water Foot Print. Integrated approach for reduction in water footprint is compiled in Fig. 2.

Observations & Findings

Promoter & Developers agreed to implement all the recommendations to reduce Water Consumption from 135 to 90 LPCD. The Complex has three quality of water (Drinking, Utility and Recycle) & two sewer line (Gray & Black water). The additional cost for extra pipe lines was 15 to 17.5%, which is accepted by the Builder as part of the Construction cost. Initially little reluctance was observed however everyone got tuned up to do the task. House dwellers of Residential Complex RC-A, RC-B & RC-C has accepted the concept of reduction of Water Foot Print

The Water Foot Print of Drinking water produced from RO Plant is 2 l/l of Drinking water. Water Foot Print of Utility water is 1.04 l per liter of Utility water. 19.02 LPCD is Green Water Foot Print due to direct use of rain water during rainy season. Typical calculations of Reduction in Water Consumption for RC-B is given in Table 5

The water consumption is reduced to 89.65 LPCD in RC-B. Similar calculations carried out for RC-B & RC-C shows that water consumption is reduced to 90.8 & 90.03 LPCD respectively. Equivalent amount of water saved will be available in water reservoir. Total Water Foot Print after implementation of measures in comparison with Table 1 is given in Table 6.

Table 5 Calculation of water consumption for RC-B

	Water Consumption	
Details	**Without Measure**	**With Measure**
A. Total Water Consumption		
A.1. Total Population	2080	2080
A.2. Water supply, LPCD	135	
A.3. Drinking water @	20800	20800
A.4. Utility Water@ 90 LPCD	187200	
A.5. Water for WC Flushing @ 35 LPCD	72800	
A.6. Total Blue Water Demand l/day (A3+A4+A5)	280800	
B. Reduction in Fresh water consumption (Blue Water Foot Print)		
B.1. Recycle Water @ 35 LPCD		72800
B.2. Reduction in water Consumption, 11.5%		21528
B.3. Sub Total (B1+B2)		94328
C. Revised Fresh water consumption (Blue Water Foot Print)		186472
D. Blue Water Foot Print, LPCD		89.65

Table 6 Total water foot print after implementation of measures

Details		Values
1.	Green Water Foot Print	
1.1.	Green Water Foot Print in rainy season	19.2
1.2.	Green Water Foot Print in summer & Winter	0
2.	Blue Water Foot Print	
2.1.	Drinking water supply, LPCD	10
2.2.	Water Foot Print of Drinking water, l/l	2
2.3.	Water Footprint of Drinking water, LPCD	20
2.4.	Utility Water supply	82.84
2.5.	Water Foot Print of Utility Water, l/l	1.04
2.6.	Water Foot Print of Utility water LPCD	86.15
2.7.	Blue Water Footprint (2.4+2.6), LPCD	106.15
2.8.	Blue Water Foot Print during rainy season (2.7-1.1), LPCD	86.95
3.	Gray Water Foot Print	
3.1.	Gray Water Foot Print L, PCD	0
4.	Total Water Foot Print, (1.2+2.7+3.1), LPCD	106.15
4.1.	Total Water Foot Print as per Table 1, LPCD	4644.05
4.2.	Reduction in Total Water Foot Print, %	97.7

Reduction in total Water Foot Print after implementation of measure at RC-B & RC-C is found to be 96.8 & 97.7 % respectively. Blue Water Foot Print as calculated in Table 6 is reduced to 106.15 LPCD from 4644.05 LPCD. The measures implemented drastically reduced the Water Foot Print by 97.7 %.

Zero value of Gray Water Foot Print indicates that discharge of untreated sewage to receiving water bodies is totally eliminated. Due to recycling, hydraulic & organic load on sewerage and sewage treatment plant of Municipal authority is reduced.

Ample recycle water is available to keep complex Green throughout the year. A thought has been conceived to sale fully treated sewage for activities like building construction. In fact in RC-C the part of construction was done by using fully treated sewage. Thus complex RC-A, RC-B & RC-C has achieved sustainability of water.

Conclusion

Reduction of water consumption from 135 to 90 LPCD is inevitable to cope up with water supply for growing urbanization. The drinking water is used for all the activities of residential complexes. A first measure is the use of drinking water only for drinking & cooking. Use of recycle water for WC flush, car wash & irrigation eliminates use of precious drinking water for these activities.

The conservation measures are incorporated at designing stage. Elimination of leakages, use of water efficient gadgets, awareness program & conservative practices save around 11 to 15 % of fresh water. The implementation of measures brought down fresh water consumption from 135 to 90 LPCD. Virtual Water Foot Print is reduced from 4644.05 to 106.15 LPCD.

It is recommended that the concept proposed & implemented RC-A, RC-B & RC-C must become the integral part of residential complexes. Excess sewage left after recycling shall be made available for agriculture & industries. This will further save the Blue water at water resources. Saved amount of water will serve more population & more land can be brought under irrigation. Both water and food security will be ensured. Thus water sustainability can be achieved by integral approach as suggested by author.

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Rising Growth of E-rickshaws in Indian Traffic Context: A Challenge in Efficient Traffic Operations

Sabyasachi Mondal[1] and Pritam Saha[2]

Abstract Over the past few years battery operated e-rickshaw has become very popular in Indian transportation context. Static and dynamic characteristics of such mode are, however, quite different than those of petrol/ diesel/ CNG operated vehicles. Accordingly, they affect operations of traffic and at times become the root cause of congestion and delay on roads that are already stressed while sharing the same road space with the motorized ones. On the basis of field study on two suburban arterials of Kolkata city, this paper has shown that presence of such mode in the traffic stream reduces mobility and capacity as a consequence. Impedance caused by them to relatively faster ones resulted in frequent formation platoons and, thereby, overall speed was found to reduce by about 10 km/h. Capacity was also found to decrease by about 350 pc/h when they shared 25% of total traffic. This clearly indicates the fact that rising growth of e-rickshaws starts increasing level of congestion on roads and eventually they may make the entire transportation system paralyzed and suffocated. Further, at times they even create traffic disorder and affect safety aspects.

Keywords: Traffic operations, e-rickshaws, arterials, suburban area

Introduction

In most of the small and medium sized cities, suburban and peri-urban (rural-urban transition zone) areas, the shares of the bus systems is lower, while the intermediate public transport (IPT) system, sometimes known as ‘paratransit’ modes, are equivalent to or more than the formal bus systems. A variety of informal modes like, rickshaw (paddle tricycle), auto (motorized three-wheeler), three-wheeled van etc. are usually operated as IPT for the purpose of providing high frequency shuttle services on high-demand corridors.

Till the last decade, paddle tri cycle or rickshaw was one of the most popular IPT for making local trips in both urban as well as rural areas. However, over the past 5–7 years, a newly developed edition of rickshaw, battery operated ‘e-rickshaws’ have become very popular in Indian transportation contexts because of their low fuel cost and better efficiencies [1].

At times, e-rickshaws are even considered as an alternative of petrol/ diesel/ CNG auto-rickshaw [2] because of the fact that they provide complementary transport for the low-income people [3] and non-polluting and silent transport system for urban and rural areas of India [4]. Growth of such vehicles is quite rapid and already they have a share of about 50 percent of total traffic in many places.

The acceleration and deceleration characteristics of these vehicles are, however, quite different than those of petrol/ diesel/ CNG engine powered vehicles. Also, they have low braking capabilities and maximum speed in the range of about 20–22 km/h. As a result of it, most of the suburban arterials have already started experiencing congestion and safety related issues and warrant for capacity enhancement. On the other hand, capacity expansion is extremely difficult for those arterials since land is scarce.

This calls for an initiative to study the impact of increasing rate of ‘e-rickshaws’ on efficient traffic operations and thereby, introducing appropriate traffic management measures for traffic operational improvements. Accordingly, the current study made an attempt to investigate the change in traffic behaviour when, ‘e-rickshaw is not present’ and ‘e-rickshaw is present’ in the traffic stream based on field data.

E-mail: [1]sabyam96@gmail.com, [2]saha.pritam@gmail.com

[1,2]Indian Institute of Engineering Science and Technology, Shibpur, Howrah, India

Literature Review

Over the past couple of decades, owing to the rapid growth of urban areas across the globe, travel behaviour has changed considerably [5] which has resulted in a cognitive demand of efficient and economic public transport facilities [6]. Thus, besides rail and bus services, necessity of adequate and effective 'paratransit' modes of transportation was felt for the purpose of providing frequent and conveniently located services [7]. Research on such modes as urban and sub-urban transit system started in the international arena in the middle of 1960 [6] and a variety such modes have been developed over the years. There have been a number of literatures which have discussed their performance, impact on traffic mobility and safety.

Paratransit operates alongside a more or less conventional system like bus. The vehicles used generally are smaller than buses and often are locally made or modified versions of vehicles initially intended for uses other than public transport. Examples of new, imported vehicles being used for paratransit are few. Most are too small to permit standing passengers or the carriage of much luggage [8]. Mostly, paratransit fills the gap in public transport facilities and plays significant roles by providing the feeder service to the mass transit system [9]. Further, it provides employment opportunities for the poor and low-skilled workers; thereby, helps in socioeconomic development [10].

In the city of Cape Town, the average frequencies of city buses are 15 minutes and for the train it is 3 to 8 minutes, whereas on the other hand, paratransit services are extremely flexible and demand responsive. They quickly respond to user needs and can easily adapt to dynamic patterns of demand [11, 12]. They became more popular in many developing countries mainly due to lack of satisfactory mass transit system [13]. However, in US paratransit refers to government-subsidized transport for the elderly or handicapped persons [5].

A study in Indonesia reported that Paratransit is an efficient mode of transportation which contributes only 18% of total traffic flow but transports more than 50% of passenger trips. However, since the average speed of such mode is usually less than 15 km/h, it reduces average speed of the traffic stream significantly (was less than 20 km/h) and capacity as a consequence [14].

Moreover, different types of vehicles have been used as paratransit in different countries and accordingly they have been known by different local names. For instance, 'Angkot' and 'Angkutan Kota' in Indonesia [15, 5], 'Jeepney' in Philippines [5], 'Tuk-Tuk' and 'Songtaew' in Thailand [15, 5], 'Motodops' in Cambodia [13], 'Sidecars' in Myanmar [13], 'Tempos' in Nepal [13], 'Small Minibuses' in Hong Kong and many cities of Africa [15]. Furthermore, several types of cars, vans, and minibuses with a capacity of 12–14 seats are also used as paratransit in many cities [5].

Despite advantages and significant role of Paratransit modes, they have been sometimes blamed for producing disorder in the traffic system rather than improving it. Also, they have been found as the root cause of many traffic and environmental problems [13]. While, they can move freely with other main stream traffic, their uncontrolled stops and loading & unloading of passengers along the road side results in traffic chaos and also lead to traffic accidents [16]. Further, sometimes they come in poorly maintained condition which leads to passengers' discomfort and air and noise pollution.

Thus, future of paratransit has been uncertain in many countries and necessitated studies for its survival based on its user acceptance, safety and its impact on roadway traffic and environment. In fact, the important aspect that influences the future of any public transport modes is its performance. Therefore, an appropriate and useful analysis is needed to decide whether such systems are working in technically efficient ways [17] and providing profitability and sustainability in transport services [18].

On the other hand, since in most of the rapidly expanding cities of the developing world road-based public transport is an essential part of transport systems [10], paratransit is considered as a critical mode because they are flexible, demand-responsive and do not follow fixed routes and schedules. These modes are mostly suitable for shorter length trips and places where the connectivity is poor [19].

In India, cycle-rickshaws including man-driven three-wheeled 'cycle-vans' was introduced as an effective paratransit in the early nineteenth century [5]. With the advent of time, some motorized modes like, Auto-rickshaws, diesel motor vans etc. have come into Indian market [20]. In most of the cities, they act as a bridge of the connectivity gap with Metro, BRTS and people. In few cities like, Chennai, Alwar, Indore, Lucknow, Jaipur, Rajkot, Mumbai and Kolkata share autos are very popular because they provide services on a 'point-to-point' basis [15]. Accordingly, significant increase of such mode over the years paralyzed the transportation system and made capacity augmentation essential. In many densely populated urban areas, however, expansion of existing infrastructure is extremely difficult [20]. Further, functioning of the rickshaws on arterial roads creates jams on roads that are already under severe traffic stress [1].

Recently, e-rickshaws have been very popular in most of Indian cities and they are considered as an alternative of auto-rickshaw and pulled-rickshaw [2, 3]. These modes are eco friendly and cost effective since emission, fuel consumptions and human efforts are considerably less.

However, a study in New Delhi reported that more than 80% of passengers felt unsafe in e-rickshaws. An opinion poll of the drivers indicates that sometimes they experience situation of being toppled which is unsafe for the passengers [1]. Also, speed potential and braking capabilities of these vehicles do not permit them to merge with the main stream traffic like, arterials, highways etc.

A handful studies have reported the performance of e-rickshaws, however, their effect on overall performance of traffic is yet to be culminated. Therefore, the current study aimed at investigating impact of such mode on traffic operations.

Study Design

Methodology

The premise, on which the current study is based, thus, considers a systematic investigation of change in traffic behaviour when e-rickshaw is present in the traffic mix. Accordingly, it warrants a comparative study on roads where such mode is operating and not operating.

Large proportion of slower vehicles in traffic stream causes frequent formation of platoons and reduces capacity of roads as a consequence. Speed of traffic stream also drops to a considerable extent. This may result in congestion, delay and frustration among part of drivers. A few impatient drivers even take risk to overtake, thereby, affecting safety.

Accordingly, it was felt paramount to study how such modes affect capacity and speed of traffic stream. Further, it is imperative to evaluate their impact on operating speed of other vehicles plying on roads. Reliance on field data was considered suitable for such assessment.

Normal and logistic distributions were considered for describing speed data based on two criteria viz. spread ratio [21] and amount of outliers in the data set [22]. Decision on appropriate distribution was taken based on goodness-of-fit of the distribution models.

Two goodness-of-fit tests, namely, chi-square test and the Kolmogorov–Smirnov (K–S) test are commonly used in traffic engineering problems. However, current study has applied the K-S test while finding the best fitted distribution model since it can use data with a continuous distribution and there is no minimum frequency requirement per test intervals [23].

Study Sites and Field Data

Accordingly, field study was conducted on two suburban arterials of Kolkata city (see Fig. 1). The study sites were selected in such a way such that e-rickshaws are permitted in one section whereas other section does not allow them. Both the sections were about 7 m wide and pavement conditions were good and uniform.

Video photographic survey technique was adopted while conducting the study. A trap of 10 m was marked on the pavement and a camera was installed away from the trap. Height of the camera was adjusted in such a way so that it can cover the entire trap keeping some margin on its either side. Survey was conducted during peak and off peak daylight hours on typical week days for a period of about two hours at those locations.

A range of vehicle types including motorized and non-motorized ones were observed in the traffic stream and their composition was more or less same at both the study sites. Proportion of cars and two-wheelers was observed to be significant: in a way that share of cars and two-wheelers were about 20% and 30–35% respectively. Proportion of bus and truck was found to be insignificant (no more than 5%). Since, both the sites are at city outskirts, presence of non-motorized vehicles especially paddle tri cycle were sizable (about 10–15%).

As the second study site does not permit e-rickshaw, motorized three-wheeler operates as an effective paratransit; proportion of such mode was as high as 30%. However, a major shift of such mode was observed when e-rickshaw is introduced; a modal split of 25% (e-rickshaw) and 5% (motorized three-wheeler) was observed at the first study site.

Fig. 1 A view of study sections on sub-urban arterials of Kolkata metropolitan region: (a) study site-1 (b) study site-2 (Photos by the authors)

(a)

(b)

Result Analysis and Discussions

The necessary traffic data like type of vehicle and the time that it takes to travel the trap was extracted from the video files keeping an accuracy of 0.001s. Accordingly, spot speeds of vehicles were calculated from the lapsed time. Free flow condition was approximated when flow was about 200 veh/h. Accordingly, speed data recorded at that flow level was used for the purpose of computing free-flow speed and it was found to be about 50 km/h (see Table 1) for both the study sites.

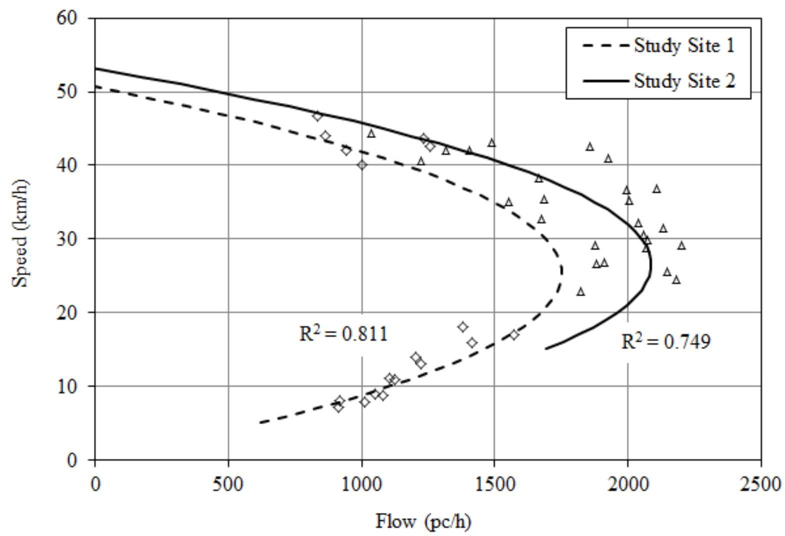
Further, speed data coupled with traffic flow was plotted and fitted to a parabolic equation with acceptable statistical validity in terms of R2 (see Fig. 2.a). The free-flow speeds obtained from the intercept values are very close to the observed ones and the error was found to be in the range of 4–7% (see Table 1). Since, such error is within the assumed working hypothesis, i.e. less than 10%, the fitted speed-flow model considered appropriate in representing field conditions. Two-way capacity was, thus, noted for both the study sites; it was approximately 1750 pc/h and 2100 pc/h respectively for study site 1 and 2 (See Fig. 2.a). Notably, passenger car equivalent for e-rickshaw was worked out based on the equation proposed by Chandra & Kumar [24].

Table 1 Field validation of speed flow relationship and comparision of goodness-of-fit of distribution models at the study sites

Study Site	Speed Flow Relationship			Speed Distribution		
					K-S Test Statistics	
	$FFS_{Intercept}$	$FFS_{Observed}$	Percent Error	$SR_{Speed\ data}$	Normal Distribution[21]	Logistic Distribution[22]
1	50.657	48.58	4.28	1.12	0.07465*	0.08739
2	53.118	49.60	7.09	0.96	0.06993*	0.08962

*Note. FFS: Free-flow speed; SR: Spread Ratio; K-S test: Kolmogorov–Smirnov test, *Lowest K-S test statistic*

Fig. 2 Comparison of flow parameters at the study sites: (a) speed-flow relationships (b) distributions of speed data



(a)

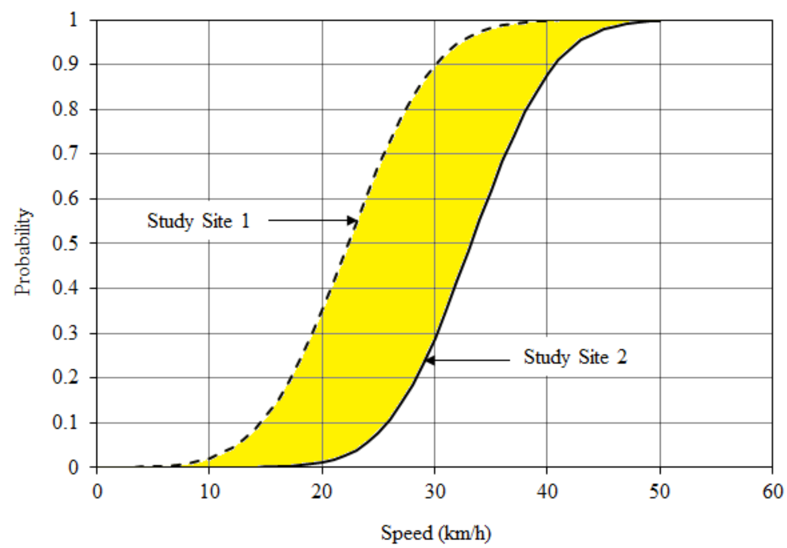


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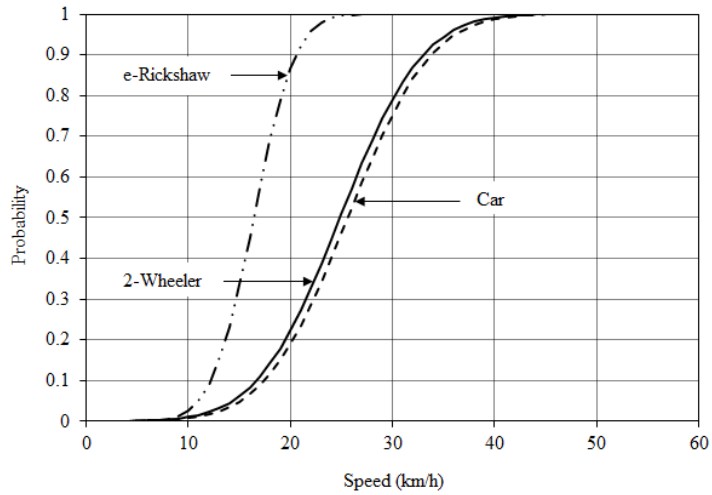
Fig. 3 Distribution of vehicle speeds showing the impact of e-rickshaw on traffic performance: (a) e-rickshaw present (b) e-rickshaw not present.



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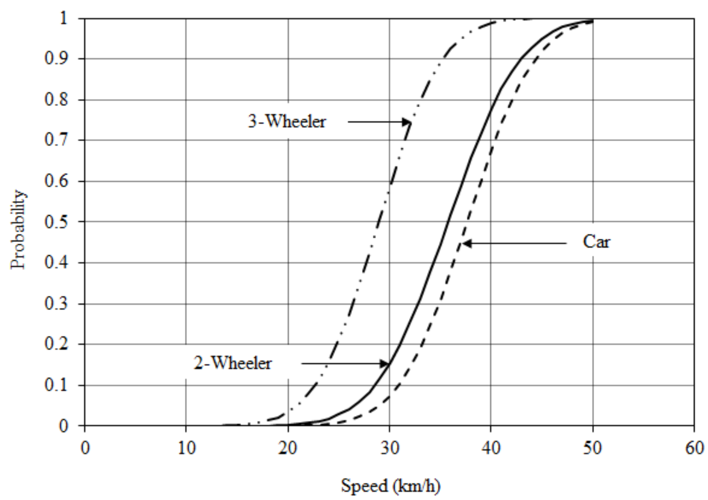

(b)

Table 2 Parameters and goodness-of-fit details of vehicle speed distribution at the study sites

Vehicle Type	**Mean**	**Standard Deviation**	**SR$_{\text{Speed data}}$**	**K-S Test Statistics**	
				Normal Distribution[21]	**Logistic Distribution[22]**
Study Site 1					
2-wheeler	25.612	6.3915	1.11	0.12085*	0.12181
Car	24.845	6.3594	1.03	0.1147*	0.13209
E-Rickshaw	16.386	3.2659	1.07	0.18783*	0.20151
Study Site 2					
2-wheeler	37.608	5.2528	0.91	0.14025	0.13127*
3-wheeler	28.939	4.9012	0.87	0.15523*	0.16139
Car	35.742	5.6034	0.86	0.12313*	0.13853

*SR: Spread Ratio; K-S test: Kolmogorov–Smirnov test, *Lowest K-S test statistic*

The speed data was distributed on the basis of a class interval of 3 km/h determined as per Struges rule [25, 26]. Normal distribution function was found appropriate in describing speed data based on goodness-of-fit tests (see Table 1). Percentile speeds at study site 1 was observed to be considerably less compared to study site 2: *Fig. 2.b* displays the variation which is about 10 km/h.

Evidently, both capacity and operating speed were found to reduce when e-rickshaw was present in the traffic. This is attributed to the fact that platoon formation is quite frequent when such mode shares the same road space because of their static and dynamic characteristics. Consequently, speed drops to a considerable extent resulting in significant reduction in capacity.

This fact was further investigated by plotting speed profiles of individual vehicles (see Fig. 3). Speed percentiles of e-rickshaw were found to be much less compared to two-wheelers, three-wheelers and cars. Also, it was apparent from the plot that speed of car and two-wheelers reduces to a considerable extent (about 35%) due to the presence of e-rickshaw in the traffic stream.

An informal opinion poll of about 50 road users reveals the fact that many passengers feel unsafe in e-rickshaws especially on roadways like arterials or sub-arterials where motorized vehicles are present. However, they feel themselves safe enough in e-rickshaws on collector or local streets where faster vehicles are relatively less.

Conclusion

Over the past few years e-rickshaw has become very popular in Indian transportation context. Frequent availability and flexible service of such mode made it an effective feeder service in urban and sub-urban region. Accordingly, this has resulted in a rapid growth of such vehicles in many cities and also in rural areas. Consequence of such growth simultaneously creates a wide range of problems in operations and safety of traffic.

On the basis of field studies conducted on two suburban arterials of Kolkata city, the current study found that presence of e-rickshaw reduces traffic mobility and capacity to a considerable extent. Thus, efficient traffic operation is compromised when such mode in introduced in traffic stream. At times, such modes even make the entire transportation system paralyzed and suffocated especially on already congested roads. An informal opinion poll also indicates that safety aspects of passengers for such type of vehicles are also not very high.

The current study, thus, creates a starting point of future initiatives aimed at performing simulation based analysis to study impact of e-rickshaw in reducing capacity, increasing level of congestion and also, how does it affect safety aspect of roads under mixed traffic conditions.

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Study on Mechanical Property of Concrete with Partial Replacement of Cretaceous Clay

Kalaignan R.[1], T. Sweetlin Salonie[2] and S. Siva Murthy Reddy[3]

Abstract In recent years, there are plenty of research on alternative for cement. Concern over the environment and awareness on pollution made the need for alternatives. Especially usage of naturally available and recycled become thrust area for research. Metakaolin, silica fume, fly ash etc become common replacement for cement. It reduces the quantity of cement as well increases the strength. Metakaolin is manufactured by calcinating the Kaolinite clay. Cretaceous clay available in Trichy-Ariyaloor region is kaolinite clay. This paper presents an overview of work carried out on the use of calcinated cretaceous clay as partial replacement of cement and its effect on mechanical property of concrete. The cretaceous clay available in Trichy-Ariyaloor region possesses pozzolanic property and this cretaceous clay is calcinated at 700°C to 800°C for 4 hours. Partial replacement of calcinated cretaceous clay has improved the mechanical property of concrete. Compressive strength and flexural strength have increased when cement is replaced with 15% of calcinated cretaceous clay. [1]

Keywords: Calcinated Cretaceous Clay, Calcination, Chemical Analysis, XRD, Compressive Strength, Flexural Strength

Introduction

Concrete is probably the most extensively used construction material in the world. It is second to water as the most heavily consumed substance. Metakaolin, which is relatively a new material in concrete industry, is effective in increasing the strength [4]. Pozzolanic reactions change the microstructure of concrete and chemistry of hydration products by consuming the released calcium hydroxide (CH) and production of additional calcium silicate hydrate (C-S-H), resulting in an increased strength and reduced porosity [2].

Pure metakaolin has been successfully used as a supplementary cementing material in concrete since 1990. The raw material in the manufacture of Metakaolin is kaolin clay. Kaolin is a fine, white, clay mineral that has been traditionally used in the manufacture of porcelain. The Meta prefix in the term is used to denote change. In case of Metakaolin, the change that is taking place is dehydroxylization, brought on by the application of heat over a defined period of time. Dehydroxylation is a reaction of decomposition of cretaceous crystals to a partially disordered structure. The results of isothermal firing show that the dehydroxylation begins at 420°C. At about 100°C - 200°C clay minerals lose most of their adsorbed water. The temperature at which kaolite loses water by dehydroxylization is in the range 500°C-800°C [1]. This thermal activation of a mineral is also referred to as calcining. Beyond the temperature of dehydroxylization, cretaceous retains two dimensional order in the crystal structure and the product is termed Metakaolin [1]. The temperature range varies in accordance with the kaolin found on different sites.

Metakaolin is neither the by-product of an industrial process nor is it entirely natural. It is derived from naturally occurring mineral and manufactured specially for cementing applications. Metakaolin is produced under careful controlled conditions to refine its color, remove inert impurities, and tailor particle size so that a much high degree of purity and pozzolanic reactivity can be obtained [2]. Calcinated cretaceous clay is white, amorphous, highly reactive aluminum silicate pozzolans forming stabile hydrates after mixing with lime stone and water, providing mortar with hydraulic properties [3]. Heating up of clay with cretaceous $Al_2O_3.2SiO_2.2H_2O$ as the basic mineral component to the temperature of 700°C-800°C causes loss of structural water with the result of deformation of crystalline structure of cretaceous and formation of an anhydrate reactive form so called metakaolin [6]. The chemical equations describing this process is

E-mail: [1]rkalaignan@gmail.com, [2]sweetlinsaloniet@gmail.com, [3]ssr.pec@gmail.com

[1]Research Scholar, Pondicherry Engineering College, Pondicherry, India

[2]PG Student, Dr. M.G.R. Educational & Research Institute, Chennai, India

[3]Professor, Pondicherry Engineering College, Pondicherry, India

$Al_2O_3.2SiO_2.2H_2O = Al_2O_3.\ 2SiO_2 + 2H_2O$ (g)

The majority of the cementitious binders used in concrete are based on Portland cement clinker, the production of which is an energy-intensive process. In addition, it produces a large amount of greenhouse gas emissions mostly CO_2, from limestone in the pyro-processing of clinker. On the other hand, the concrete industry is one of the major consumers of natural resources. In order to reduce energy consumption, CO_2 emission and increase production, cement plants produce blended cements, comprised of supplementary cementitious materials such as metakaolin, silica fume, natural pozzolans, fly ash and limestone which would increase the strength properties [7].

Concrete incorporated with calcinated cretaceous clay has several advantages over the normal mix concrete as they possesses high compressive strength parameters [13]. It also reduces the amount of cement in the formation of concrete, especially in concrete with high requirements for water resistance. The replacement of cement with calcinated cretaceous clay varies from 10%, 15%, 20% and 25%. Mechanical properties such as compressive strength and flexural strength test were carried out at 7, 14 and 28 days.

Materials Used

Cement and Aggregates

OPC 53 grade cement is used. Fine aggregate and Coarse aggregate confirming to IS: 383–1970 were used.

Cretaceous Clay

Cretaceous clay taken from Kaarai, Trichy- Ariyalur region is kaolinite clay. This clay is calcinated at 700^0C to 800^0C for 4 hours. And in M30 grade of concrete, cement is replaced by calcinated cretaceous clay in various proportions 10%, 15%, 20% and 25% and strength is found at 7, 14 and 28 days.

Experimental Investigation

Analysis of Cretaceous Clay for Pozzolanic Property

Chemical requirements for pozzolanic properties was carried out as per IS: 1727–1967 and the limits were checked with IS: 3812–1981. The results are listed in Table 1.

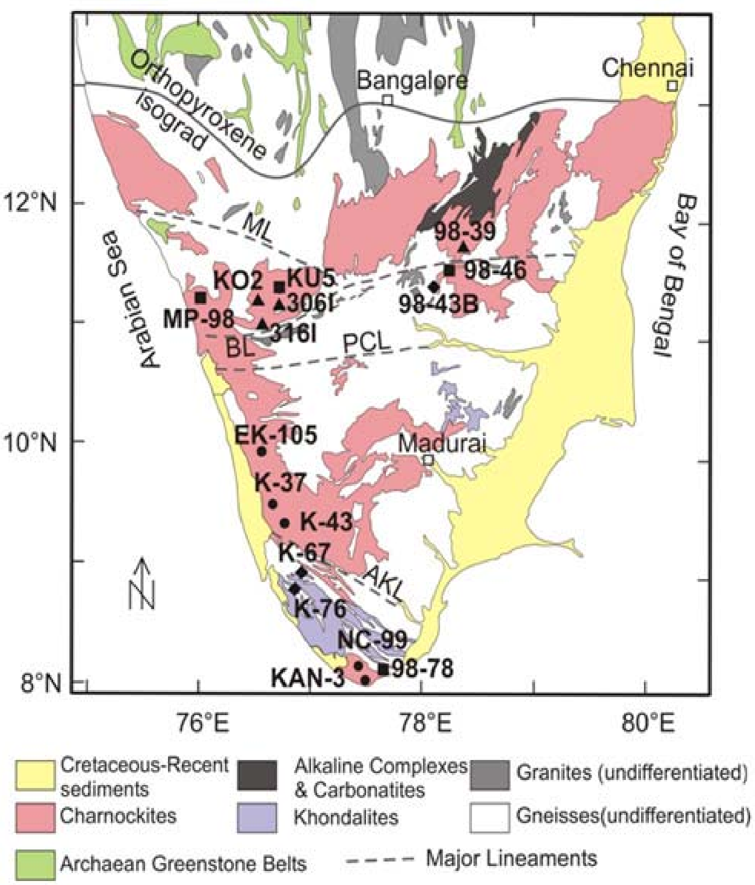

Fig. 1 Clay availability in south India

Table 1 Chemical Composition

S. No.	Chemical Requirements (%) Tested as per IS: 1727–1967	Kaarai	Limits as per IS: 3812–1981
1	Silica + Alumina + Iron oxide	83.92	70% Min
2	Silica	51.79	35% Min
3	Magnesia	1.83	5% Max
4	Total sulphate as SO_3	0.34	2.75% Max
5	Total loss on ignition	11.01	12% Max
6	Alkali Tested as per IS: 4032–1968	0.0049	1.5% Max

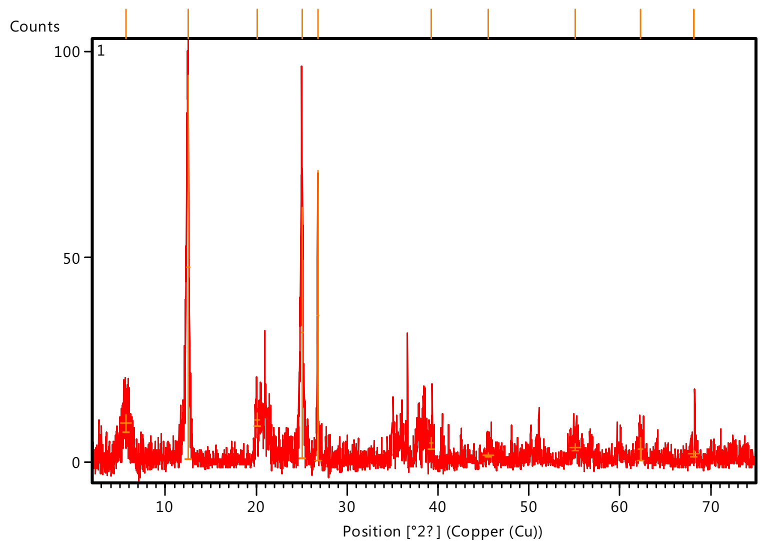

Fig. 2 Natural cretaceous clay

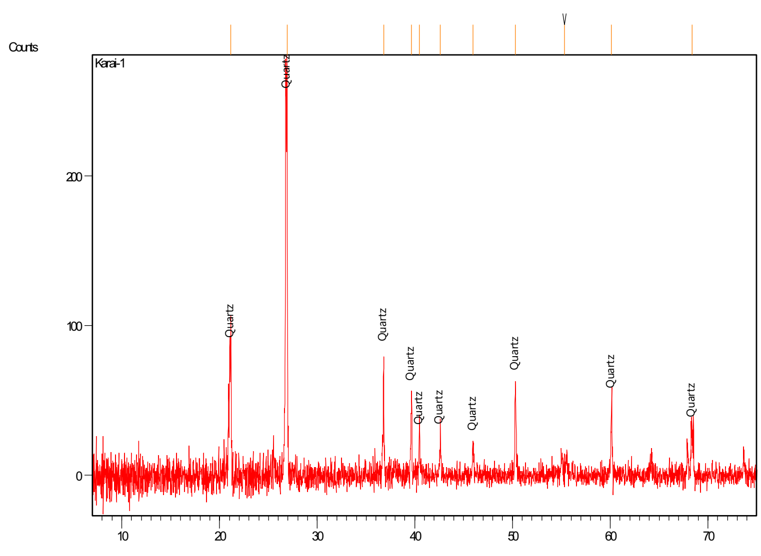

Fig. 3 4 hrs of calcination

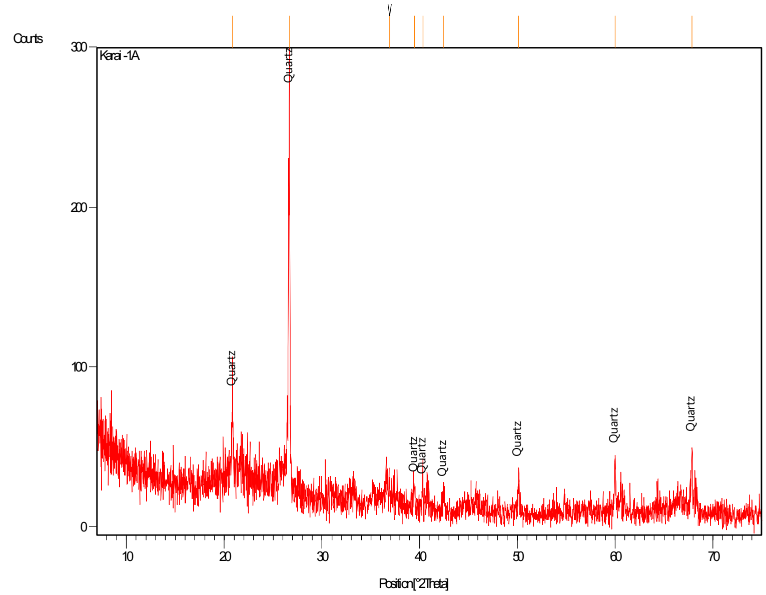

Fig. 4 6 hrs of calcination

Table 2 Water absorption of M30 concrete incorporated with calcinated cretaceous clay

Mix	**Water Absorption (%)**		
	7 Days	**14 Days**	**28 Days**
0%	1.986	1.465	1.225
10%	3.124	2.901	1.213
15%	2.983	1.801	1.166
20%	2.640	1.277	1.123
25%	2.600	1.187	1.003

Table 3 Compressive strength of calcinated cretaceous clay incorporated concrete cubes

Mix	**Compressive Strength (N/mm^2)**		
	7 Days	**14 Days**	**28 Days**
0%	22.3	25.1	33.5
10%	23.6	27.4	37.4
15%	26.6	32.3	40.1
20%	22.7	26.1	34.4
25%	22.1	25.8	33.9

Table 4 Flexural strength of calcinated cretaceous clay incorporated concrete prism

Mix	**Flexural Strength (N/mm^2)**		
	7 Days	**14 Days**	**28 Days**
0%	2.52	2.68	2.81
10%	3.46	3.62	4.24

Mix	Flexural Strength (N/mm^2)		
	7 Days	14 Days	28 Days
15%	4.41	4.51	5.54
20%	3.22	3.56	3.80
25%	2.64	2.82	3.27

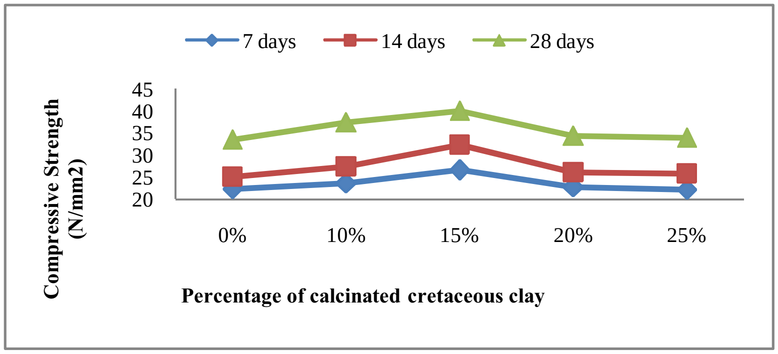

Fig. 3

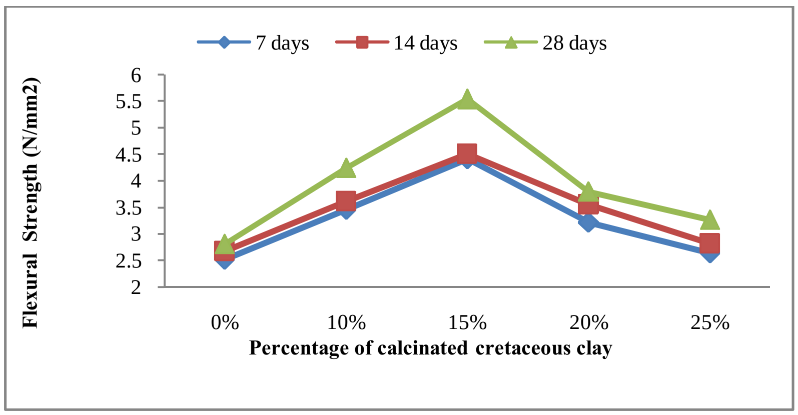

Fig. 4

When cement is replaced with 15% of calcinated cretaceous clay the flexural strength is 5.54 N/mm^2.

XRD Analysis

XRD was carried out for cretaceous clay on three samples. 1) Natural cretaceous clay, 2) 4 hrs of calcination, 3) 6 hrs of calcination.

Slump Cone Test

Test was conducted as per IS: 1199-1959. And the slump value of M30 grade concrete is 60mm.

Water Absorption

The water absorption of concrete is gradually reduced with the increase in percentage of calcinated cretaceous clay. The concrete with 25% of calcinated cretaceous clay has shown water absorption less than that of control at 14 and 28 days. The results are tabulated in Table 2.

Compressive Strength

Compressive strength of M30 concrete cubes incorporated with calcinated cretaceous clay was tested at 7, 14 and 28 days. It was observed that the compressive strength has increased with varying percentage of calcinated cretaceous clay as replacement for cement. Results of the test are presented in Table 3.

It has been found that at 15%, the compressive strength has increased. The concrete made with 20% calcinated cretaceous clay has yielded less compressive strength than the concrete with 15% calcinated cretaceous clay. However, concrete with 20% calcinated cretaceous clay has shown significantly higher than control.

Flexural Strength

Concrete prism made by M30 concrete incorporating calcinated cretaceous clay was tested at 7, 14 and 28 days. The results are tabulated in Table 4.

It is found that at 15% replacement of cement with calcinated cretaceous clay the flexural strength has increased. The concrete made with 20% calcinated cretaceous clay has yielded less flexural strength than the concrete made with 15% of calcinated cretaceous clay. However, even concrete with 20% calcinated cretaceous clay has shown higher flexural strength than control.

Result & Discussion

Kaolinite clay (cretaceous clay) taken from kaarai location was analyzed for its pozzolanic property. Chemical analysis was conducted as per IS: 1727 - 1967 and the results were compared with IS: 3812 - 1981. It is found that the cretaceous clay has pozzolanic property. The sample was subjected to calcination process at a temperature between 700°C to 800°C for 4hrs and 6hrs. From the XRD analysis it is found that the sample calcinated for 4 hrs is more amorphous and suitable for reaction.

In M30 concrete,cement is partially replaced with calcinated cretaceous clay in proportions varying from 0% to 25%. Test for water absorption was carried out and it was found that 15% replacement shows more absorption than 20% in initial days and after 14 days the value started decreasing and the difference is significant.

Considering the values from compressive strength and flexural strength, 15% of replacement shows significant improvement. The value started increasing from 0% of replacement and reached the maximum value in 15% of replacement and then started decreasing.

The compressive strength of M30 concrete when cement is replaced with 15% of calcinated cretaceous clay is 40.1N/mm^2.

Conclusion

From the above study and experiments, it is found that the cretaceous clay taken from Kaarai (*Trichy-Ariyaloor region*) is Kaolinate clay. This clay is suitable for replacement of cement, when it is calcinated for 4 hours at a temperature of 700°C to 800°C. In M30 concrete when the cement is replaced by 15%, of calcinated cretaceous clay, it increases the compressive and flexural strength significantly with good workability and less water absorption.

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Trend in Daily and Annual Maximum Discharge Time Series in Kerala

Vinayakam Jothiprakash[1], Drissia Thottungal[2] and Alayil Bahuleyan Anitha[3]

Abstract Changes in climate and consequent change in hydrological parameters is visible globally. Trend in Rainfall and temperature were studied in common to find the indication of climate change. In this study, long term changes in daily and annual maximum discharge is explored. About 43 gauging stations in west flowing rivers in Kerala were analysed in this study. For the trend analysis, Mann Kendall trend test, Sen's slope, Pearson test and Spearman rank correlation test were carried out. Mann Kendall trend test, Sen's slope and Spearman's rank correlation test are non-parametric test which does not require the time series to follow normal distribution. Daily discharge data showed a mixture of increasing and decreasing trend with 24 gauging station indicate a significant decreasing trend and 14 stations a significant increasing trend by Mann Kendall trend test and Sen's slope test. But in the case of annual maximum series, significant decreasing trend was identified in 16 gauging stations only, the other stations do not exhibit any significant trend. Pearson (r) correlation gave almost similar result as the Mann Kendall test with 30 gauging station showing weak trend in case of daily discharge time series. Whereas Spearman's rank correlation test gave 38 gauging stations exhibiting weak trend in case of daily time series. In case of annual maxima series, both Spearman's rank correlation test and Pearson (r) correlation showed similar result with 40 gauging station showing weak trend. The study indicates that flood time series is having significantly decreasing trend in few parts of the study area, though daily time series show signs of significant decreasing trend in majority of stations. Since water availability of the river basin is estimated using river flow, a decreasing trend in river flow is a serious issue in water management sector.

Keywords: Trend Analysis, Mann Kendall Test, Sen's Slope, Spearman Rank Test, Pearson Correlation Test

E-mail: [1]drissia13@gmail.com, [2]vprakash@iitb.ac.in, [3]aba@cwrdm.org

[1,2]Indian Institute of Technology Bombay, Mumbai

[3]Centre for Water Resources Development and Management, Kozhikode, Kerala

Introduction

The water yield of a river basin mainly depends on stream flow. Though rainfall is the primary parameters that influence the stream flow, it is in turn affected by many parameters like catchment area, slope, length of the streams and basin characteristics. The climate change and changes in the parameters that affect stream flow due to human intervention can cause variation in stream flow [1]. Changes in precipitation and temperature are reported in many places including India [2, 3]. Like all the other hydrological parameters, temporal variation of stream flow is also reported [4].

Daily, seasonal, annual maximum and minimum stream flow were found to show variation [5]. Mann Kendall trend test was employed in most studies to detect trend in any time series. The magnitude of the change can be determined using Sen's slope method [6]. In a study conducted in Turkey trend was computed using the Sen's T, the Spearman's Rho, the Mann-Kendall, and the Seasonal Kendall test [7]. All the above tests are non-parametric test which does not require the time series to be normal. In another study trend test was computed for different time periods in Switzerland [8]. The changes in streamflow was examined together with the changes in precipitation and temperature.

From the reported studies, it was understood that the increasing or decreasing the time series of hydrological parameters is specific to each location. Therefore, a study is attempted to understand the variation in annual maximum and daily discharge time series in west flowing rivers of Kerala.

Study Area and Data

Kerala, the southernmost state of India is taken as the study area. The location of the State is $8^o18'$ and $12^o48'$ N latitude and $74^o52'$ and $77^o22'$ E longitude. Kerala receives rainfall in two seasons (South west and North easte monsoon) with an average annual rainfall of 3000 mm [9]. There are 44 rivers in Kerala of which 41 flows towards westwards and joins Arabian Sea. The area of the river basins ranges from

6186 km^2 (Bharathapuzha) to 52 km^2 (Ramapuram). Some of the small river basins in Kerala does not possess gauging.

The stream gauge stations located in the west flowing rivers in Kerala is analysed to detect any changes in the streamflow. The daily and annual maximum discharge data of 43 gauging stations were obtained from Centre Water Commission, Government of India (20 stream gauge stations) and Water Resources Department, Government of Kerala (23 stream gauge stations). These stream gauge stations represent 26 west flowing rivers in Kerala. The details of the stream gauge stations are given in Table 1. The data availability ranges from 12 to 46 years. The location of the gauging stations is given in Fig. 1. The number given in the figure is same as the number given in the Table 1.

Table 1 Details of stream gauge stations

Sl. No.	Stream Gauge	River Basin	Starting Year	Ending Year
1	Manjeswaram	Manjeswar	1982	2008
2	Anakkallu	Uppala	1982	2011
3	Shiriya US	Shiriya	1965	2008
4	Shiriya DS	Shiriya	1980	2008
5	Madhur	Mogral	1982	2007
6	Moonnamkadavu	Chandragiri	1965	2010
7	Erivanjipuzha	Chandragiri	1985	2012
8	Kakkadavu	Karingode	1965	2008
9	Mangara	Kuppam	1980	2011
10	Irude	Valapattanam	1966	2009
11	Palapuzha	Valapattanam	1969	2010
12	Perumannu	Valapattanam	1985	2012
13	Kannavam	Anjarakandy	1969	2008
14	Meruvambai	Anjarakandy	1965	2011
15	Kuttiyadi	Kuttiyadi	2000	2012
16	Kollikkal	Korapuzha	1980	2011
17	Chaliyar	Chaliyar	1965	2006
18	Kanjirapuzha	Chaliyar	1965	2008
19	Kuniyil	Chaliyar	1981	2012
20	Karathodu	Kadalundi	1986	2012
21	Ambarampalayam	Bharathapuzha	1978	2011
22	Kumbidi	Bharathapuzha	1980	2012
23	Mankara	Bharathapuzha	1985	2002
24	Pudur	Bharathapuzha	1986	2012
25	Pulamanthole	Bharathapuzha	1986	2012
26	Arangaly	Chalakudy	1978	2012
27	Karuvannur	Karuvannur	1965	2009
28	Ambalakadavu	Chalakudy	1980	2004
29	Neeleeswaram	Periyar	1971	2012
30	Kalampur	Moovattupuzha	1986	2012
31	Ramamangalam	Moovattupuzha	1978	2012
32	Kidangoor	Meenachil	1986	2012

Sl. No.	Stream Gauge	River Basin	Starting Year	Ending Year
33	Teekoy	Meenachil	1980	2006
34	Manimala	Manimala	1970	2008
35	Kallooppara	Manimala	1986	2012
36	Malakkara	Pamba	1986	2012
37	Thumpamon	Achankoil	1978	2012
38	Kallelli	Achenkoil	1985	2008
39	Kollakkadavu	Achenkoil	1970	2010
40	Punalur	Kallada	1965	2010
41	Pattazhi	Kallada	1978	2012
42	Ayilam	Vamanapuram	1979	2012
43	Ottasekharamangalam	Neyyar	1971	2011

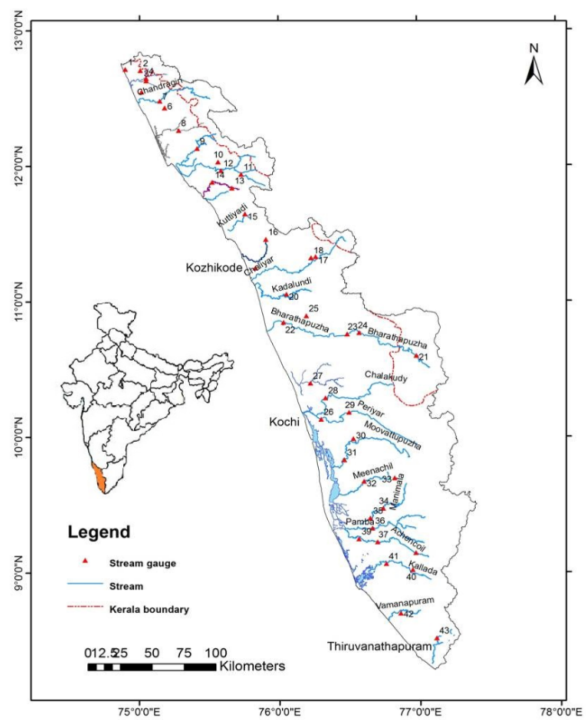

Fig. 1 Location of stream gauge stations

Methodology

Trend analysis was carried out by four methods 1. Mann Kendall trend test, 2. Sen's slope, 3. Spearman's rank correlation test and 4. Pearson rank correlation test. These methods are discussed in detail in following sections.

Mann Kendall Trend Test

Mann Kendall, a non-parametric test for identifying trends in time series data is used for the study. Non parametric test compares the relative magnitudes of sample data rather than the data values themselves. The Mann Kendall test was run at 5% significance level. The null hypothesis of no trend was checked with alternative hypothesis of decreasing or increasing trend. Let x_1, x_2, …... x_n represent n data points where x_j represents the data point at time j [10]. Then the Mann-Kendall statistic (S) is given by

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sign}(x_j - x_k) \quad (1)$$

Sign $(x_j - x_k) = 1$ if $x_j - x_k > 0$

$= 0$ if $x_j - x_k = 0$

$= -1$ if $x_j - x_k < 0$

The variance of S is calculated by,

Table 2 Results of trend analysis

Sl. No.	Stream Gauge	Catchment Area, km^2	Annual Maximum Discharge					Daily Discharge				
			Kendall's tau	Sen's Slope S	Pear Son r	Spear Man r	Trend	Kendall's tau	Sen's Slope S	Pear Son r	Spear Man r	Trend
1	Manjeswaram	25.44	-0.07	-0.186	0.09	0.017	DT	-0.026*	0.000	0.031*	0.000	SDT
2	Anakkallu	166.25	0.00	0	0.03	0.001	IT	0.188*	0.0006	0.032*	0.060	SIT
3	Shiriya US	322.56	-0.24*	-6.573	0.17*	0.180*	SDT	-0.062*	-0.000	0.014*	0.002*	SDT
4	Shiriya DS	348.00	-0.21	-6.166	0.21*	0.094	DT	-0.027*	0	0.012*	0.007*	SDT
5	Madhur	66.04	0.03	0.235	0.07	0.002	IT	-0.078*	0	0.034*	0.013*	SDT
6	Moonnamkadav	216.80	-0.19	-4.787	0.08	0.090*	DT	-0.036*	-0.000	0.000	0.002*	SDT
7	Erivanjipuzha	957.00	0.07	3.312	0.01	0.007	IT	-0.029*	-0.000	0.000	0.001*	SDT
8	Kakkadavu	276.50	-0.30*	-9.328	0.23*	0.220*	SDT	-0.119*	-0.000	0.012*	0.031*	SDT
9	Mangara	109.60	-0.35*	-19.30	0.00	0.273*	SDT	0.043*	0.000	0.003*	0.005	SIT
10	Irude	189.63	-0.26*	-12.40	0.17*	0.169*	SDT	0.003	0.0006	0.001*	0.000	IT
11	Palapuzha	237.25	-0.32*	-5.650	0.17*	0.195*	SDT	-0.011	-0.000	0.012*	0.154	DT
12	Perumannu	1070.00	0.23	19.392	0.14*	0.127	IT	0.021*	0.0009	0.000	0.001	IT
13	Kannavam	60.75	-0.25*	-1.249	0.14*	0.142*	SDT	-0.045*	-0.000	0.011*	0.005*	SDT
14	Meruvambai	180.00	-0.03	-0.435	0.00	0.051	DT	-0.017*	-0.000	0.000	0.000	DT
15	Kuttiyadi	238.00	-0.18	-5.911	0.00	0.016	DT	0.082*	0.0004	0.006*	0.019	SIT
16	Kollikkal	34.82	-0.13	-0.638	0.05	0.059	DT	0.043*	0.0002	0.002*	0.005	SIT
17	Chaliyar	386.00	-0.36*	-8.649	0.21*	0.241*	SDT	-0.213*	-0.001	0.024*	0.096*	SDT
18	Kanjirapuzha	64.00	-0.37*	-2.346	0.25*	0.309*	SDT	-0.088*	-0.000	0.003*	0.016*	SDT
19	Kuniyil	1876.00	-0.09	-8.317	0.00	0.016	DT	-0.094*	0.0003	0.000	0.021*	SDT
20	Karathodu	750.00	0.00	0.053	0.00	0.000	IT	-0.059*	0.0001	0.000	0.006*	SDT
21	Ambarampalayam	950.00	0.01	0.042	0.00	0.002	IT	0.078*	0.0002	0.001*	0.014	SIT
22	Kumbidi	5755.00	-0.07	-7.492	0.00	0.013	IT	0.009	0	0.000	0.000	IT
23	Mankara	2775.00	-0.06	-2.523	0.03	0.008	DT	0.020*	0.0006	0.000*	0.001	SIT
24	Pudur	1313.00	0.07	0.864	0.00	0.011	IT	0.000	0.0003	0.000	0.000	NT
25	Pulamanthole	940.00	0.05	3.517	0.00	0.003	IT	-0.002	0.0009	0.000	0.000	NT
26	Arangaly	1342.00	0.03	0.571	0.01	0.000	IT	-0.071*	-0.001	0.001*	0.011*	SDT
27	Karuvannur	725.00	-0.47*	-7.407	0.31*	0.418*	SDT	-0.090*	0	0.051*	0.015*	SDT
28	Ambalakadavu	1160.00	-0.49*	-21.08	0.38*	0.422*	SDT	0.143*	0.002	0.007*	0.053	SIT
29	Neeleeswaram	4234.00	-0.25*	-20.27	0.13*	0.140*	SDT	0.072*	0.003	0.001*	0.010	SIT
30	Kalampur	405.00	0.19	5.466	0.08	0.066	IT	-0.105*	-0.000	0.003*	0.021*	SDT
31	Ramamangalam	1208.00	0.17	5.011	0.06	0.060	IT	0.035*	0.0009	0.000	0.002	IT
32	Kidangoor	615.00	0.16	4.850	0.07	0.045	IT	-0.029*	0.0003	0.000	0.002*	SDT
33	Teekoy	57.00	-0.30*	-2.724	0.19*	0.236*	SDT	-0.105*	0	0.031*	0.019*	SDT
34	Manimala	490.00	-0.31*	-10.96	0.15*	0.171*	SDT	-0.087*	-0.000	0.018*	0.006*	SDT
35	Kallooppara	731.00	-0.01	-0.611	0.00	0.000	DT	-0.031*	-0.000	0.001*	0.002*	SDT
36	Malakkara	1713.00	-0.16	-10.53	0.09	0.066	DT	-0.056*	-0.001	0.002*	0.007*	SDT
37	Thumpamon	810.00	-0.02	-0.141	0.00	0.001	DT	-0.053*	-0.000	0.001*	0.006*	SDT

Sl. No.	Stream Gauge	Catchment Area, km^2	Annual Maximum Discharge					Daily Discharge				
			Kendall's tau	Sen's Slope S	Pear Son r	Spear Man r	Trend	Kendall's tau	Sen's Slope S	Pear Son r	Spear Man r	Trend
38	Kallelli	419.00	-0.41*	-7.533	0.35*	0.175*	SDT	0.112*	0.0006	0.001*	0.043	SIT
39	Kollakkadavu	952.71	-0.20	-2.765	0.06	0.106*	DT	-0.194*	-0.002	0.052*	0.078*	SDT
40	Punalur	870.00	-0.46*	-6.952	0.09*	0.401*	SDT	0.048*	0.0002	0.013*	0.004	SIT
41	Pattazhi	1210.00	-0.26*	-5.862	0.16	0.134*	SDT	0.027*	0.0003	0.005*	0.002	SIT
42	Ayilam	540.00	0.19	3.209	0.02	0.087	IT	-0.071*	0.0002	0.000	0.012*	SDT
43	Ottasekhara-mangalam	247.35	-0.01	-0.074	0.00	0.000	DT	0.232*	0.0002	0.033*	0.193	SIT

IT- increasing Trend, DT-Decreasing Trend, SIT-Significant Increasing Trend, SDT-Significant Decreasing Trend, NT-No Trend

$$\mathrm{Var}(S) = \frac{n(n-1)(2n+5)-\sum_{p=1}^{g} t_p\,(t_p-1)(2t_p+1)}{18} \quad (2)$$

The Z statistics is calculated as follows

$$Z=(S-1)/\ \mathrm{Var}\ (S)^{1/2} \text{ if } S>0 \quad (3)$$
$$=0 \text{ if } S=0$$
$$=(S+1)/\ \mathrm{Var}\ (S)^{1/2} \text{ if } S<0$$

The value of S illustrates the magnitude of increasing and decreasing trend depending upon positive and negative value respectively. But this has to be checked with the probability associated with S and number of data n to compute the significance of the trend. If the probability is lower than the significance level, then the null hypothesis was rejected.

Sen's Slope Method

Sen's slope estimator is a non-parametric estimator based on Kendall rank correlation method [11]. The unbiased estimator is the median of a set of point connecting each other. Slope estimator is estimated for N number.

$$X_{i,j}=(Y_j-Y_i)/(t_j-t_i) \quad (4)$$

Where Y_j and Y_i are data values at time t_j and t_i respectively provided j>i. N is the number of data pairs where j>i. The median of the X values is defined as the Sen's estimator of slope. The median is obtained by

Sen's Slope Estimator

$$S = X_{(N+1)/2} \text{ if N is odd} \quad (5)$$
$$=1/2\ (T_{N/2}+T_{(N+2)/2}) \text{ if N is even}$$

The sign of the S value indicates the decreasing and increasing trend and its magnitude given an idea of change per unit time.

Spearman's Rank Correlation

The Spearman's rank correlation coefficient was used to make sure that there is no trend present in time series. This method is also a non-parametric method. The Spearman's rank correlation coefficient, R_{sp} is estimated as follows.

$$R_{sp} = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \quad (6)$$

Where n is the number of data points, d is the difference in the rank which is computed by

$$d_i=kx_i-ky_i \quad (7)$$

Where kx_i is the chronological order number of variable x and ky_i is the rank equivalent of variable y by assigning corresponding order number in ranked series. The null hypothesis Ho is taken as R_{sp} is zero indicating there is no trend and alternative hypothesis, H1is taken as R_{sp} is greater than or less than zero indicating there is trend.

$$t=R_{sp}\ \sqrt{((n-2)/\ (1-R_{sp}^{2}))} \quad (8)$$

Where t is student's t statistics

Pearson Correlation Coefficient

Pearson correlation coefficient test is a parametric test. The assumption made in this are the time series is normally distributed. The test is similar to Spearman's rank correlation test which is explained in the above section.

Results and Discussions

Trend in daily and annual maximum discharge time series were analysed using Mann Kendall test, Sen's slope, Pearson rank correlation method and Spearman rank correlation method. The results of trend test are given in Table 1. The stations that showed significant trend in more than one method are considered with trend.

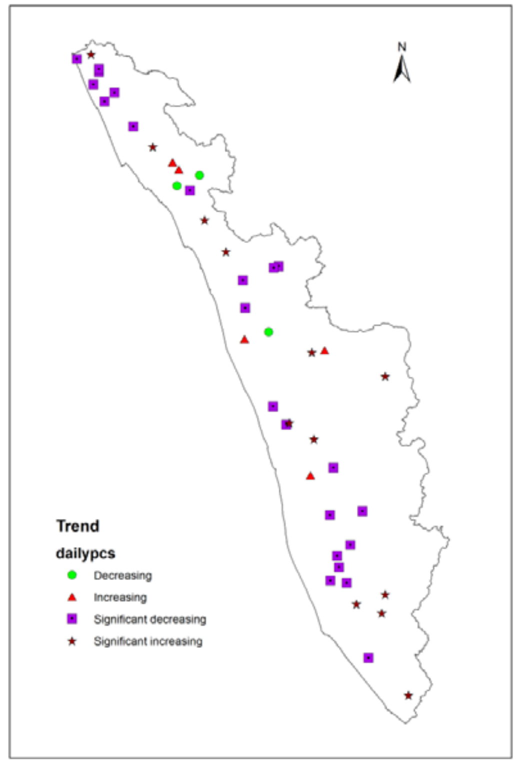

Fig. 2 The location of stream gauges showing significant decreasing and increasing trend in daily discharge series

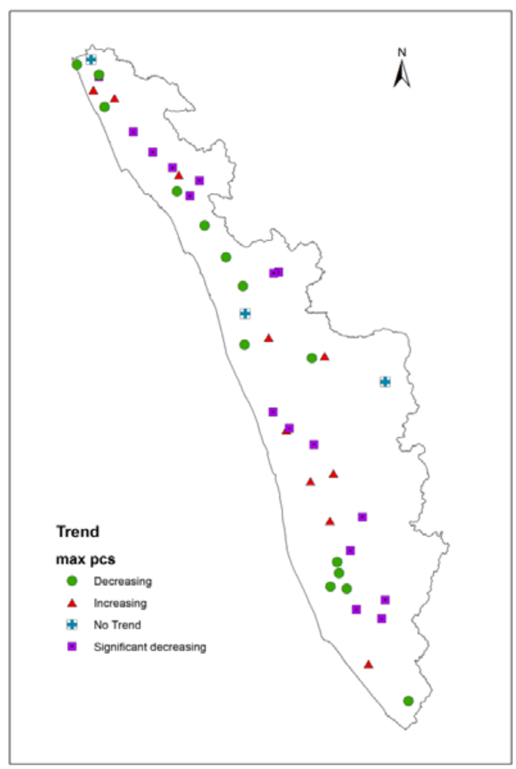

Fig. 3 The location of stream gauges showing trend in annual maximum discharge series

Daily discharge series exhibits significant trend majority of station with 23 gauging station exhibiting significant decreasing trend and 12 significant increasing trend. The strength of the trend is analysed form Pearson correlation coefficient and Spearman's rank correlation method. Based on the values of the Spearman's rank correlation coefficient except three gauging station all the stations show r value less than 0.39 only. The value less the 0.39 indicates weak trend [12]. In daily time series, though most of the stations exhibit significant trend, the strength of the trend is very weak. Also the magnitude of change estimated using Sen's slope is very meagre almost nearer to zero. The location of gauging station showing significant and insignificant trend in daily discharge series is shown in Fig. 2. The stations located in North Kerala and near to South which are draining to Vembanad lake are exhibiting decreasing trend. Significant increasing trend in daily discharge is visible in six stations Mangara, Ambalakkadavu, Neeleswaram, Kalleli, Punalur and Pattazhi.

Annual maximum discharge series is significantly decreasing in some stations. Significant decreasing trend is found in only 16 gauging stations and no significant increasing trend. In this case also the strength of the trend is weak except in Punalur, Ambalakkadavu and Karuvannur site. The magnitude of significant change in annual maximum discharge as per the Sen's slope varies from 1.249 m^3/s in Kannavam to 21.084m^3/s in Ambalakkadavu. The location of gauging station showing significant and insignificant trend is shown in Fig. 3. The stations with significant decreasing trend are located spatially throughout the basin. There are eight gauging stations that is significantly decreasing in both daily discharge and annual maximum discharge series. Altogether, the number of stations with decreasing trend and significantly decreasing trend is more both in Daily time series as well as annual maximum discharge series. This shows that the quantity of flow in the rivers is getting reduced year by year.

Conclusion

The trend analysis was carried out by Mann Kendall trend test, Sen's slope, Spearman's rank correlation test and Pearson test. Each test has its own characteristics. Daily discharge series appeared to be significantly increasing and decreasing in 81% of stations (53 % decreasing and 28% increasing). But the magnitude and strength of the trend is meagre. In the case of annual maximum discharge only decreasing trend was proven that too in 37% of stations. These observations were made with the observed stream flow data. There are many hindrances in the flow such as dams, weirs and check dam existed. Yet the study gives an insight to the long term trend in the observed stream flow and its spatial variability.

Acknowledgment

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Under Water Acoustic Recording System for the Arctic Region

Thirunavukkarasu Ayyadurai[1], Raguraman Govindan[2], Ashokan Muthuraj[3], Latha Ganesan[4], Venkatesan Ramasamy[5], Dhanaraj Chinnaya[6], Nithyanandam Kannan[7] and Edwards Durai Paulsamy[8]

Abstract The measurement of ambient noise in the Arctic region is challenging due to ice coverage and sub-zero temperature prevailing in the region. In India, under Ocean Acoustics programme of National Institute of Ocean Technology (NIOT), an autonomous under water acoustic recording system has been developed and incorporated with Indian Arctic (IndARC) mooring system developed by Ocean Observation System (OOS) programme of NIOT. The objective of the underwater acoustic recording system is to record time series ocean ambient noise data in Kongsforjden of the Arctic region and to study the dynamics of the sea ice cover, movements and oscillations of ice flows and also various mammal noises. This paper presents the design and development of the system for withstanding the harsh environment prevailing in the region. The system consists of two major components; (i) the hydrophones used for passive acoustic measurements and (ii) the data acquisition system with indigenously developed underwater pressure casing. Cetacean make hydrophone has been used for collecting the data. Data acquisition system is enclosed in an underwater pressure casing along with the battery pack. Stainless steel 316L pressure casing has been developed asper American Society of Mechanical Engineers (ASME) code with a pressure rating of 10bar. After completion of various testing with pressure casing, data acquisition system with battery pack and the acoustic sensor, the system has been successfully collected data for 240 days in Kongsfjorden of the Arctic region along with Ind ARC mooring of the OOS.[1]

Keywords: Hydrophones, Pressure casing, Data Acquisition System

E-mail: [1]vathiru@niot.res.in

[1,2,3,4,5,6,7,8]National Institute of Ocean Technology, Chennai, India

Introduction

The research study of underwater ambient noise in the arctic region started back in the year 1960 and the area of study was further extended to the Arctic fjord in the year late 2011 which contain glaciers and fresh water ice [1]. There are already well developed systems available to study the ice glacier and its movement using Global Positioning System (GPS), Radar, Satellite images, Seismometer etc. The study of ambient noise for short term measurement [2] was carried out in the year 2007. Similarly ambient noise measurements were conducted from a rubber boat with a omnidirectional hydrophone for a day [3] in the year 2011. But only very few underwater acoustic recording systems for long term study of ambient noise were carried out in the Arctic region due to design limitations for the harsh environment prevailing in the region. Data collection using the acoustic recording system from Comprehensive Nuclear Test Ban Treaty organization [4] deployed in the Framstrait nearer to polar region collected data for 16 months. The knowledge and experience gained from the underwater acoustic recording system development of the Indian seas helped much to develop the underwater acoustic recording system for polar region measurements and incorporation of the same with the IndARC mooring system developed by OOS programme of NIOT.

Methodology

National Centre for Antarctic and Ocean Research (NCAOR) established in 1998 that works under the Ministry of Earth Sciences (MoES) takes the lead in scientific expedition including long term monitoring of the Kongsfjorden system of the Arctic region for climate change studies. NIOT, jointly with NCAOR, has deployed a mooring system called "IndARC" in Kongsfjorden fjord, Arctic for long term measurements. IndARC system consists of sensors for subsurface measurements including CTD (Conductivity, Temperature and Depth), ADCP (Acoustic Doppler Profile), and current meter along with underwater acoustic recording system for time series measurements for one year. In the year July 2015, Ocean Acoustic group of NIOT developed and deployed an underwater acoustic recorder with single hydrophone and the system was retrieved in the year July 2016.The system collected data for more than 270 days. Further enhancement of the acoustic recording system with two hydrophones, the acoustic recorder was carried out and deployed in July 2016 and retrieved during July 2017 with total ambient data collection of 240 days.

SYSTEM DESCRIPTION

Underwater acoustic recording system for the Arctic Region has two distinct components. First one is the Data Acquisition System (DAS) with indigenously developed underwater pressure casing (Fig.1) and the other is the two numbers of cetacean make hydrophone (Fig.2) used as an acoustic sensor with cable. This has been incorporated in the IndARC mooring and fixed in a Polyvinyl chloride (PVC) fixture to avoid bio-fouling and corrosion. Data acquisition system consists of National Instruments based data acquisition card along with a processor card and flash drive memory of 1 Tera Byte. The DAS is designed for 8 months data collection.

Fig. 1 DAS with underwater pressure casing

Fig. 2 Cetacean make hydrophone

Fig. 3 Battery enclosure

Table I System configuration

Sampling rate	25 kHz.
Sampling time	180 seconds.
Sampling period	Hourly once
System memory availability	1TB
Number of hydrophone	2Nos Cetacean make
Hydrophone depth	34m & 36m from surface
Battery pack Capacity	510 Ah

An indigenously developed battery enclosure (Fig. 3.) with a rating of 18V, 510Ah connected in parallel is fixed inside the pressure casing which has been rated for 10 bar. The system configuration of the Acoustic recording system for the Arctic shown in the below Table I.

TESTING OF THE SYSTEM

Major constraints involved in the development of the underwater acoustic recording noise system for the Arctic region is low temperature. The system and its component should always maintain the ruggedness and capability to withstand the low temperatures. The following were the various testing carried out at NIOT before the shipment of the ambient noise measurement system to the Arctic. The tests are:

2.2.1 Pressure testing of underwater casing
2.2.2 Buoyancy testing of pressure casing
2.2.3 Environmental testing of the system
2.2.4 Air and Wet Lab testing of the system

Pressure Testing of the Underwater Casing

The pressure casing that contains with special underwater connectors was tested for a pressure of 10 bar for 1 hour duration at Hyperbaric Test Facility of NIOT.

Buoyancy Testing of the Pressure Casing

Buoyancy is an important factor for deciding the weight of the underwater pressure casing when it is to be considered for the sub surface mooring particularly for the Arctic–IndARC System. The underwater pressure casing was indigenously designed and developed as per ASME code VIII [5]. Elastomer made O-ring as per IS 9975 was used in the pressure casing with three sub Conn made underwater connectors. Net buoyancy of the pressure casing was 46kg (negative). To get the neutral buoyancy of the system, appropriate floats were added to compensate the negative buoyancy. The photos which taken during the pressure testing were shown in the below Fig. 4.0.

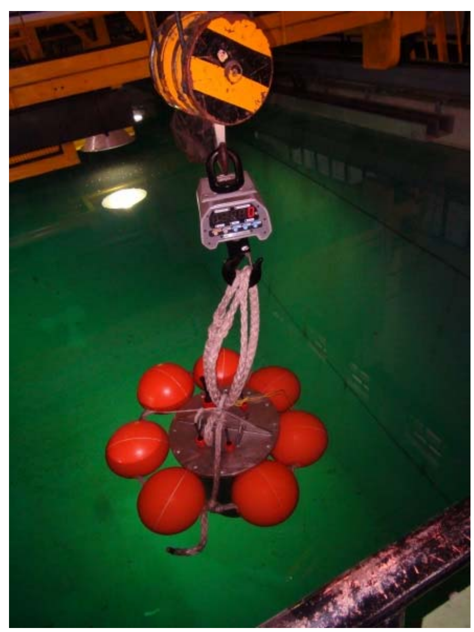

Fig. 4 Buoyancy testing of pressure casing

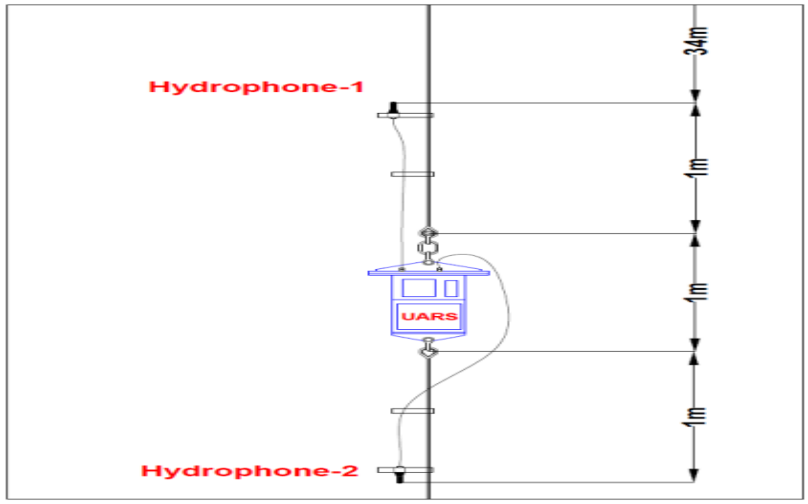

Fig. 5 Acoustic system with IndARC mooring

Environmental Testing of the Acoustic Recording System

Low temperature is a key factor in the polar region. All the system and its components related to the Arctic region were assembled and successfully tested at the Environmental Test Facility of NIOT for the temperature range from -5°C to 40°C with a duration of 6 hour. Ambient Noise system along with a thermistor was simultaneously acquired the data to check the functioning of DAS and Battery casing. In addition to that other materials like Adhesives–Anabond 666, Silicon Grease, Tie-wrap, Insulation tape and rubber tape used for the Arctic region were also successfully tested in the environmental chamber.

Air/Wet Lab Testing of the System

Testing of Data Acquisition system with hydrophone in the air was carried out after assembly of the system with Pressure casing. Similarly the assembled system was tested with known signal at Acoustic Test Facility of NIOT.

Testing of System at the Arctic Environment

The system assembled with data acquisition and batteries were tested at Longyearbyen, Norway with hydrophone before transit to the deployment location Norway. Proper adhesives and anode for anti-corrosion were provided on the underwater pressure casing. Suitable electrical insulation agents were applied to the various electronics of the DAS.

Integration of the Acoustic Recording System with IndARC Mooring

The integration of the underwater acoustic recording system with the IndARC mooring was carried out by connecting steel floats and two glass floats of 50kg buoyancy that are used to maintain the neutral buoyancy of the acoustic recording system with hydrophone. The Acoustic system is fixed at 34m from the sea surface and the hydrophone is fixed at 1.0m above and below the underwater pressure casing. The hydrophones are kept looking to the sea surface as well as to collect the major noise induced due to wind, waves, ice braking and other noise sources. The details of the connections are shown in the following Fig. 5.

Deployment of IndARC with Acoustic Recording System

The deployment of the IndARC mooring was performed availing the Norwegian polar Research Institute research vessel R. V. Lance with buoyancy steel floats, glass floats, underwater acoustic recording system, hydrophone, and environmental sensors like CTD, ADCP, Acoustic release and finally sinker weight. The deployment was carried out on 27/07/2016 at 190m ocean depth at the location Latitude of N78°56.789′ and Longitude of E012°00.889′.

Retrieval of Underwater Acoustic Recording System

The deployed underwater acoustic recording system with IndARC mooring components were retrieved on 19/07/2017 with a successful ambient data collection for the expected design life.

Results and Discussion

Ambient Noise measurements were made with purpose built directional acoustic data buoy [6] consisting of two ITC made hydrophones mounted 0.43m apart on a horizontal bar and connected to surface float by a 1m long vertical support and collected data for short period only. The underwater acoustic recording system developed by NIOT, India for the polar region measurement has measured data for 8 months continuously. The data analysis have revealed significant results which would be useful in climate change studies and rises the confidence of making for the higher configuration system.

Conclusion

The prestigious underwater acoustic recording system with a rated depth of 100m developed first time in India for the polar measurement has been successfully deployed and it proved its stability and extreme weather conditions for all the seasons in a year. The design of a system for more depth rating with array of hydrophone has already started for further research work.

Acknowledgement

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Waste Water Treatment using Water Hyacinth

Rajendra B. Magar[1], Afroz N. Khan[2] and Abdulrazzak Honnutagi[3]

Abstract The roots of Water hyacinths (WH) naturally absorb pollutants including lead, mercury, and strontium-90, as well as some organic compounds which are carcinogenic and have concentrations of approximately 10,000 times that is present as in generically found water. WH can be cultivated for waste water treatment and it can be used to aid the process of water purification either for industrial waste water or sewer water, in addition to available techniques. The root structures of water hyacinth provide a suitable environment for aerobic bacteria to remove various impurities present in water. This study attempts to evaluate the effect of WH in two different types of sewer or drainage line, one from water closet and another from bath or shower room. Further, the reading for various parameters like Potential of hydrogen (pH), Turbidity, Chemical oxygen demand (COD), chloride and color has been periodically taken every 24 hrs for 5 days. The effect of WH has resulted in significant decrease in turbidity and due to which the removal of flocs and reduction in organic matters in water have been observed. The primary purpose of this study is to make use of the water hyacinth plant for the purification of the industrial waste water and its treatment.

Keywords: Hyacinth Plant; Aquatic Plants; Water Purification

Introduction

Conventional treatment methods such as trickling filter, activated sludge process etc. are used in order to treat sewage. Thus energy, cost, manpower is consumed in a large amount. Just as non-conventional sources are now necessary over conventional sources for the mode of energy, eco-friendlier and energy saving ways to treat sewage is the need of time and should be put to use. The natural ways are extremely cost saving. Water hyacinth is a free-floating perennial aquatic plant native to tropical and sub-tropical South America. With broad, thick, glossy, ovate leaves, water hyacinth may rise above the surface of the water as much as 1 meter in height. The leaves are 10–20 cm across, and float above the water surface. They have long, spongy and bulbous stalks. The feathery, freely hanging roots are purple-black. An erect stalk supports a single spike of 8–15 conspicuously attractive flowers, mostly lavender to pink in color with six petals. One of the fastest growing plants known, water hyacinth reproduces primarily by way of runners or stolons, which eventually form daughter plants. It also produces large quantities of seeds, and these are viable up to thirty years. The common water Hyacinth (Eichhorniacrassipes) is vigorous growers known to double its population in two weeks. The plant is extremely tolerant and has a high capacity for the uptake of heavy metals, including Cd, Cr, Co, Ni, Pb and Hg, which could make it suitable for the bio-cleaning of industrial wastewater. In addition to heavy metals, Eichhorniacrassipes can also remove other toxins, such as cyanide, which is environmentally beneficial in areas that have endured gold mining operations. Water hyacinth removes arsenic from arsenic contaminated drinking water. It may be a useful tool in removing arsenic from tube well water in Bangladesh.

The conventional treatment system like activated sludge process and trickling filters require energy input for treatment of waste water. Moreover, in rural areas it is very difficult to practice such treatment process due to economic and space concern. Also skilled labors are required to operate such treatment plants. Hence we need to find economical and efficient substitute for such treatment plants which should be eco-friendly. Water hyacinth is a type of aquatic floating plant systems which do not require any energy consumption. It can be adopted in rural areas where conventional treatment methods cannot be used due to economic and space concern. It is an eco-friendly type of system and hence has greater scope in nearby future and can

E-mail: [1]rajendramagar69@gmail.com, [2]afroz.nk@gmail.com, director.aiktc@gmail.com

[1]Professor and Head, Civil Engineering Department, Kalsekar Technical Campus, School of Engineering and Technology, New Panvel, Maharashtra, India

[2]Lecturer, Civil Engineering Department, Kalsekar Technical Campus, School of Engineering and Technology, New Panvel, Maharashtra, India

[3]Director, Kalsekar Technical Campus, School of Engineering and Technology, New Panvel, Maharashtra, India

be proved as a beneficial substitute for conventional treatment method. The objective of the study is to measure the growth rate and Evapotranspiration of water hyacinth test its efficiency parameters like Chemical Oxygen Demand (COD) removal, total solids (TS) removal and compare it with waste stabilization pond.

Literature Review

Phytoremediation is one of the biological wastewater treatment methods [1], and is the concept of using plants-based systems and microbiological processes to eliminate contaminants in nature. The remediation techniques utilize specific planting arrangements, constructed wetlands (CW), floating-plant systems and numerous other configurations [2]. The removal of wastewater constituents is achieved by different mechanisms like sedimentation, filtration, chemical precipitation, adsorption, microbial interactions, and uptake of vegetation [3], among which, the most effective technology is phytoremediation strategy using CW technology. Besides water quality improvement and energy savings, CWs have other environmental protection features such as promoting biodiversity, providing habitat for wetland organisms and wildlife (e.g. birds and reptiles in large systems) [4], serving climatic (e.g. less CO_2 production [4]; hydrological functions and bio methylation [5]). These systems are generally cost effective, simple, environmentally non-disruptive [1,6] ecologically sound [7] with low maintenance cost [8] and low land requirements [9]. The principles of phytoremediation system are to clean up contaminated water, which include identification and implementation of efficient aquatic plant; uptake of dissolved nutrients and metals by the growing plants; and harvest and beneficial use of the plant biomass produced from the remediation system [9].

The most important factor in implementing phytoremediation is the selection of an appropriate plant [1,10], which should have high uptake of both organic and inorganic pollutants, grow well in polluted water and easily controlled in quantitatively propagated dispersion [1]. The uptake and accumulation of pollutants vary from plant to plant and also from specie to specie within a genus [11]. The economic success of phytoremediation largely depends on photosynthetic activity and growth rate of plants [7], and with low to moderate amount of pollution [12]. Many researchers have used different plant species like Water Hyacinth (Eichhorniacrassipes (Mart.) Solms) [12–20], Water Lettuce (Pistia stratiotes L.) [21–25], Duckweed (Water Lemna), Bulrush (Typha), Vetiver Grass (Chrysopogonzizanioides) [1, 26–28] and Common Reed (Phragmites Australis) for the treatment of water. Researchers have used these species for different types of contaminated waters, effluents etc.

Mkandawire and Dude [29] have used duckweed and they found its growth was restricted above 34 C and pH sensitive. Mashauri *et al.* [30] used bulrush and his study revealed that the total dissolved solids (TDS) and electrical conductivity (EC) concentration was increased after treatment. Baskar *et al.* [31] in his study of kitchen wastewater treatment found only 4% TDS removal by common reed. Hence water hyacinth, water lettuce and vetiver grass were selected for review because they efficiently remove the heavy metals and other pollutants with high reproduction rate, efficiency and tolerance of ecological factors. In this paper, role of these plant species have been discussed for the removal of water contaminants.

Methodology

Conventional wastewater treatment consists of a combination of physical, chemical, and biological processes and operations to remove solids, organic matter and, sometimes, nutrients from wastewater. General terms used to describe different degrees of treatment, in order of increasing treatment level, are preliminary, primary, secondary, and tertiary and/or advanced wastewater treatment. In some countries, disinfection to remove pathogens sometimes follows the last treatment step. A generalized wastewater treatment diagram is shown in Fig. 1.

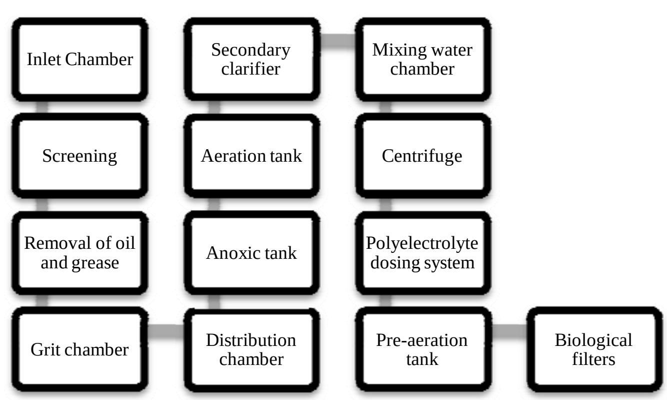

Fig. 1 Sewage treatment process

Table 1 Influent and effluent standards at stps

Parameter	Influent	Effluent
Temperature (in ºC)	Ambient	Ambient
pH	6–8.5	6.5–8.5
BOD_5 (mg/l)	250	< 20
COD (mg/l)	400	< 250
Oil and Grease (mg/l)	30	< 10
Total Solids (mg/l)	350	< 30
Residual Chlorine (mg/l)	–	< 1
Nitrate (mg/l)	–	< 10
NH3 (mg/l)	–	1.5–2

Fig. 2 Water hyacinth being weighed

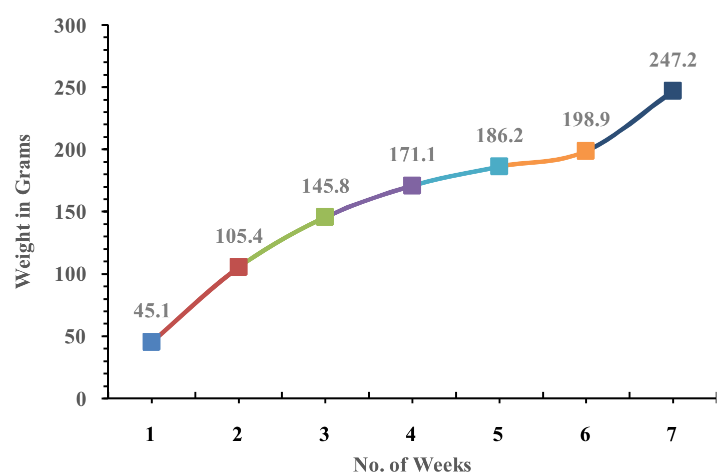

Fig. 3 Per week growth rate of water hyacith

Table 2 Observation table for evapotranspiration

Day	Mean Temp (°C)	Evaporation (cm/Day)	Evapotranspiration (cm/Day)
Feb-15	26.5	0.4	1.0
Feb-16	26.5	0.4	1.0
Feb-17	26.4	0.4	1.0
Feb-18	27	0.4	1.0
Feb-19	27	0.4	1.0
Feb-20	26.5	0.4	1.0
Feb-21	27	0.4	1.0
Feb-22	27.5	0.4	0.9
Feb-23	27.5	0.4	1.1
Feb-24	28	0.4	1.1

Table 3 Results of batch 1 samples

Test	Sample 1 (Water Hyacinth)			Sample 2 (Waste Stabilisation Pond)		
	Day 1	Day 3	Day 5	Day 1	Day 3	Day 5
Ph Paper	8	7	7	8	7	7
Ph Meter	6.95	6.93	6.93	6.95	6.96	6.94
Ts	937	400	280	937	360	240
Ds	533.6	280	150	576	160	100
Ss	403.4	120	130	360	200	140
Cod(mg/lit)	550	757.57	549.24	550	314	180
Chloride	179.9	174.95	169.95	180	179.95	179.95
Color	Black	Light Grey	Dark Grey	Black	Brown	Dark Brown

From the above Fig. 1, The different processes of conventional waste water treatment include, such as Inlet Chamber, Screening, Removal of Oil and Grease, Grit Chamber, Distribution Chamber, Anoxic Tank, Aeration Tank, Secondary Clarifier, Mixing water chamber, Centrifuge, Polyelectrolyte Dosing System, Pre- Aeration Tank and Biological Filters.

The standards of Influent and Effluent have been obtained from Sewage Treatment plant as shown in Table 1.

As the Sewage treatment plants (STPs) mainly comprises of units like Aeration Tank, mixing water chamber, Centrifuge, Polyelectrolyte Dosing System, Pre-aeration tank, Biological filters and Chlorine Mixing tank etc. hence high amount of electricity is required for various operations of mixing and aeration purpose. STP is located at a place where load shedding is prominent which has resulted into decrease in the efficiency of plant. Humus formed is difficult to remove. Moreover, the efficiency of COD removal was also low.

Waste Water Treatment by Water Hyacinth

Water hyacinth is aquatic vascular plant with rounded, upright and shiny green leaves and lavender flowers similar to orchids. It is fast growing perennial with great reproduction potential. Growth of water hyacinth is primary dependent on ability of plant to use solar energy, nutrient composition of water, cultural methods and environmental factors. Optimal water pH for growth of this aquatic plant is neutral but it can tolerate pH values from 4 to 10. This is very important fact because it points that water hyacinth can be used for treatment of different types of wastewater. Optimal water temperature for growth is 28–30oC. Temperatures above 33°C inhibit further growth.

Table 4 Results of batch 2 samples

Test	Sample 1 (Water Hyacinth)			Sample 2 (Waste Stabilisation Pond)		
	Day 1	Day 3	Day 5	Day 1	Day 3	Day 5
Ph Paper	8	7	7	8	7	7
Ph Meter	6.95	6.93	6.93	6.95	6.96	6.94
Ts	2650	1113	660	2650	1018	712
Ds	1100	578	300	1100	500	750
Ss	1550	535	360	1550	518	362
Cod(mg/lit)	815	420	250	815	460	290
Chloride	50	49	48	50	50	50
Color	Black	Grey	Dark Grey	Black	Brown	Dark Brown

Growth Rate

Water hyacinth is fast growing perennial aquatic macrophyte. It is a member of pickerelweed family. This tropical plant spread throughout the world in late 19th and early 20th century. Today it is well-known for its reproduction potential and as a plant that can double its population in only twelve days. Water hyacinth is also known for its ability to grow in severe polluted waters. Just like all other biological processes growth of water hyacinth depends on various ecological factors. The qualities of water and air temperatures are considered as main limiting factors for regular plant development and growth. Water hyacinth is growing fastest at temperatures from 200C to 300C, but growth fully stops at temperatures from 80C to 150C.To understand the growing ability of water hyacinth, its growth rate was studied.

Above Fig. 2 shows a water hyacinth plant which was taken and allowed to grow in a bucket of capacity 16 lit. with fresh water. Weight of this water hyacinth plant was taken weekly in a digital weighing machine (Least count of 0.1g) for seven consecutive weeks and a weight Vs time graph was obtained. Fig. 3 shows the growth rate of water hyacinth was 33 gm/week

Fig. 3 shows the growth rate of water hyacinth was 33 gm/week. Especially in the seventh week the growth of water hyacinth was more due to the growth of new leaves and development in its root system. From the graph obtained it can be concluded that water hyacinth can double its population in less than two weeks, with an average local temperature of 240 C to 340C.

Evapotranspiration of Water Hyacinth

Two barrels of 50 litres capacity each (one with water hyacinth and another without water hyacinth) were taken and filled with equal volume of water (30 litres). After 24 hours the depleted water levels were measured in both the barrels. The difference between the readings of the barrels will give the transpiration rate of water hyacinth whereas the reading of the barrel in which the water hyacinth was kept will give the Evapotranspiration. Below Table. 2 shows an observation for evapotranspiration.

From the Table. 2 it has been observed that, the evapotranspiration of water hyacinth was found to be 1.235 cm/day in the month of Feb-2017.

Results and Discussions

The waste water sample taken for Batch 1 was the effluent from the toilet and bathroom chamber. Both the barrel was filled with the effluent waste water. The water hyacinth barrel was stocked with 2kg net weight of plants, having roots 10–40 cm long. The detention time of 5 days was applied to both the barrels. Table 3 gives the reduction in waste water quality parameters for batch 1.

From Table 3, it has been observed that, the total solid (TS) efficiency using water hyacinth (WH) was 70.11% and that of the waste stabilisation pond was 74.38%. The dissolved solid (DS) using WH is 71.89% to that of 82.6% of waste stabilisation pond (WSP). The Chemical oxygen demand (COD) using WH gave efficiency up to 0.14 % as compared to 63.7% using WSP. It may be because of excess weight of plant used in the WH barrel. More than 2kg/m2 plant weight were introduced in the barrel with waste water. Hence the plant did not give the maximum results and the COD in fact increased instead of decreasing.

The waste water sample taken for Batch 2 was the effluent from the toilet and bathroom chamber. Both the barrel was filled with the effluent waste water. The water hyacinth barrel was stocked with 2kg net weight of plants, having roots 10–40 cm long. The detention time of 5 days was applied to both the barrels. Table 4 gives the reduction in waste water quality parameters for batch 2.

The TS efficiency using water hyacinth was 75.09% and that of the waste stabilization pond was 68.2%. The DS using WH is 72.89% to that of 31.6% of WSP. The COD using WH gave efficiency up to 69.33% as compared to 64.41% using WSP. The plant showed great capacity to treat the waste water in this range. The efficiency increased almost two fold and the COD reduced to a considerable extent.

Summary and Conclusion

Water hyacinth can be used to treat sewage with effluent standards within the range 750–850mg/lit. It is highly suitable for tropical wet and dry climate. Also, requires minimal space for the set-up and if the waste water flow is high, then a series or parallel set-up of water hyacinth can be done, thus using land and space to the maximum extent. The plant doesn't require any energy for its function and hence it is suitable where there isn't proper supply of power or where the cost of energy is too high.

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Group B

- **Computer Engineering**
- **Electrical Engineering**
- **Electronics & Telecommunication Engineering**

A Survey Paper on Implementation of VLSI Architecture for Internet of Things Applications

Anitha V.[1] and T. Menakadevi[2]

Abstract The "Internet of things" (IoT) is becoming a growing topic of in both the workplace and also outside of it. It's a concept that not only has the potential to impact how we live but also how we work. The IoT can integrate physical world directly to the computer-based systems it also allows objects to be sensed or controlled remotely across the existing network infrastructure. IoT results in improved efficiency, accuracy and economic benefit in addiction to reduced human invention. The challenge for IoT is to handle vast amount of sensing the data generated from smart devices that are resource limited and subject to missing data due to link failures. The IoT applications on VLSI (Very Large Scale Integration) platform have received a significant attention from the research community in the past few years. A survey for implementing the VLSI architectures for IoT applications is proposed in this paper for analyzing various architectures such as Application Specific Integrated Circuit (ASIC), Field Programmable Gate Array (FPGA), System On Chip (SOC) etc.

Keywords: VLSI, Internet of Things (IoT), Field Programmable Gate Array, Application Specific Integrated Circuit, System On Chip.

Introduction

Internet of Things (IoT)

Internet of Things (IoT) is a system of connected physical objects or devices that are accessible through the internet. The 'thing' in IoT could be a person with a heart monitor or an automobile with Built-in-sensors, i.e. objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention. The embedded technology which has been embedded in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken. IoT connects a number of devices embedded to the main server internet. When devices/objects can represent themselves digitally they can be controlled from anywhere. This connectivity then helps us to collect more data from more places, ensuring lot of ways in increasing efficiency and improving safety and security.

IoT is a transformational force that can help the sectors to improve their performance through IoT analytics and IoT Security to deliver better results. businesses in the utilities, oil and gas, insurance, manufacturing, transportation, infrastructure and retail sectors.

All these can improve the benefits of IoT by making it more informed decisions, aided by the flow of interactional and transactional data at their disposal. This new way of connectivity is going beyond laptops and Smart phones which are towards connected cars, Smart homes, connected wearable, smart cities and connected healthcare [1]. Basically it is said to be a connected life. According to Gartner report as shown in Table I, by 2020 connected devices across all technologies will reach to 20.6 billion.

The Architecture of an IoT System

Internet of Things is a global environment where every day devices become smarter, processing becomes intelligent, and communication becomes informative. A survey by P.PRay describes about the IoT oriented architectures which are capable enough to improve the understanding of related tool, technology, and methodology to facilitate developer's requirement [2]. The survey describes the current trends of architectures to motivate the academics and industries to get involved into the exact power of IoT.

The architecture of an IoT system includes the following four stages namely:

E-mail: [1]aniveluece@gmail.com., [2]menaka_sar@rediffmail.com.

[1]Ph.D Scholar, Department of Electronics and Communication Engineering, Adhiyamaan College of Engineering, Hosur, Tamil Nadu, India

[2]Professor, Department of Electronics and Communication Engineering, Adhiyamaan College of Engineering, Hosur, Tamil Nadu, India

Table 1 Estimated number of connected devices

Year	Number of Connected Devices
1990	0.3 million
1999	90.0 million
2010	5.0 billion
2013	9.0 billion
2025	1.0 trillion

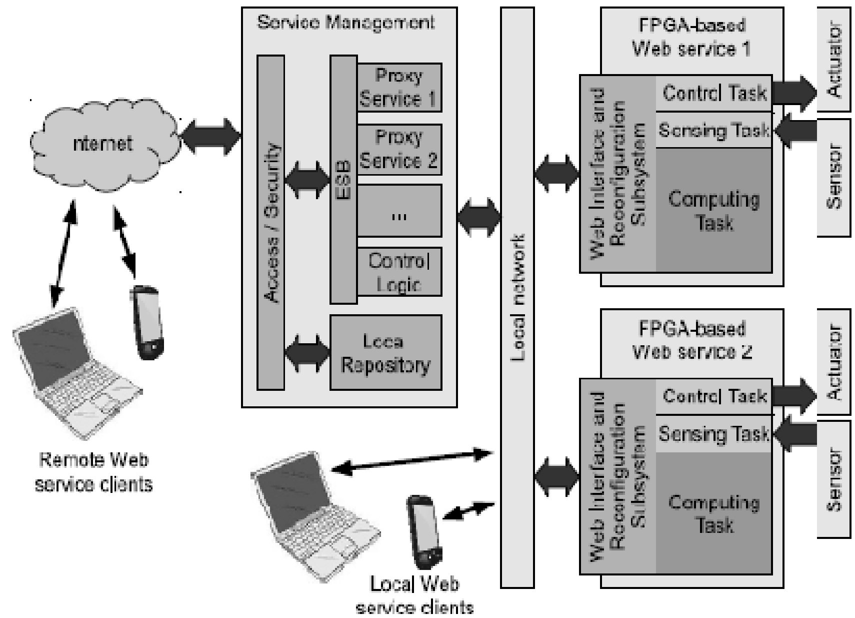

Fig. 1 General concept of networked reconfigurable FPGA based web service

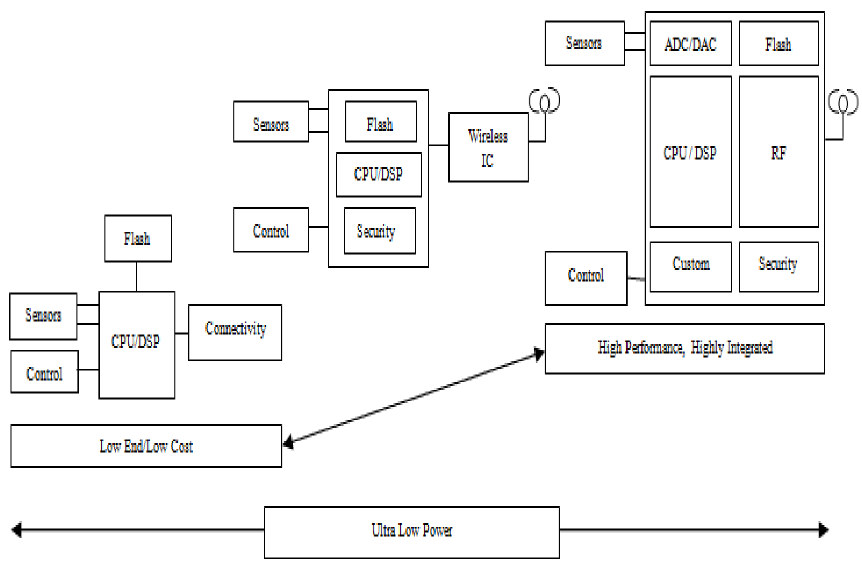

Fig. 2 Example ASIC configurations

Stage 1 Of an IoT architecture consists of networked things, typically wireless sensors and actuators.

Stage 2 Of the architecture includes sensor data aggregation systems and Analog-to-Digital data conversion.

Stage 3 Edges the IT systems to perform pre-processing of the data before it moves on to the data center or cloud.

Stage 4 The processed data is analyzed, managed, and stored on traditional back-end data center systems.

FPGA

Field-Programmable Gate Array (FPGA) like devices is expected to drive the IoT environment soon, because these devices can interface with the outside world very easily and has an advantage of providing lowest power, lowest latency and best determinism. IoT sensors can be interfaced with temperature, humidity, acceleration, position, pressure, analog-to-digital converters (ADCs), digital-to-analog converters (DACs), current and voltage, among others [3]. The general concept of reconfigurable FPGA based web service is shown in Fig. 1.

FPGA has an advantage of being coupled with an ARM processor [4] in order to leverage the higher-level software functions like Web servers or security packages, if higher level of processing is required. The major key consideration is the programmable aspect of an FPGA platform. In the process of development of the IoT environment cycle, a supplier development kit is intended to configure FPGA, while a Printed Circuit Board (PCB) is developed with specific sensor/communication/display components, as required.

ASIC

Creating the ASIC platforms for IoT applications includes some basic concepts like System Company, or a startup. It also requires the consideration of end user cases in the various IoT vertical markets such that their configurations are as given in Fig. 2. Creating such platform requires creating an end-to-end system with edge devices, including a gateway and a cloud back-end.

But ASICs have significant advantages to offer the IoT design community [5]. Surprisingly, the traditional ASIC has cost advantage in high-volume production and is not necessarily one of them.

Challenges and Issues

IoT challenges include security, privacy, unauthorized access, malicious control and denial of service. To reach the billions or trillions of devices projected to make up the IoT, designers will have to overcome significant implementation challenges [6]. Some of the key among them will be making IoT devices power efficient, handling incompatible interfaces, and providing a processing growth path to handle the inevitable increase in device performance requirements. An FPGA based design approach can help addressing such challenges. Approaching the hardware design on the SoC level with respect to security and implementation of the necessary functionalities is vital for the fully securing devices and platforms such as FPGAs, wearable, smart phones, tablets and other intelligent appliances.

Literature Survey

A Low-Power Narrow Band (NB-IoT) Transceiver (TRX) has been designed by Zheng Song *et al.,* [7]. A fully integrated 750–960 MHz wireless TRX is presented for single-tone NB-IoT applications. Specifications of the transceiver are presented in Table II. In order to address various design challenges effective design methodologies and techniques, from the system level to circuit level has been proposed while achieving low-power consumption.

The proposed TRX consists of a low Intermediate Frequency receiver and a digital polar transmitter with the signal bandwidth of 180 KHz and 3.75 KHz respectively, and a fractional frequency synthesizer. Passive current mixer is employed in the receiver to improve the linearity and avoid the sensitivity degradation due to noise. Two prototypes are implemented in 180nm CMOS.

By optimizing analog baseband configuration in the receiver and utilizing the revised Thermometer-coding and Binary-coding based array placement in the DPA, the receiver achieves a better noise fig.

Anitha V. *et al.,* [8] have designed VLSI Architecture of a Clock-gating Turbo Encoder for WSN applications. The proposed work is implemented using clock gating technique in order to reduce the power consumption. The architecture uses the fundamental Add Compare Select (ACS) operation. Due to the parallel processing operation of ACS blocks it has low processing steps, so that low transmission energy and less complexity about 71%. The proposed work implementation has a throughput of 1.03 Mb/s, memory requirement of 128.8 Kbps, the complexity is reduced by 4% and the power consumption is reduced by 32%.

A Low-Complexity FPGA Implementation of Multispectral and Hyper spectral Lossless Compressor (HyLoC) for Space Applications is presented by Luis Berrojo *et al.,* [9]. An efficient compression of hyper spectral images onboard satellites is mandatory in current and future space missions in order to save bandwidth and storage space. Reducing the data volume in space is a challenge that has been faced with a twofold approach: to propose new highly efficient compression algorithms and to present technologies and strategies to execute the compression in the hardware available on-board.

Table 2 Specifications of the nb-iot transceiver

Receiver		**Transmitter**	
Frequency	750–960 MHz	Frequency	750–960 MHz
Bandwidth	180 KHz	Bandwidth	π /4 DQPSK
Sampling rate	480 KHz	Sampling rate	3.75 KHz
Sensitivity	-130 DBm	Sensitivity	60 KHz
Adjacent channel rejection	30 dB @ 200 KHz offset	Adjacent channel rejection	<19.5%
Input Power Range	-130 ~ -25 dBm	Input Power Range	36dB @ 9 KHz offset
Dynamic Range	20 ~ 120 dB	Dynamic Range	- 40–23 dBm (3dB/step)

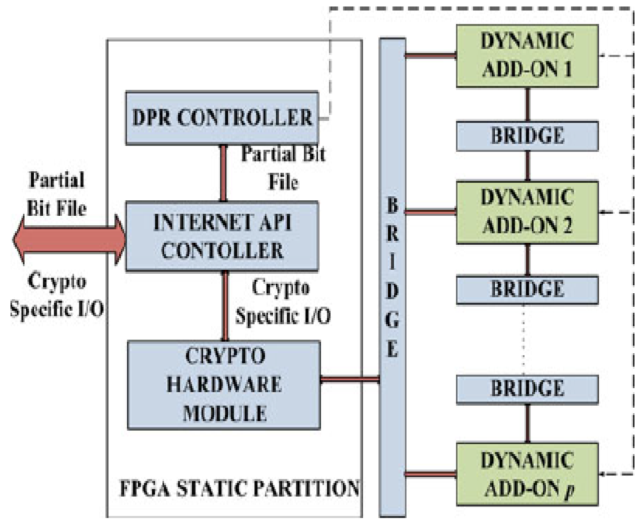

Fig. 3 The basic building block for DPR-enabled FPGA

The hardware architecture is conceived and designed with the aim of achieving low hardware occupancy and high performance on a space-qualified FPGA from the micro semi family. The resulting FPGA implementation is therefore suitable for on-board compression.

The benefits of the proposed implementation are further evidenced by a demonstrator, which is implemented on a commercial prototyping board from Xilinx. Finally, a comparison with other FPGA implementations of on-board data compression algorithms is provided.

Dr. T. Menakadevi *et al.,* [10&11] has designed and implemented a Direct Digital Synthesizer using CORDIC approach, to increase the speed with minimum area requirement in FPGA. COordinate Rotation DIgital Computer (CORDIC) algorithm is an interesting technique for phase to sine amplitude conversion which provides provide fast and area efficient computations of sine and cosine functions. The proposed CORDIC design uses the pipeline architecture for data path. By using pipeline architecture, the design is able to calculate continuous input, has high throughput, and doesn't need ROM or registers to save constant angle iteration of CORDIC.

The CORDIC algorithm is used for phase to amplitude conversion and it is utilized for dynamic transformation instead of Read Only Memory (ROM) static addressing. The frequency resolution and phase resolution are achieved as 0.023 Hz and 0.088 degree, respectively, at the maximum operating frequency of 199.288 MHz for the proposed DDS architecture. The spectral purity of the proposed design has been improved to 114 dBc with a throughput of 94% of total power reduction as compared with conventional DDS.

Fiber-Wireless Sensor Networks (Fi-WSNs) composed of a hybrid Fiber-Wireless (FiWi) network enhanced with sensors will play a key role in supporting Machine-to-Machine (M2M) communications to enable a wide range of Internet of Things (IoT) applications, of which smart grids represent an important real-world example.

Dung Pham Van *et al.,* [12] explores the opportunities of designing an energy-efficient Fi-WSN based on Ethernet

Passive Optical Network (EPON)/10G-EPON, Wireless Local Area Network (WLAN), wireless sensors, and passive fiber optic sensors as a shared communications infrastructure for broadband services and smart grids.

A novel energy conservation scheme for Sensor enhanced FiWi networks (ECO-SFiWi) is addressed to reduce the overall energy consumption. ECO-SFiWi maximizes energy efficiency by leveraging Time Division Multiple Access (TDMA) to schedule power-saving modes of EPON's optical network units, wireless stations, and wireless sensors and incorporate them into EPON's bandwidth allocation algorithm. Results provide deep insights into the tradeoff between energy savings and frame delays. Noticeably, ECO-SFiWi achieves significant amounts of energy saving, while maintaining low delay for FiWi traffic and sensor data under typical deployment scenarios.

The Internet of Things (IoT) is a dynamic, ever-evolving "living" entity. Hence, modern Field Programmable Gate Array (FPGA) devices with Dynamic Partial Reconfiguration (DPR) capabilities, which allow in-field noninvasive modifications to the circuit implemented on the FPGA, are an ideal fit [13]. Usually, the activation of DPR capabilities requires the procurement of additional licenses from the FPGA vendor as shown in Fig. 3.

The modified DPR methodology does not require any paid "add-on" utility, to implement a lightweight cryptographic security protocol this describes the advantage of DPR capabilities of FPGA on IoT platform. This also analyzes the possible threats that can emerge due to the availability of DPR at IoT nodes, and also proposes some possible solutions based on Physically Unclonable Function (PUF) circuits to prevent such threats. Cognitive radios (CR) enable efficient spectrum utilization by performing spectrum sensing to gain the knowledge of current spectrum occupancy and dynamically reconfiguring the communication parameters, making them highly suitable for IoT systems.

B.Jagadish *et al.,* [14] proposes a mixer less low complex QPSK based transmitter architecture as shown in Fig. 4. A prototype has been developed using Bipolar Junction Transistors (BJTs) and FPGA as the base band controller. The proposed design can be easily adapted to the MOSFET technology and modulation can be achieved without generating the carrier externally. The developed prototype was successfully tested by generating input frequencies of range varying from 1 KHz - 120 MHz. The proposed architecture can also be used for any other digital modulation scheme such as Binary Phase Shift Key (BPSK), Frequency Shift Key (FSK) etc.

Abhishek Ambede *et al.,* [15] presents the Variable Digital Filter (VDF) based hardware implementation of a spectrum sensing scheme for CR (Cognitive Radio) based IoT applications that require large bandwidth. The proposed algorithm has been implemented on FPGA as shown in Fig. 5 which tends to achieve high performance, while consuming less resources and at fractionally higher power consumption.

Comparison and Discussion

This survey paper presents a survey of the current VLSI architectures and algorithms designed in the IoT domain as of 2017. This paper identifies the design principles for an ideal architecture from the shortcomings of other architectures. Various issues such as interoperability, performance and security issues have been addressed. The comparison of some basic parameters and the characteristics of ASIC and FPGA platforms respectively is presented in Table III.

A comparative analysis of the proposed VLSI architectures shows that the advantage of an ASIC is that it can provide very high performance because of its dedicated type of operation but some drawbacks are:

1. High cost to volume ratio.
2. Extended delay between designs to end product.
3. Incapability to include new changes after the system is fabricated and
4. Difficulties in debugging errors.

FPGAs fill the gap between hardware and software and offer numerous advantages such as:

1. Flexibility
2. Reliability
3. Low cost
4. Fast time-to-market and
5. Long term maintenance.

Considering all the above survey and discussions, it is concluded that an FPGA is the best reconfigurable hardware platform for the implementation of IOT applications.

Conclusion and Discussion

IoT can be concluded as the expected future of the Internet. IoT connects billions of devices and enables Machine-to-Machine communication. It can transform daily life with everyday objects connected to each other and the Internet. Currently, this field is in a very nascent stage. The technologies in the core infrastructure layers are showing signs of maturity. However, a lot more needs to happen in the areas of IoT applications and communication technologies. These fields will definitely mature and impact human life in inconceivable ways over the next decade.

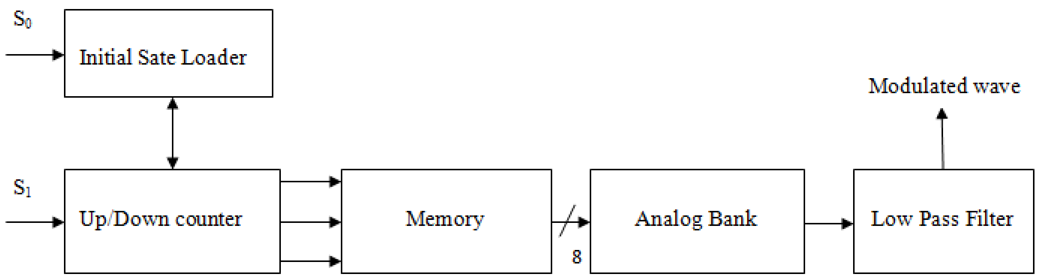

Fig. 4 Architecture of low complex QPSK modulator

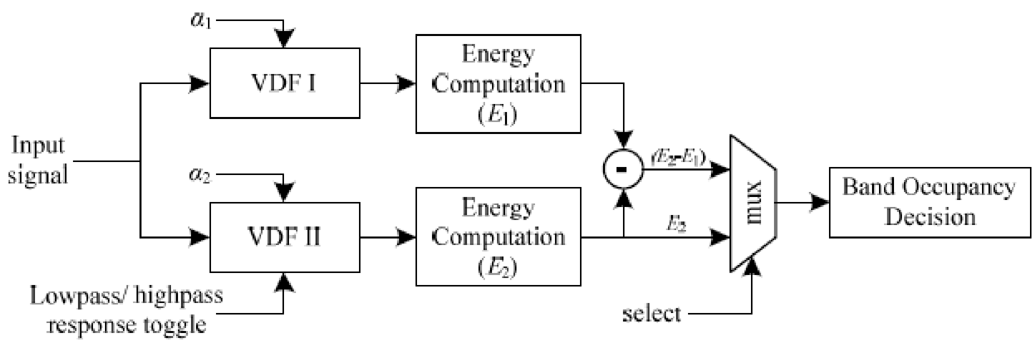

Fig. 5 Block diagram of the VDF based spectrum sensing scheme

Table 3 Comparative analysis of asic vs fpga parameters and its characteristics

S. No.	Parameters	ASIC Design	FPGA Design
1	Operating frequency	70.4–127.4 MHz	>500 MHz
2	Power consumption	115mW	49 W
3	Voltage	1.8 V	1.2 V
4	Current	22.8–28.5 mA	0.8 A
5	CMOS Design	0.18 µm	28 nm
6	Time taken to develop the application	Less	More
7	Cost	Less	High
8	Re-programmability	Can be done	Cannot be done
9	High volume applications	Not applicable	Applicable

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Carotid Artery Ultrasound Image Segmentation by Particle Swarm Optimization Variants

S. Latha[1] and Dhanalakshmi Samiappan[2]

Abstract Atherosclerosis, stroke and other heart related diseases are caused by vulnerable plaque in the carotid artery. B mode ultrasound images are used in identifying abnormalities in the carotid artery, facilitating for further treatment to be undergone. The acquired image which has multiplicative speckle noise is denoised by curvelet decomposition. The filtered image is segmented by Particle Swarm Optimization (PSO) technique, Darwinian PSO and Fractional order DPSO to get the intima media thickness and plaque diameter if available. The segmentation results are compared with ground truth segmented image with segmentation performance criteria. PSO Segmentation proves to be one of the best segmentation technique compared to the available state of art techniques.

Keywords: Carotid, Segmentation, Ultrasound, Curvelet, Speckle

Introduction

Biomedical image processing in terms of denoising, segmentation and classification is of great importance in recent days because of vast number of disease progressions [1]. Vulnerable fat deposits called plaque in the carotid artery causes cardiovascular diseases like stroke, heart attack and atherosclerosis. The fast increasing mortality rate of heart attack claims for valid risk assessment tools and suitable treatment methodologies for patients suffering from heart related diseases. Ultrasound images are non-invasive, cost effective and does not cause any trouble of radiation. B mode ultrasound images are generally used for carotid artery imaging for disease screening purpose [2][3].

The thin innermost layer intima with a maximum diameter of 250µm, the thin echolucent middle layer called the Media which is composed of soft muscle cells ranges from 125 µm to 350 µm and the loose connective tissues made up of adventitia layer consist of fibroblasts and associated collagen fibers. The subjective methods of identifying carotid artery abnormalities depends on visually estimating the pattern and the appearance of the gray scale carotid artery ultrasound image, which relies fairly on observer reproducibility. The computer assisted objective methods are semiautomatic segmentation and classification methods, which also are radiologist dependent.

Normalized and denoised images give better segmentation and classification results. Wavelet denoising focusses on coherent signal and has concentrated energy present in high magnitude coefficients, and the noise components present in the low magnitude coefficients which can be easily separated [4]. Empirical and Variational mode decomposition which are fully adaptive multi-resolution decomposition, a combination of spatial and frequency domains and representation of original signals in terms of variational modes extracted simultaneously respectively. Contrast variation of Multiresolution transforms like wavelet, Ridgelet and curvelet transforms increases the accuracy of the perceptual processing for high frequency of attenuation sensitivity [5].

By decomposing the noisy image into intrinsic mode function, are transformed into curvelet domain and by choosing different thresholds based on the noise intensity, noise suppression is performed [6]. The curvelet transform is frequency localized and spatially pseudo localized, with coherent data present in the high frequency components involving an insignificant overlap.

Particle Swarm Optimization (PSO), established by Dr. Kenney and Dr. Eberhart in 1995, is a population based stochastic practice for finding solution for both continuous and discrete optimization problems. Image segmentation may be done by bi-level or multi-level thresholding. To choose the optimal threshold value is the optimization problem, which can be performed by a heterogeneous Particle Swarm Optimization (PSO) process by sub classifying the problem into four sub swarms [7]. Swarm intelligence can be used in identifying and classifying the aorta data, which leads to more accurate localization [8].

E-mail:[1]latha.su@ktr.srmuniv.ac.in, [2]dhanalakshmi.s@ktr.srmuniv.ac.in

[1,2]SRM University, Kattankulathur, India

The paper is organized as follows. Section II explains the underlying problem of identifying fat deposit in ultrasound carotid artery image, its noise effects and the curvelet denoising approach used. Section III gives the significance of PSO in image segmentation and the performance evaluation measures. Section IV summarizes the results and discussions and Section V concludes the paper.

Despeckling the Carotid Artery Ultrasound Image

Significance of Ultrasound Imaging

Stroke has a major effect in the recent population and is a leading cause for death. Better techniques are required for early identification of the disease cause. Carotid artery fat deposit is found to be the cause and ultrasound imaging is the best modality for plaque identification, since it is non-invasive and inexpensive. Carotid artery is the major artery which supplies pure blood from heart to the brain and the front of the face. In the artery, the endothelium layer is the layer in contact with blood directly and lumen is the hollow center through which blood flows. Identifying the intima-media, adventitia layers thickness and the plaque diameter will give the information about the disease progress.

Denoising by Curvelet Decomposition

The B mode ultrasound image has high multiplicative speckle noise content, and thus removing the noise, normalization and optimization will lead to better segmentation results. The useful information which is embedded along with the speckle should also be preserved. Initially, the multiplicative noise is converted to additive by homomorphic filtering by a logarithmic approach. Speckle filtering is by moving a kennel over each pixel in the image and replacing the center pixel with a calculated value by the filter. But the low pass characteristics of these filters remove some fine details from the speckle in-spite of good preprocessing. Wavelet transform was introduced, which effectively can retrain non-stationary signals from the noise components [9][10]. The speckle noise follows the universal gamma distribution, with pdf given by

$$p_Z(z) = \frac{\gamma^{z(\gamma v-1)}}{\propto\gamma^{v}\Gamma(v)} e^{(-\frac{z}{\alpha})^{\gamma}}, \text{ z>0, α, v, ?>0} \quad (1)$$

The homomorphed samples are scattered with Fisher-Tippett pdf given by

$$PY(y) = \frac{\gamma}{\Gamma(v)} \exp\{(\gamma v(y - lna)) - \exp\{\gamma(y - lna)\} \quad (2)$$

The obtained ultrasound image is modelled homomorphically by

$$g(a,b) = f(a,b) * h(a,b) + a(a,b) \quad (3)$$

Where h(a, b) is the speckle density function of the imaging system, f is the image pixel intensity and a is the additive noise component. By iteratively modelling the pdf of the wavelet transformed reflectance image and the noisy image with the inverse Gaussian distribution, high frequency components which comprises the image details are preserved and optimized. Blurring of the edges happens while reconstruction of the original image after wavelet transformation because of the shrinkage of the 2D-DWT coefficients, loosing parsimony of representation. Ridgelet transform was introduced to overcome this restraint in continuous domain. A misleading local wave vector estimates at negligible signal locations were identified which led to the anisotropic curvelet transforms, which is best suited for curved edges and banded wavefronts [11]. The curvelets, based on multi-scale Ridgelet , organized with spatial band pass filtering to separate unlike scales for 2D image is given by

$$W_{a\theta b}(x) = a^{\frac{t+s}{2}} e^{2\pi i a(x-b).e_\theta} W(A_a R_\theta^{-1}(x-b)) \quad (4)$$

The variable anisotropy value increases with decreasing scale like a power law. Thresholding and decomposition provides optimum N term representations, thus preserving edges and fine details. Curvelet transform restores sparsity by dropping redundancy across the scales. Dyadic scale sequence and filter banks are used, followed by smooth partitioning and renormalization.

Particle Swarm Optimization

Swarm Optimization Technique

PSO belongs to swarm optimization technique, which can effectively solve optimization problem. The basis behind PSO is birds flocking together. Consider the situation where there are a cluster of birds in search for food in a zone. Consider food is available in a location only. Though they couldn't identify where the food is, they recognize how close they are to the food at the end of each iteration. They decide to follow the bird which is closest to the food. Updation of each value in PSO is done by pbest and gbest. Pbest, called personal best is the track of the coordinates of the solution space with best fit attained so far. Gbest, the global best is the best values obtained by any neighborhood particle of the system. At each iteration, the positions of the particles are modified by the current velocities, positions, the distance of the current position, measured with pbest and gbest. With these observations, each particle's velocity and position are updated by

$$\mathrm{V[\ ]} = \mathrm{V[\ ]} + \mathrm{C_1} * \mathrm{rand(\ )} * [\mathrm{pbest[\ ]} - \mathrm{ppresent} + \mathrm{C2}*\mathrm{rand}*[\mathrm{gbest}-\mathrm{present}] \quad (5)$$

$$\text{present[]=present[]+v[]} \quad (6)$$

where present[] is the current solution of the particle, and v[] is the particle velocity. C1 and c2 are learning factors and rand is a random number between 0 and 1. The flow diagram of PSO is as follows.

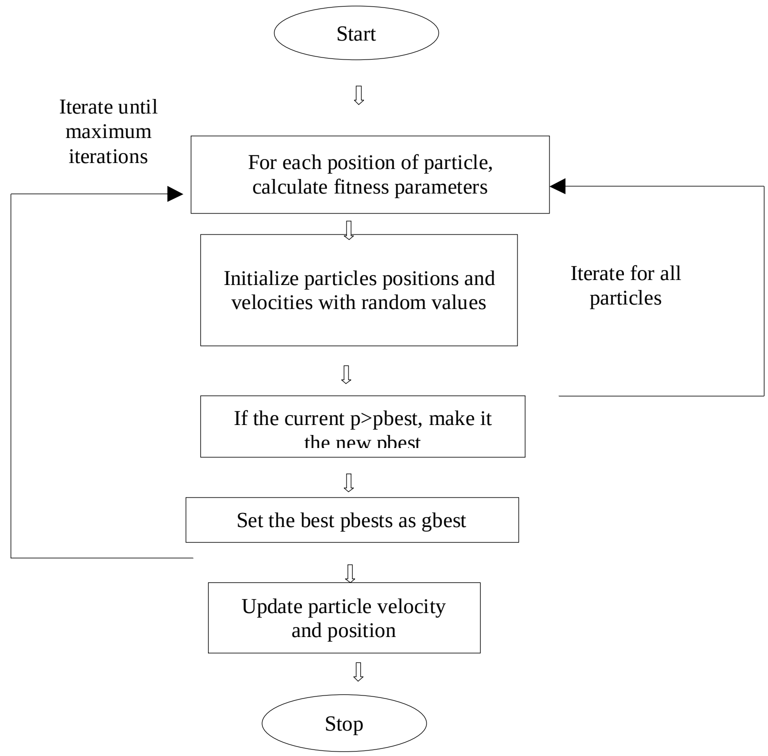

Fig. 1 PSO flow diagram

The optimal solution gbest is derived by the above procedure. The optimal threshold value is chosen and the particles are moved in the solution space. The particles life is extended if it has good position and velocities and its life span is reduced for poor values [7][12].

Table 1 Segmentation performance measures

Sl. No.	Metrics	Explanation
1	Jaccard Coefficient	For comparing similarity and diversity of sample sets Jaccard Index = (the number in both sets) / (the number in either set) * 100; Higher value - better
2	Dice Coefficient	spatial overlap index and a reproducibility validation metric; 0 – no spatial overlap; 1- Complete Overlap
3	RFP	False Positive Ratio - Propotion of negative inputs incorrectly classified
4	RFN	False Negative Ratio – Propotion of positive inputs incorrectly classified
5	Hausdorff Distance	Measures the degree to which each point of a model set lies near some point of an image set and vice versa. To determine amount of likeness among two objects that are overlaid on one another.
6	Probablistic Rand Index	1 – Good match with ground truth segmented image Normalized index = (Index − Expected index)/ (Maximum index − Expected index)
7	Global Consistency Error (GCE)	It assumes that one of the segmentations must be a modification of the other, and forces all local alterations to be in the alike path.
8	Variation of Information	Measures the sum of data loss and data gain among the two clusterings, and thus it coarsely measures the degree to which one segmentation can clarify the other. The VOI metric is nonnegative, with lesser values signifying greater correspondence
9	Cophenet	Measure of how faithfully a dendrogram preserves the pairwise distances between the original unmodeled data points

Table 2 Segemntation performance evaluation compared with chan-vese algorithm

PSO Levels	Jaccard	Dice	RFP	RFN	Hausdorff Dist	Rand Index	Global Consistency Error gce	Variation of Information vi	Cophenet	Fitness
PSO Level 2	0.9370	0.9675	0.0392	0.0263	6.9282	0.9101	0.0876	0.5296	0.9416	627.7051
Level 3	0.8494	0.9186	0.1771	1.3970 e-04	7.4162	0.7784	0.1406	0.7993	0.9731	760.5062
Level 4	0.9365	0.9672	0.0297	0.0357	6.4807	0.9101	0.0883	0.5325	0.9434	798.8254
DPSO Level 2	0.9340	0.9659	0.0473	0.0218	8.1854	0.9056	0.0904	0.5429	0.9433	632.5336
Level 3	0.7562	0.8612	0.3223	3.9070 e-05	8.1240	0.6725	0.1763	1.0333	0.9707	749.5646
Level 4	0.9398	0.9690	0.0257	0.0361	6	0.9150	0.0833	0.5091	0.9427	806.5799
FODPSO Level 2	0.9252	0.9611	0.0562	0.0229	7.8740	0.8935	0.1009	0.5925	0.9382	624.1731
Level 3	0.8490	0.9183	0.1777	1.7391 e-04	8.2462	0.7770	0.1397	0.8007	0.9741	754.1809
Level 4	0.9342	0.9660	0.0389	0.0294	7.1414	0.9068	0.0913	0.5468	0.9446	800.2649

The probability distribution for selecting the optimum threshold value for PSO is given by:

$$p_i = \frac{h_i}{N}$$

$$\sum_{i=0}^{L-1} P_i^c = 1 \qquad (7)$$

Where the probability p is found in the specific intensity level i, with N pixels in the image and h is the number of pixels for a particular intensity in a given component.

The total average of each component is given by

$$\mu_T^C = \sum_{i=0}^{L-1} i p_i^c = 1 \qquad (8)$$

Performance Evaluation Metrics

The image segmented by PSO, DPSO and FO-DPSO, at different levels are compared with the ground truth segmented image to get the performance quality of the PSO method in image segmentation. Chan-vese algorithm is implemented on the sample image to get the ground truth image [13][14]. The following performance evaluation metrics were used for the segmented result analysis. It is proved that the normalized and denoised image when subjected to segmentation gives better segmentation accuracy than segmenting raw image.

Results and Discussions

Sample carotid artery ultrasound B mode images are despeckled with homomorphic filtering and curvelet decomposition to get a speckle free image. The denoised image is segmented by PSO, DPSO and FO-DPSO at levels 2, 3 and4. The segmentation is evaluated by the performance metrics to get the goodness of the algorithms. The metrics prove that the PSO and its variants are also suitable in segmenting the carotid artery ultrasound image similar to the proven Chan-Vese Algorithm. The figures 4 and 5 are the thresholded versions of the segmented images by DPSO and chanvese respectively. Visually they both are alike, proving the DPSO as a segmentation standard for segmenting the intima media thickness and lumen adventitia.

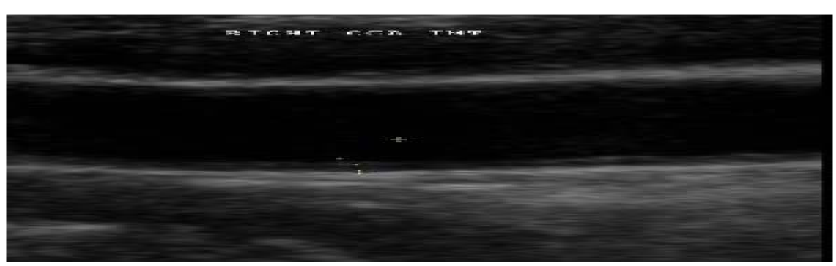

Fig. 2 Sample image

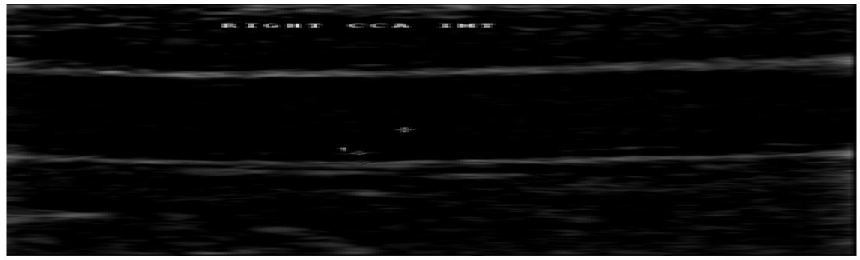

Fig. 3 Denoised by curvelet decomposition

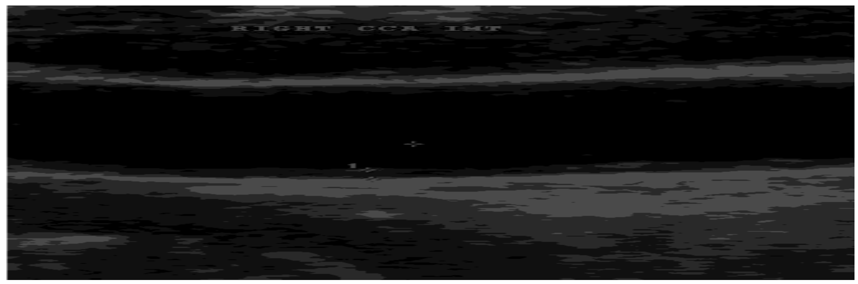

Fig. 4 DPSO Level 4

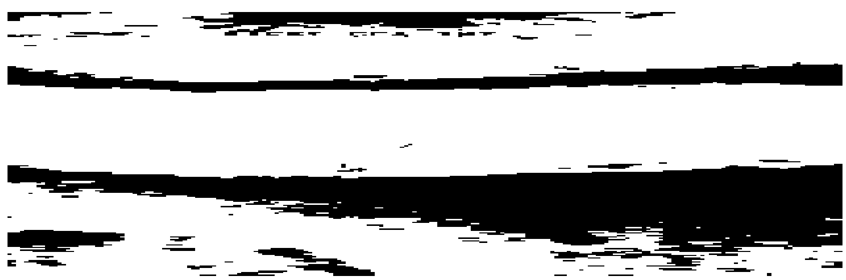

Fig. 5 DPSO Level 4 thresholded

Conclusion

Stroke and atherosclerosis early detection by carotid artery ultrasound images can be facilitated by improvised denoising and segmentation algorithms. The speckle in the ultrasound image needs to be removed, preserving fine details in the image. Curves are more sharply recovered by the anisotropic curvelet decomposition method. Automatic Segmentation to get the intima-media, adventitia thickness is obtained by an improved Particle Swarm Optimization technique, with optimum threshold selection. The Segmented experimental result is compared with the segmentation performance measures and is proven to be an equivalent good segmentation technique for identifying abnormalities in carotid artery.

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Comparison of Different Time-Frequency Representations for Waveguide Synthesis of Speech Signal

Samridha Kumar[1], Vineet Malik[2] and Mihir Mohanty[3]

Abstract Speech is the primary means of communication between people. But the computer, mobile phone and so many other processing devices cannot communicate using this simple technique. For it to be possible these devices should be able to recognize what is being said by human beings, interpret it, then form its reply if required and say it. Speech Synthesis has been an exciting field of research over the last two to three decades. The main idea is to automatically generate human speech i.e. to generate speech waveforms artificially using a system. Recent progress in speech synthesis has produced synthesizers with very high intelligibility. Sound produced by them is more natural. The quality and intelligibility of the synthetic speech produced using the latest methods have been remarkably well for most of the applications. Sound modeling is an important part of the analysis–synthesis process since, it combines sound processing and algorithmic synthesis within the same formalism. Its aim is to make sound simulators by synthesis methods based on signal models or physical models, the parameters of which are directly extracted from the analysis of natural sounds. In this article, the successive steps for making such systems are described. These are numerical synthesis and sound generation methods, analysis of natural sounds, particularly time–frequency and time–scale[1] (wavelet) representations, extraction of pertinent parameters, and the determination of the correspondence between these parameters and those corresponding to the synthesis models. We emphasize on the digital waveguide modelling technique which has gained much popularity among both researchers and engineers. A major improvement is achieved by estimating the model parameters and the excitation signal from the sound of an acoustic source.

Keywords: Speech Synthesis, STFT, Wavelet, Gabor Transform, Waveguide.

Email: [1]samashu@gmail.com, [2]vineetmalik06@gmail.com, [3]mihir.n.mohanty@gmail.com

[1,2]Indian Institute of Technology, Kharagpur, India

[3]Institute of Technical Education and Research, Bhubaneswar, India

Introduction

Unlike physical modeling, where a set of algorithms and equations is used to simulate the different parts of the sound source, spectral sound synthesis uses the spectral representation of the sound itself. This spectral approach has been applied to model speech signals based on their sinusoidal representation, before it was adapted to musical sounds for the Spectral Modeling Synthesis (SMS) framework. We propose a synthesis model, the Reduced Parameter Synthesis Model (RPSM), that is almost completely independent from a previous spectral analysis without using high level sound attributes. The method is based on a frequency and an amplitude model with a reduced number of synthesis parameters compared to the standard SMS. The model also allows the synthesis of musical sounds outside the range of a particular instrument by preserving the timbre of the instrument and the naturalness of the sound [1].

A lot of research has been done in the area of speech synthesis, a brief review of which is described henceforth.

In [2], the authors have analyzed a system for the synthesis of backing vocals by pitch shifting of a lead vocal signal is presented. The harmonization of the backing vocals is based on the chords, which are retrieved from an accompanying instrument. The system operates completely autonomous without the need to provide the key of the performed song.

The authors in [3], have devised physically inspired sound synthesis techniques for several instruments including guitar. Among those, less well studied are methods to model the interactions of the player with strings and of the strings with other mechanical parts of the instrument.

R. McAuley and *T. Quatieri,* in [4], have analyzed sinusoidal model for the speech wave form used to develop a new analysis synthesis technique that is characterized by the amplitudes, frequencies, and phases of the component sine waves. These parameters are estimated from the STFT using a simple peak-picking algorithm. It was found that the representation was sufficiently general that high-quality reproduction was obtained for a larger class of inputs including: two overlapping, superposed speech waveforms; music waveforms; speech in musical backgrounds; and certain marine biologic sounds.

In [5], the authors have analyzed the quality of speech generated from Hidden Markov Model (HMM)-based Speech Synthesis System (HTS) and proposed an excitation model to improve the parametric representation of speech in HTS which suffered from 'buzzing' problem due to over simplified vocoding technique. Listening tests showed that this proposed technique could generate better sound than pulse train excitation model.

In 2012, Wu Lifang and Zhang Linghua have analyzed an algorithm to extract the excitation source based on the Harmonic plus Noise Model, which decomposes the source voice to harmonic components and random noise component. By the proposed algorithm, the LPC parameters of the harmonic components are extracted through linear prediction method, and then the LPC inverse filter is used to get the harmonic residual signal as the excitation source. This excitation source avoids artificial modifications and contains more speaker personality characteristic. Finally the synthesized speech is superimposed on the random noise component compensation. Experiments demonstrate that proposed algorithm improves the target tendentiousness and naturalness of the synthesized speech. [6]

In [7], the authors have analyzed the typical 'buzz' problem which Speech synthesized in LPC-like vocoders suffered from.

In 2010, Tuomo Raitio, Antti Suni, Junichi Yamagishi, Hannu Pulakka, Jani Nurminen, Martti Vainio, and Paavo Alku have done this paper describes an hidden Markov model (HMM)-based speech synthesizer that utilizes glottal inverse filtering for generating natural sounding synthetic speech. Experiments show that the proposed system is capable of generating natural sounding speech, and the quality is clearly better compared to two HMM-based speech synthesis systems based on widely used vocoder techniques. [8].

In 2006, Ixone Arroabarren and Alfonso Carlosena have analyzed Inverse filtering provides a noninvasive method to extract the voice source, and thus get insight into voice quality. Although this technique is widely used in speech analysis, this is not the case in singing voice, where its use has been even questioned by some authors. [9]

In our work, we propose an analysis-synthesis approach to reconstruct a given natural sound. We first present the most commonly used synthesis methods. Then analysis methods such as time-frequency and wavelet transforms are described, as well as algorithms for separating and characterizing spectral components. We conclude by showing how the analysis of real sounds can be used to estimate the synthesis parameters corresponding to different classes of sound models

The paper is organized as follows: The various transforms used for the analysis of the recorded speech are explained in Section II. Section III describes the Spectral Time-Frequency Analysis. Section IV explains the Parametric Synthesis based on results of the analysis. Finally, Section V concludes this piece of work.

Spectral Transforms

Discrete Fourier Transform

Digital signals have a finite length and are sampled with a certain sampling frequency. This finite length and sampling introduces several problems that we will discuss in this and the following sections. Let us consider a discrete signal $x[n]\ n=1,\ldots,N,$ which has been derived from a continuous signal $x(t)$ by sampling at equal time intervals Δt (i.e. with a sampling frequency $f_s = \frac{1}{\Delta t}$). Obviously, the length of the signal is $T = N * \Delta t$.

The discrete Fourier Transform (DFT) is defined as:

$$X[k] = \sum_{n=0}^{N-1} x[n]\, e^{-j2\pi kn/N} \quad k = 0,\ldots,N-1 \tag{1}$$

And the signal $X[n]$ can be reconstructed with the inverse discrete Fourier Transform (IDFT):

$$x[n] = \frac{1}{N}\sum_{n=0}^{N-1} X[k]\, e^{j2\pi kn/N} \tag{2}$$

The Fourier coefficients $X[k]$ are complex no.s

Short Time Fourier Transform

STFT is essential in the case of non-stationary signals like EEG, speech signals. Speech or EEG signals are non-stationary signals as their frequency content changes with time. So, we need a combined time-frequency representation as either time domain or frequency domain analysis becomes inadequate to describe the nature of non-stationary signals completely. The STFT maps a signal into a two dimensional functions of time and frequency and provides some information about when and at what frequencies a signal event occurs [11-13].

STFT of a signal *x(n)* as given in [14] is:

$$X_m(w) = \sum_{n=-\infty}^{\infty} x(n) w(n - mR) e^{-jwn} \tag{3}$$

where;

x(n) =input signal at time n

w(n) =length M window function

$X_m(w)$ =DTFT of windowed data centered about time mR.

R =hop size, in samples, between successive DTFT samples.

Wavelet Transform

Due to the non-stationary nature of EEG signal, it should be analyzed in both time and frequency. Therefore, the wavelet transform (WT), as a time-frequency analysis tool, is a suitable choice. The wavelet transform is quite similar to the Short Time Fourier Transform (STFT) except the window is not fixed as in STFT. Wavelet decomposition overcomes the short comings of the classical STFT for the analysis of non-stationary signals, permitting higher time resolution of higher frequencies, as well as temporal localization of non-stationary signals. The Discrete Wavelet Transform (DWT) is a versatile signal processing tool that finds many engineering and scientific applications. One area in which the DWT has been particularly successful is analyzing non-stationary EEG signals, such as the epileptic seizure detection, because it captures transient features and localizes them in both time and frequency content accurately. The DWT is a representation of signal $x(t)$ using an orthonormal basis consisting of a countably infinite set of wavelets. DWT employs two functions, φ(t) the scaling function and ψ(t), the wavelet function, which are associated with low and high pass filters, respectively. Both of these functions are shifted and scaled as shown below:

$$\forall k,n,k \wedge n \in Z : \varphi_{k,n}(t) = 2^{-k/2}\varphi\left(2^{-k}t-n\right) \tag{4}$$

$$\forall k,n,k \wedge n \in Z : \psi_{k,n}(t) = 2^{-k/2}\psi\left(2^{-k}t-n\right) \tag{5}$$

The wavelet representation of a signal $x(t)$ in terms of the scaling and wavelet functions is given by:

$$x(t) = \sum_{n=-\infty}^{\infty} a_{k_0,n}\varphi_{k_0,n}(t) + \sum_{k=k_0}^{\infty}\left(\left(d_{k,n}\psi_{k,n}(t)\right)\right) \tag{6}$$

Where $a_{k_0,n}$ and $d_{k,n}$ are called approximation and detailed coefficients, respectively.

Gabor Transform

The Gabor transform, named after Dennis Gabor, is a special case of the STFT whrein the window used is a Gaussian Window. It is used to determine the sinusoidal frequency and phase content of local sections of a signal as it changes over time. The function to be transformed is first multiplied by a Gaussian function, which can be regarded as a window function, and the resulting function is then transformed with a Fourier transform to derive the time-frequency analysis. The window function means that the signal near the time being analyzed will have higher weight. The Gabor transform of a signal $x(t)$ is defined by:

$$G_x(t,f) = \int_{-\infty}^{\infty} e^{-\pi(\tau-t)^2} e^{-j2\pi f\tau} x(\tau)\, d\tau \tag{7}$$

The Gaussian function has infinite range and it is impractical for implementation. However, a level of significance can be chosen (for instance 0.00001) for the distribution of the Gaussian function.

$$\begin{cases} e^{-\pi a^2} \geq 0.00001; & |a| \leq 1.9143 \\ e^{-\pi a^2} < 0.00001; & |a| > 1.9143 \end{cases}$$

Outside these limits of integration ($|a| > 1.9143$) the Gaussian function is small enough to be ignored. Thus the Gabor transform can be satisfactorily approximated as:

$$G_x(t,f) = \int_{-1.9143+t}^{1.9143+t} e^{-\pi(\tau-t)^2} e^{-j2\pi f\tau} x(\tau)\, d\tau \tag{8}$$

This simplification makes the Gabor transform practical and realizable. The window function width can also be varied to optimize the time-frequency resolution trade-off for a particular application by replacing the $-\pi(\tau-t)^2$ with $-\pi\alpha(\tau-t)^2$ for some chosen α.

Spectral Time-Frequency Analysis

We have attempted to design a spectral domain model for synthesis of speech. First, a speech sample – "why do you make easy things complicated?" was recorded and the same was analyzed in MATLAB.

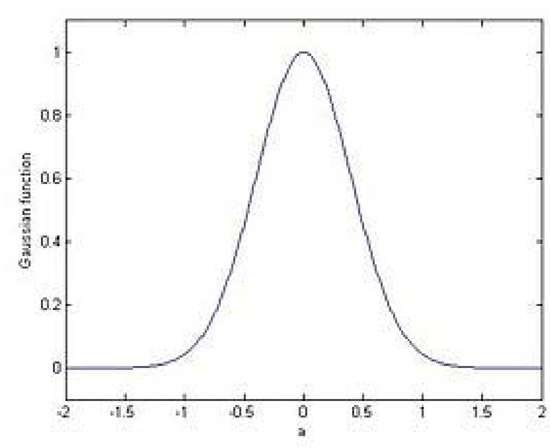

Fig. 1 Magnitude of gaussian window

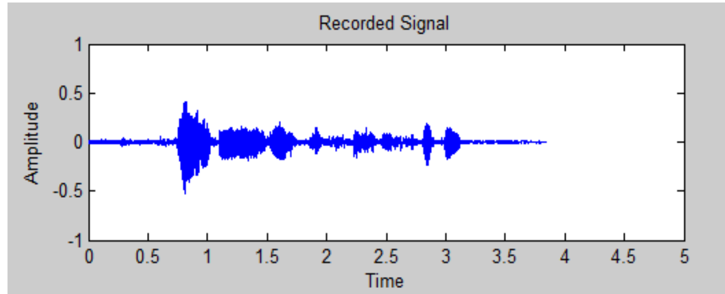

Fig. 2 Recorded speech-“why do you make easy things complicated?”

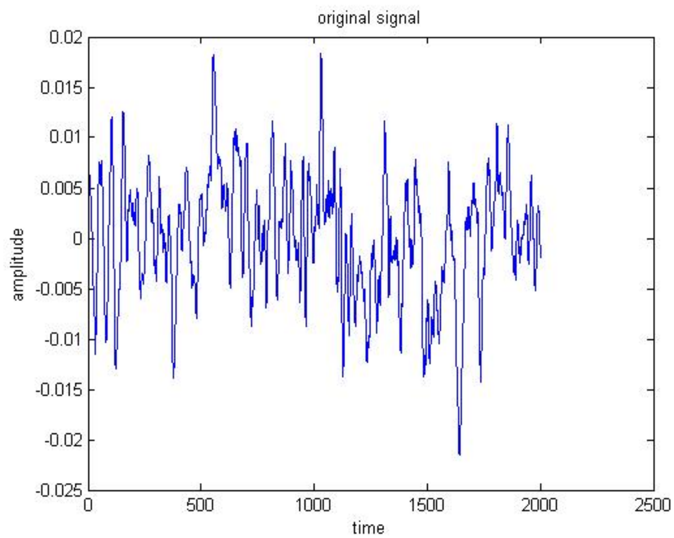

Fig. 3 Original speech signal

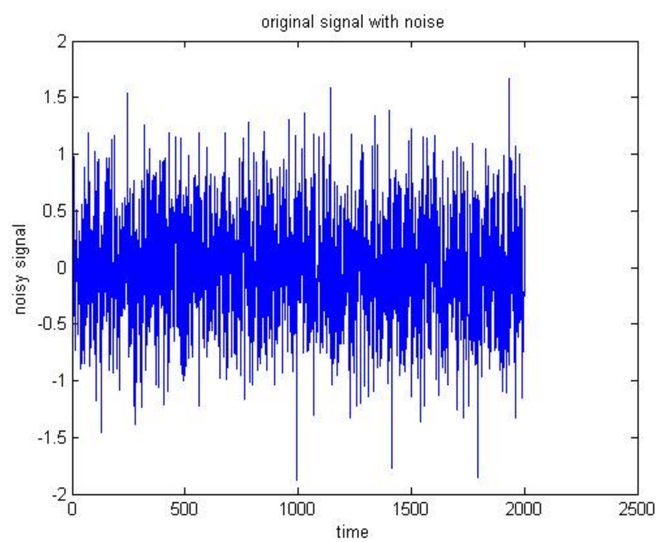

Fig. 4 Speech signal after adding noise

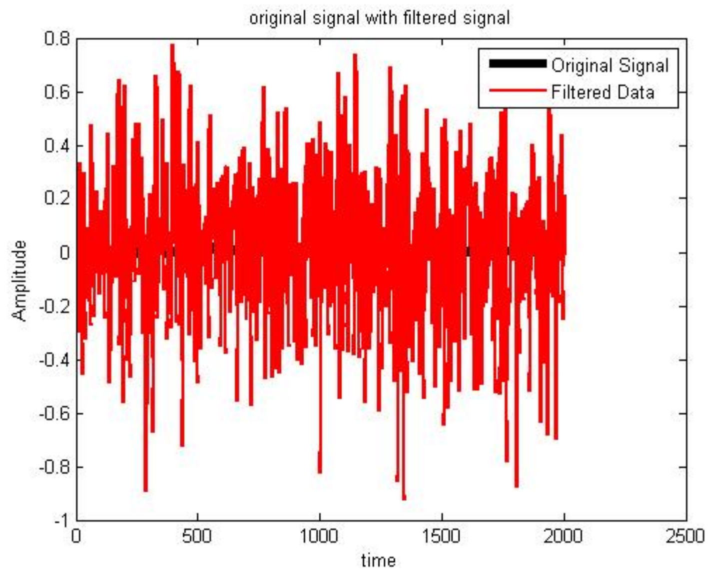

Fig. 5 Comparison of filtered signal with original signal

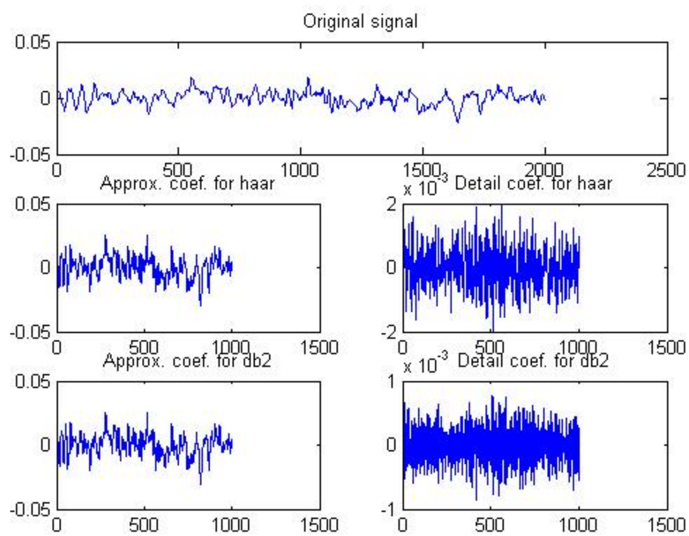

Fig. 6 Wavelet transform using haar and DB2 transform

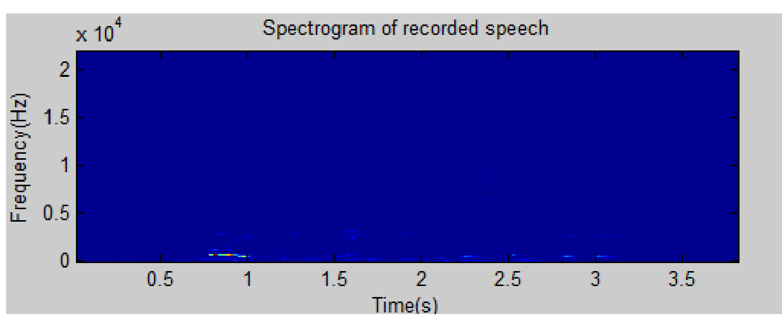

Fig. 7 The spectrogram of the recorded speech obtained using STFT with gaussian window

As the objective of our work is spectral model based synthesis, so we have attempted initially with Discrete Fourier Transform (DFT) and developed the model based on it. For our speech signal it is required to design this model with low-pass filter. The result is depicted as:
For the taking care of the disadvantages of DFT used for speech signal we have approached with wavelet transform based model.

The major advantage of it is as follows:

Localization of time and frequency component of speech signal.

Scaling factor for time domain and frequency domain at the time of frequency analysis.

The result of wavelet based approached is show in figure:

In the analysis, we have heavily relied on short-time processing techniques, mainly Short-Time Fourier Transform (STFT). The reasons for using STFT instead of normal FT are mentioned below:

- Like many other phenomena we observe in the world, speeches are transient or non-stationary signals whose properties change markedly as a function of time. As such, FT would not be suitable for analysis as it is helpful for periodic and stationary signals.
- Also, due to Heisenberg's Uncertainty Principle, we require some compromised solution between time and frequency localization.

For feature set Gabor Transform is used and the features have been saved. Gabor Transform means Short Time Fourier Transform using Gaussian window. i.e.

$$G_x(t,f) = \int_{-\infty}^{\infty} e^{-\pi(\tau-t)^2} e^{-j2\pi f\tau} x(\tau)\, d\tau \tag{9}$$

Parametric Synthesis

For accurate resynthesis of speech sample, we have used techniques from [1] to estimate the parameters of our model based on the recorded sample. Our model incorporates a delay line, loop filter and an excitation signal. Loop filter models the frequency dependent damping and once the loop filter is designed, the excitation signal can be easily extracted via. Inverse- Filtering.

The works of [2] and [4] incorporated a fractional delay filter which addresses the problem of the equation

Number of delays = sampling rate/ frequency

which limits the order of the delay filter to integer values .We have implemented a Delay Filter and a Fractional delay filter using a 3rd order Lagrange interpolator.

Loop Filter Design

We have used a Robust Algorithm for estimation of the loop filter and calculation of its magnitude response as given in [1].

The steps are as follows:

- Compute the short-time Fourier transform (STFT) with Gaussian window of the speech to be resynthesized;
- Measure the magnitude of each detectable harmonic in the gabor transform frames and form a sampled envelope curve for every harmonic.
- Fit a straight line on a logarithmic (dB) amplitude scale to each sampled envelope curve;
- Compute the corresponding loop gain for each slope;
- Design a digital filter to match the magnitude spectrum that is formed by the collection of loop gain estimates at different frequencies.

The model presented above was used for the implementation of our loop filters. After computing the Gabor Transform, the multi-frequency estimation and envelope detection was done by using Goertzel algorithm as suggested by [4]. The estimated envelopes were converted to logarithmic scale and the slope of the envelope was accurately estimated using linear regression.

The corresponding loop gain, g of the loop filter (at the frequency of the overtone in question) was computed as:

$g(f_k) = 10^{\beta_k L/20H} \quad \forall\, k = 1, 2, 3 \ldots K$

where, β_k is the estimated slope of the k^{th}harmonic, f_k is the frequency at which it occurs, H is the hop size(overlap size) used in the Gabor Transform analysis, K is the no. of harmonics to be extracted, and L is the length of the delay line of the model.

The length L is determined as the ratio of the sampling frequency to the fundamental frequency of the analysed speech and is assumed to be real valued.

i.e. $L = {Sampling\ Frequency}/{Fundamental\ Freq.}$ (10)

The loop gain parameters were fed into the IIR filter design block and the loop filter was designed using the resulting magnitude response as prototype.

Inverse Filtering

Once the loop filter is determined, the excitation signal that is a more accurate model of an actual speech, can be generated from the recording via Inverse Filtering. This involves putting the recorded signal through a inverse waveguide filter:

$A(z) = 1 - H_L(z) * z^{-L}$

where, $H_L(z)$ is the loop filter designed above.

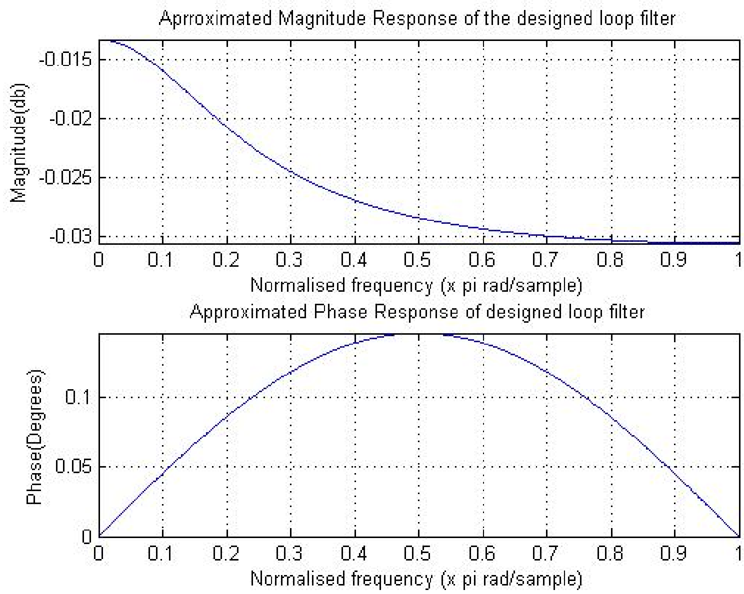

Fig. 8 The magnitude and phase response of desired loop filter

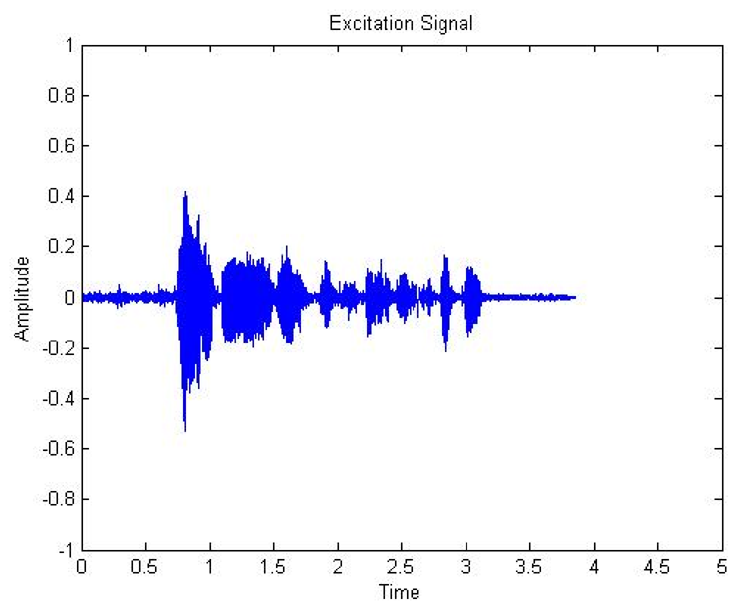

Fig. 9 Excitation signal generated via. inverse filtering

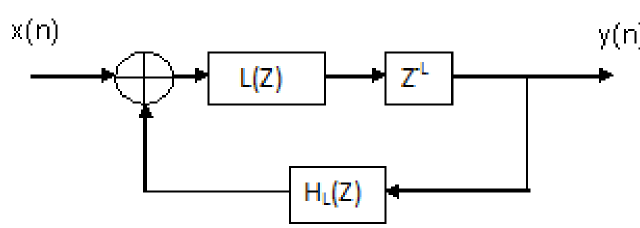

Fig. 10 Model for synthesis

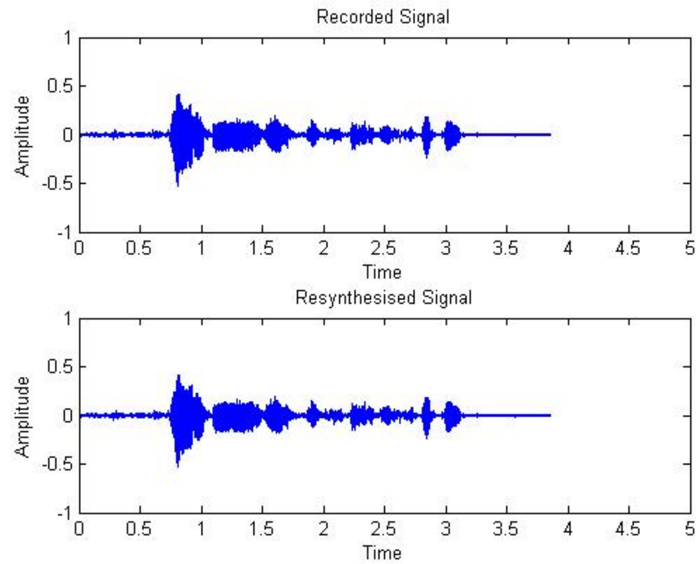

Fig. 11 The comparison between original speech and synthesized speech

The loop filter coefficients were extracted as:
B = [0.9941 -0.4498]
A = [1.0000 -0.4540]
Hence, the resulting filter had the following transfer function:
$H_L(z) = (0.9941 - 0.4498z^{-1})/(1 - 0..4540z^{-1})$
Also, the length of the delay line was calculated as:
$L = 88$, with a fractional delay of 0.2.
Hence, the corresponding model for synthesis is developed as:
where, $L(z)$is the lagrange's interpolating filter and $H_L(z)$ and z^{-L} have been specified before. Utilising the above model, the speech is resynthesized. The plot showing the original speech and the synthesized speech as shown:

Conclusion

In this work, we have proposed a method to Synthesis a given speech signal using Physical modeling based on Synthesis Approach. This method results in much more realistic synthesis than the earlier methods which used the artificial excitation. Naturally, the synthesis can still be enhanced by a more carefully designed or a higher order loop filter after that we found resynthesized speech from the recorded speech.

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Design and Development of Acoustical Missile Tracking in Combat Vehicles using Adaptive Directional Transceiver

Tarun Kumar[1], Michael Nadin A.[2] and Padmavathy T.V.[3]

Abstract The Indian Armed Forces have a reported strength of more than a million personnel in active, reserve and paramilitary category personnel, making it one of the world's largest military forces. Poising to become one of the four largest military powers in the world by the end of the decade, India is working on innovative technologies to strengthen the military power. In recent times, most of the authors have proposed the protection of military vehicles against anti-armour vehicles by Microwave Multi-Sensor System that it has problems with reliability of accuracy for finding the position of missile. In order to overcome the existing drawbacks the proposed system is a novel method for protecting military vehicles from anti-armour threat missiles. The acoustical sensor system that uses ultrasonic waves is able to detect approaching missiles. The ultrasonic waves from the sensor are transmitted through special adaptive directional antennas affixed in combat vehicles. The waves on striking the missile gets reflected back carrying the information needed to trace the trajectory and to evaluate the exact time of attack. Thus the counter measures can be initiated instantly from the processed information. This system ensures a high level protection for combat vehicles from aerial attacks in a cost effective.

Keywords: Microwave; Ultrasonic Sensor; Adaptive Directional Antenna; Position of missile; Tracing Trajectory

Introduction

Combat vehicles are essential to joint combined arms operations, operations that integrate infantry, armor, artillery, engineers, aviation, and joint capabilities. Combat vehicles have proven their value in all types of terrain and tactical environments from open desert to mountains, jungles, and cities. Combat vehicles provide general capabilities to Soldiers that enhance their ability to fight, including networked communications, load carrying, and power generation.

This paper outlines the use of acoustic sensor technology for combat zone purposes from the early 1900s to the present. The acoustic signatures of vehicles such as battle tanks, aircraft, helicopters, and submarines can easily be detected through the use of acoustic sensing technology. During World War I, flash and sound ranging equipment was used to find the exact direction of enemy artillery [1]. The Italian-developed passive acoustic location system (PALS), the sound ranging system-6 (SOARS-6) developed in Sweden, and the Russian inspired SCHZ-6 are a few of the early attempts to use acoustic sensing technology for battlefield applications around the time of World War I. During World War II, air defense was provided by simple airplane-noise detection devices such as giant stethoscopes that were pointed at the sky on both sides of the English Channel to locate, track, and identify aerial combatants and their direction of movement [1]. Combat vehicle modernization efforts must solve the "combat vehicle challenge;" that is, designing combat vehicles that protect Soldiers against threats and deliver precision lethality, while providing both tactical mobility and global responsiveness within the limitations of vehicle cost and weight.

Modern acoustic sensing technology is based on robust sensors with high dynamic ranges, imbedded computing and state-of-the-art signal processing and is being used for ground-based, aerial, and naval battlefield applications. The design requirement for a military combat vehicle for Indian environmental includes maneuverability and survivability, Off-road efficiency, Stealth design, Compact size without compromising the interior features like munitions storage, protection, comfort, communication equipment, etc. and more lethal force.

Methodology

Block Diagram

An Adaptive Directional Transceiver (ADT) has been used recently a lot in military applications as well as in civilian. It shows great advantages and importance in the search and rescue, real-time surveillance, reconnaissance operations,

E-mail: [1]taru15426.ec@rmkec.ac.in, [2]mich15235.ec@rmkec.ac.in, [3]tvp.ece@rmkec.ac.in

[1,2,3]Department of ECE, RMK Engineering College, Chennai, India

traffic monitoring, hazardous site inspection and range extension. An Adaptive Directional Transceiver placed on the body of the combat vehicle transmits ultrasonic sound waves. The transceiver is adapted in such a way that the transmitted ultra sonic waves senses the approaching missiles by reflected sound signals. The information is processed by the internal systems in the vehicle and thus the trajectory of the missile is traced. Hence the position and exact time of approach is determined, providing a security warning for those vehicles. Figure 1 shows the block diagram of Acoustical Missile Tracking in Combat Vehicles Using Adaptive Directional Transceiver.

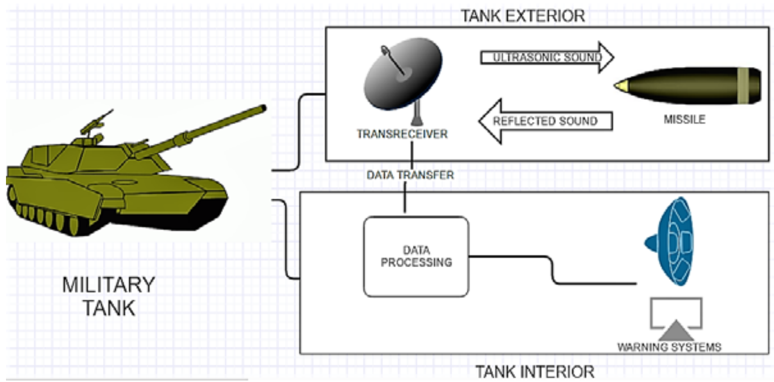

Fig. 1 Block diagram of acoustical missile tracking system using ADT

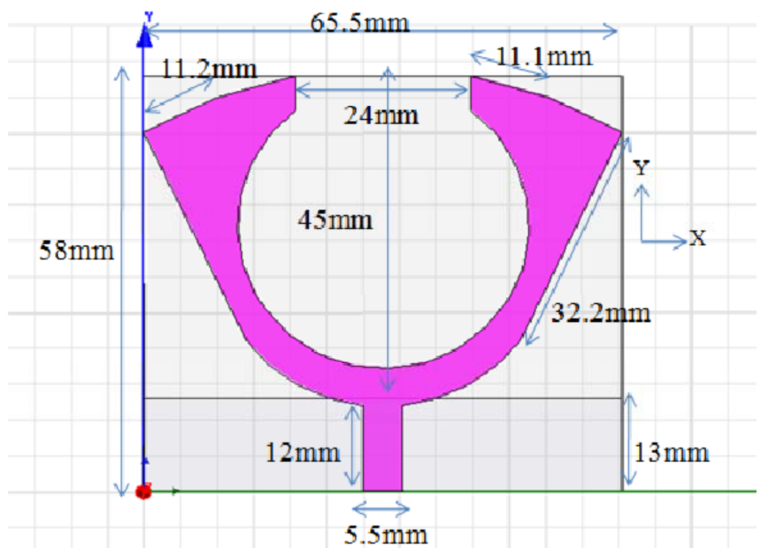

Fig. 2 Sensing antenna design

An Adaptive Directional Transceiver are low-profile, low cost, simple to fabricate, mechanically robust, capable of dual and triple frequency operations and ease to integrate with microwave integrated circuits. The designed ADT is used for sensing the sonic waves and transceiver purpose.

Sensing Antenna Design

The sensing antenna is a wideband antenna for spectrum sensing. The antenna is printed on a substrate of 65.5mm x 58mm Rogers Duroid 5880 with dielectric constant of 2.2 and height of 1.6mm. The antenna design topology consists of two layers. The top layer is the polygon shaped patch and bottom layer is the partial ground with dimensions of 65.5mm x 13mm. The patch is slotted in order to locate the reconfigurable antenna for transmission purpose i.e. the sensing and reconfigurable antenna both into the same substrate. The ground is fed via a microstrip line to produce radiation above and below the substrate. The microstrip section is matched to 50Ω feed to the input impedance of the patch. The corresponding antenna structure is shown in Fig. 2.

Practical Adaptive Directional Transieiver

Figure 3 shows a typical directional transciver. The vector OD defines an orientation for an antenna. This orientation vector as K. ∠AOA is the maximum possible beamwidth. This will denote as angle α. Similarly ∠COC is the minimum possible beamwidth and it is denoted as angle β. ∠BOB is the angle at which a given antenna transmits at any given point. This is denoted by θ. Clearly $\beta \leq \theta \leq \alpha$. α and β are properties of the antenna and cannot be changed. θ Is a variable and can be changed but it always ranges from a maximum of α and a minimum of β. Also note that the beamwidth cannot be changed arbitrarily, i.e., the beamwidth changes in such a manner that it is symmetrical with respect to the orientation vector K.

Structure of Adaptive Directional Transceiver

The designed reconfigurable antenna is a narrowband antenna used for communication purpose in vehicular networks applications. Reconfigurable antennas provide the ability to djust various antenna parameters like operating frequency, radiation pattern and polarization also reduces the effects from interference and jamming. The reconfigurability is achieved mostly by active switches such as electronic and mechanical or optical switches. Electronic switches like RF MEMS, pin diode and FET transistors may employ with reconfigurable antennas for electronic tuning. The proposed frequency reconfigurable antenna is a rotatable one, where the simple rotation of antenna will produces different resonance frequencies. This method wont required any biasing lines to activate elements like switches; these biasing lines may affect the antenna performance. The designed antenna is a modified shape of two triangle patches separated with the distance of 7mm. The required substrate is Rogers Duroid 5880 with dimensions of 65.5mm x 58mm and height of 1.6mm.The microstrip line is connected to 50Ω feed to produce radiation above and below the substrate. The ground plane is partial with dimensions of 18mm x9mm.Here the antenna reconfigurability is achieved by 180° rotation of narrowband antenna patches.

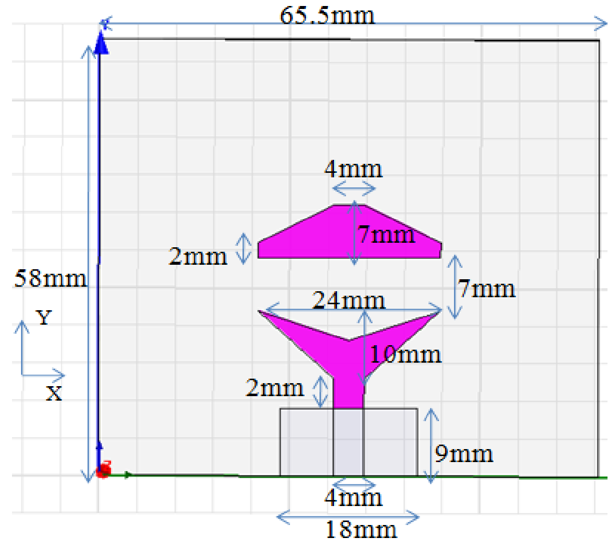

Fig. 3

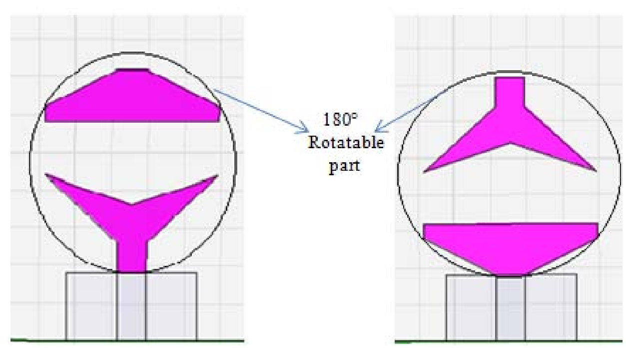

Fig. 4 Process of rotation of adaptive directional transceiver

Figure 3 shows the design of reconfigurable antenna; it has two different shapes of patches. Rotating the antenna patches by 180°, different structure is being fed to microstripline. For each rotation the antenna produces different resonance frequencies. The design of patch, the partial ground plane and feed matching section guarantee to produce different resonances at different positions

Figure 4 shows two different rotating position of reconfigurable communicating antenna. The antenna tunes from 3.1- 4.7 GHz (position1) to 5.1 to 9.6GHz (position2).

References

A literature survey is conducted to understand the about the Indian Defense Scenario and the threat to current and future forces. Also study includes the armor protection required and consideration for future light armored vehicles. The original tracking algorithms were built into custom hardware that became common during World War II. This includes storage tubes used with planned position indicator displays, range height indicator displays, and pen-plotting boards used for civilian air traffic control and waterway management. Position location technologies have traditionally been of interest to the military and intelligence communities.

The authors in [2] proposed that a protection of military vehicles is based on standard steel armors seems to be less effective. The main reason for that is an easy availability of missiles that are able to destroy even very thick armors.

The Interacting Multiple Model (IMM) algorithm uses multiple models to represent the target, which can be combined to generate a better tracking model than a Kalman filter can provide [3]. Examples of the models are the constant velocity and constant acceleration models, when moving in a straight line, or the turning model, when the other models could not be applied.

Every radar has several types of biases: location bias, azimuth bias and range bias [4]. Location bias is around 200 ft and reflects the uncertainty of the radar's own position. Azimuth bias stems from the incorrect alignment of the zero degree mark and misalignments between the antenna's soft- and hardware. The magnitude of this bias is around 0.3 degrees. It is azimuth dependent and varies with time. It causes a position error which increases with range. Range bias, in the order of 300 ft, is introduced by the normal design limits such as the range sampling clock.

Combining the results of multiple sensors can provide more accurate information than using a single sensor [5], [6]; this allows either improved accuracy from existing sensors or the same performance from smaller or cheaper sensors. In recent times, most of the authors have proposed the protection of military vehicles against anti-armour vehicles by Microwave Multi-Sensor System that it has problems with reliability of accuracy for finding the position of missile [7].

In addition to the traditional applications of position location technologies, novel techniques have incorporated in this paper.

This paper aims to solve the problem of detecting the approaching missiles from inside the tank. Present day's tanks do not possess any sensor system to detect the approaching missiles due to which there is being an increased threat to be hit by the enemy missiles. This system consisting of the ultrasonic sound wave sensors determines the exact position of the missile fired by the enemy tanks thereby predicting the exact time of attack and thereby alerting the soldiers inside the tank.

Combat vehicle modernization efforts is used to solve the combat vehicle challenges occur in the present day; that is, designing combat vehicles that protect Soldiers against threats and deliver precision lethality, while providing both tactical mobility and global responsiveness within the limitations of vehicle cost and weight.

Equations

The equation of the trajectory of the missile approaching the tank is determined from the coordinates of the missile position obtained from the ultrasonic reflected sound. The information is processed and the following are determined using the formulas:

Equation of Trajectory is given by

$$y = xtan\theta - \frac{gx^2}{2v^2cos^2\theta} \quad (1)$$

Where,

y is the horizontal component,

x is the vertical component,

g = gravity value,

v = initial velocity,

θ = angle of inclination of the initial velocity from horizontal axis

Time of flight of the Trajectory is given by

$$t = \frac{2\,v_0 sin\theta}{g}\text{s} \quad (2)$$

Maximum height reached by the Trajectory is given by

$$H = \frac{v_0^2 sin^2\theta}{2g}\text{m} \quad (3)$$

Horizontal range of the Trajectory is given by

$$R = \frac{v_0^2 sin2\theta}{g}\text{m} \quad (4)$$

Conclusion

A brief overview of contemporary techniques tracking in Combat Vehicles Using Adaptive Directional Transceiver was presented in this paper. This discussion is based on ultrasonic waves from the sensor are transmitted through special adaptive directional antennas affixed in combat vehicles. The waves from sensor striking on the missile gets reflected back carrying the information needed to trace the trajectory based on coordinate system and to evaluate the exact time of attack. Thus the counter measures can be initiated instantly from the processed information.

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Floating Solar Photovoltaic (FSPV): An Innovative Novel Technology in Competitive Energy Market

Mehebub Alam[1] and Mandela Gain[2]

Abstract This paper presents a comprehensive analytical overview of Floating Solar Photovoltaic (FSPV) power plant which can be considered as a novel technology based solution for clean and green power in today's highly competitive energy market. The rapid increasing trend in the electricity demand, fast depletion of fossil fuels, along with environmental concerns throughout the world has led to the requirement of commissioning Solar PV plants in large scale. However the 100GW Solar Power (by year 2022) target set by Govt. of India under JNNSM needs optimum utilization of available area for deployment of Solar PV panels. But solar power plants with conventional technology require huge open area to produce adequate amount of energy. In Indian context, this land intensive technology is uneconomical due to congestion and overpopulation. It has another difficulties like heating of PV panels which affects efficiency of the plant. Though land & roof tops are considered as focus areas, Floating Solar PV (FSPV) on large reservoirs & other water bodies also offers significant potential. In such a situation to conserve the valuable land & water, installing Floating Solar PV (FSPV) system on water bodies like lakes, lagoons, reservoir, irrigation ponds, dams and canals can be an attractive option. In the era of highly competitive market open market, an organization can't survive without nurturing innovative ideas in engineering and technology. An innovative technology of Floating Solar Power Plant is fast emerging technology as an alternative to conventional one. Several pilot projects are already started in few countries like Australia, China, Japan, UK, India etc. PV panels are mounted on platforms that floats on water body (Lakes, reservoirs, canals etc) and anchored tightly to prevent any movement in adverse weather conditions. In this paper various types of FSPV systems are discussed. Further, techno economic analysis and feasibility of a typical Floating Solar Photovoltaic (FSPV) system is also analyzed with Indian context. A brief study of power generation potential and water saving potential through FSPV system is also highlighted considering the major reservoirs in India. Moreover, several key aspects and challenges associated with FSPV system are described considering the technical, social, economical and environmental issues. Finally some recommendations are given for smooth implementation and development of FSPV system in India to harness the existing resources in optimum manner. This paper will be very much helpful and will provide complete guideline to the academicians, researchers, professional engineers as well as manufacturers and industries directly or indirectly involved with solar based generation.

Keywords: Floating Solar Photovoltaic (FSPV), Liquid Solar Array (LSA), Techno Economic Analysis, Jawaharlal Nehru National Solar Mission (JNNSM), Sustainability

Introduction

The hindrances to fast moving advancements and developments of civilization are the limitation of natural resources and environmental degradation. To overcome this situation and make our development "sustainable", we need innovative ideas and up gradation in our technology. Energy is the basic necessity for growth and development of a nation and per capita energy consumption is considered as development index across the globe. Till date production of energy around the world is based on fossil fuels mostly which is depleting day by day. Apart from this, excessive use of fossil fuels causes environmental degradation rapidly. Over the last few decades it's a matter of high concern and every country are discouraged to use coal guzzling, smog-blanketed technology to produce energy. An endeavor started to move forward to renewable energy technologies. Various researches [1–7] have shown the need of solar energy along with several associated issues. Floating Solar PV (FSPV) technology is an innovative emerging way of producing clean and green energy by utilizing the water

E-mail: [1]mehebubjgec1990@gmail.com, [2]gain.mandela@gmail.com

[1]Executive Engineer (E), RTPS, DVC, Raghunathpur, Purulia, India

[2]Assistant Engineer (E), WBSEDCL, Malda, India

bodies like Lakes, reservoirs, canals, dams etc. Several aspects of FSPV technology have been presented in [1–4,8,9,10]

Components of FSPV

FSPV plant mainly consists of following components [4] (Fig. 1)

- *Floating System*: A floating body (Structure along with Floater) that allows the installation of the PV module
- *Mooring System*: Can adjust to water level fluctuations while maintaining its position in a southward direction
- *PV System*: PV generation equipment, similar to electrical junction boxes, that are installed on top of the floating system
- *Underwater Cable*: Transfers the generated power from land to the PV system development. Even though no electrical components are under water, properly rated cables and water proof IP67 junction boxes are important with floating solar projects.

The structure should easily adapt to changes in water level in reservoirs. i.e. irrespective of water levels the system, should float on the water bodies. The floating material should be completely recyclable. The characteristics of these structures should be:

- The material used for structure should be completely non toxic, resistant to salt water and alkalis acids, UV rays resistant and completely recyclable.
- The structures should be able to withstand temperatures from -60°C to 80°C.
- Long life time that is 30 years withstand capability under water.

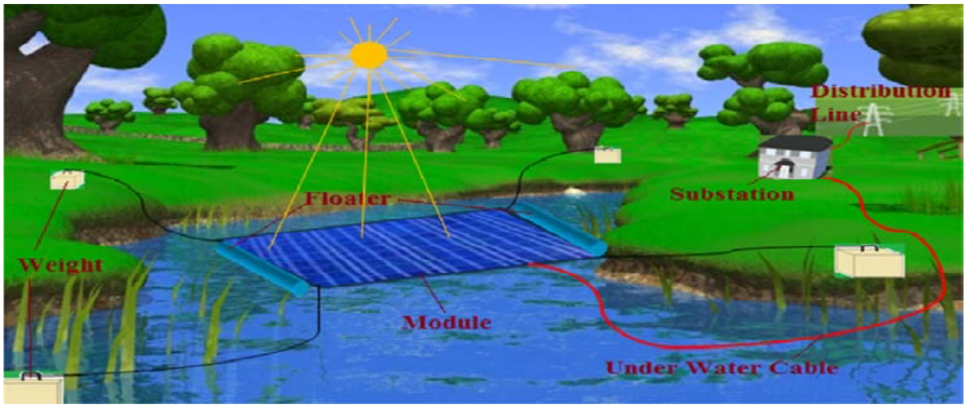

Fig. 1 Typical layout of FSPV plat[1]

Fig. 2 The floating tracker cooling concentrator (FTCC) design, italy [1]

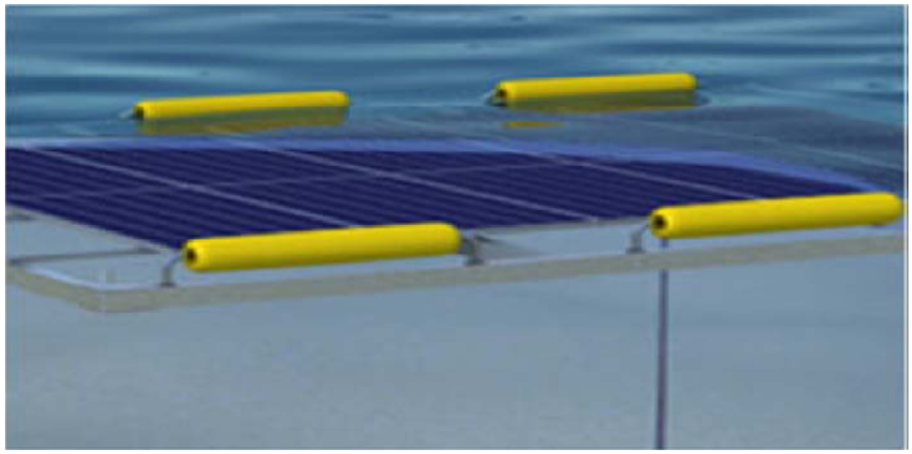

Fig. 3 Submerged PV system design, australia [1]

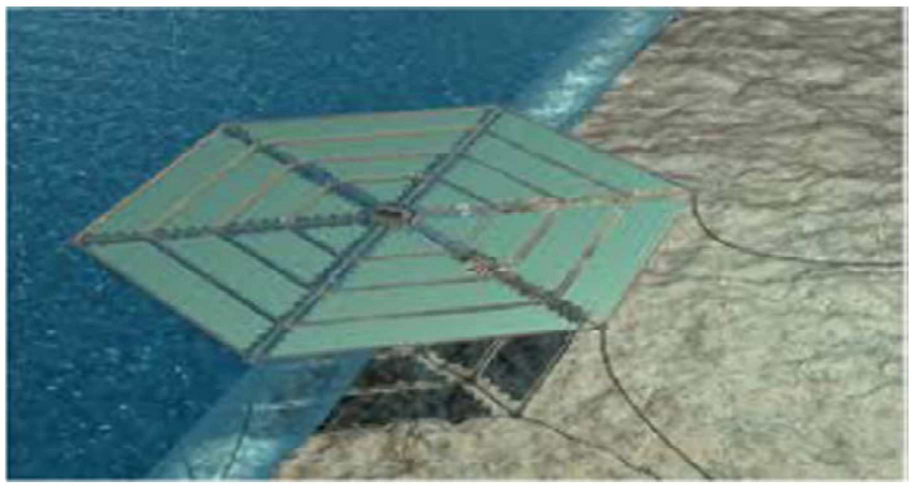

Fig. 4 Floating hexagonal PV system design [1]

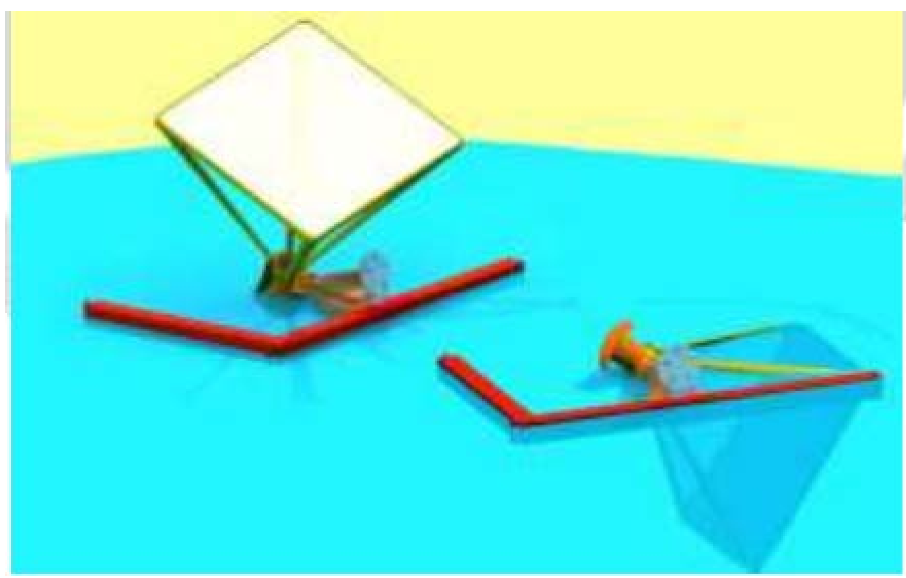

Fig. 5 LSA operated and protected position [3]

Types of FSPV

Floating Tracker Cooling Concentrator (FTCC)

This technology uses reflectors to increase the efficiency of the solar energy capture during different times of the day. The FTCC[1] (Fig. 2) also uses water to help stay cool, reduce costs to about 20% less than conventional, ground based systems.

Submerged Photovoltaic Solar Panel

In this configuration (Fig. 3) the panels are immersed in water and this allows us to realize again in efficiency of approx. 20% in summers compared to a normal panel exposed to the air

The other flexible floating PV concept is called SUNdy (2012), realized by Det Norske Veritas (Fig. 4). This design consists of a series of thin film PV panels connected together and then on to the electrical buslines running through the hexagonal vertices.

Liquid Solar Array (LSA)

Liquid Solar array (LSA)[3] was invented by *Mr. Phil Connor, Executive Director* and Chief Technology Officer of the Australian solar power company *Sunengy Pvt Limited.* The solar energy from direct sunlight is focused by a thin acrylic lens down through a glass lid, into a sealed, partially submerged metal well, containing photovoltaic cells. Collectors rotate tracking the movements of the sun by both a light sensor and dead reckoning software. A wind sensor is connected to the sun tracking software to submerge each unit into the water should winds rise above a predetermined force and return the lens to its tracking position once the winds have abated. The lens is water-sealed and is cleaned automatically. An inverter converts LSA (Fig. 5) power from direct current to alternating current, which is then connected to the power supply system (Grid). Each array is anchored to allow for changes in the water level and to keep them in position.

Benefits and Challenges

Major benefits [1,2,3,4] of FSPV technologies are:

- Photovoltaic cells used are naturally cooled by convection of the water to give top silicon efficiency.
- Structure & Concentrator lens can be made from very light-weight, low cost plastics as they are protected from extreme weather forces.
- Minimal land & setup cost (dual use of water)[3]
- LSA has the potential to produce solar power at around half the cost of conventional solar technology right now and achieve price parity with fossil fuels in the medium term.
- An LSA installation could match the power output of a typical hydro dam using less than 10% of its surface area and supply an additional six to eight hours of peak power per day.
- For tropical monsoonal hydropower sites the low-solar periods correspond with high rainfall periods so the match with the LSA system is extremely good.
- Such a package is a much more reliable producer of power than hydropower alone, as the system is far less dependent on water supply: In drought conditions it will be possible to continue daytime solar power generation from the LSA with no consumption of water at all.
- The systems can also improve water quality. By shading the water, algae growth is reduced, minimizing the associated treatment and labour costs.
- Reduce evaporation by up to 70%. A 3–acre storage pond covered with solar panels could save over 4 million gallons of water each year.

Various challenges [1,2,3] associated with FSPV technology are:

- Connection with power system, distribution line, distance to distribution line, distance to load
- Legal restrictions, water source protection area
- Environment Preservation Act, Protection of Wild Fauna and Flora Act, fishing prohibition area, marine leisure activity prohibition area, civil complaints, excessive compensation expense, inducement of environmental problems, etc
- Factors that affect installation and maintenance: depth of water (water level fluctuation), frozen region, inflow of floating matters, accessibility, interference by dam facilities (water intake tower, waste-way), etc
- The water Current could be maximum max speed 2 m/s
- Though the project is initially tested in still water but it also has a scope to have height up to 1 meter.
- Temperature limits under which the solar panel can operate is between -5°C to50°C
- The maximum Wind speed that the plant can bear is up to 210 km/h. This is the reason Cyclonic and Typhoon area covered with special design to prevent any damage.

Table 1 Techno economic analysis of 1 MW FSPV plant

Total Capacity of Plant	**1 MW**
Capacity of each module	250 WATT
No of modules	4000
Total installation cost	8 Crores
Average generation hour/day	6 hour
Total generation hrs	2190
Total generation in MU/Day	0.006
Total annual generation in MU/Year	2.19
Total selling cost@ Rs 6/Kwh	1.314 crores
Total O&M cost(20% selling cost)	0.2628 crores
Earning per year	1.0512 crores
Simple pay back period (SPP)	7.61 years (approx)

Techno Economic Analysis

Key design factors are:

- Layout of pond/reservoirs
- Floating structures/geometry
- Orientation of PV panel

Techno economic analysis [1] of a typical 1 MW FSPV plant is demonstrated in table 1.

Scope of FSPV in India

Potential of solar energy and water saving potential [2] considering Indian major reservoirs is given in table 2.

Case Study of DVC

Cummulative catchment area of DVC [11] (Damodar valley corporation) owned Maithon, Panchet, Tilaiya and Konar dam is 12000 square km (approx). Total reservoir surface area (including maithon, panchet and konar) is 120.84 square km (approx). Based on the experience in various previous installations and indication by various installers or manufacturers, a conservative estimate of 40 MWp capacity [2] FSPV can be taken per square km of reservoir surface area covered. The coverage of minimum 20 % of total reservoir surface area can be considered with negligible impact on environment [2]. The coverage in the sites listed above is 22% to 43% of reservoir surface area. The saving in water due to reduction in evaporation losses is taken as 1250 million litres [2] per year per sq. km.(4 million gallons per acre per year).

Proposed area (30%) coverage for FSPV = 120.48X 0.3 = 36.252 square km

Proposed FSPV rating = 36.252X40 = 1450 MW

Water Saving per year = 36.52X1250 = 45650 million litres

Goi Initiatives

Government of India has aimed to achieve 100 GW [5] through solar under JNNSM [Jawaharlal Nehru national solar mission] till 2022. Under this mission government is planning to set up power plants throughout the country using solar thermal and solar photovoltaic technologies. Plenty of solar power projects were commissioned by the previous Government in last couple of years. However, only a few are operational. The new Government has prioritized the solar power sector in its Budget, but the implementation should be done on war footing. Solar energy will only then prove to be the goose that lays the golden eggs. GOI proposed 30% subsidy support from National Clean Energy Fund (NCEF). The system cost also includes annual maintenance charges for 2 years. The manner of disbursal of subsidy is as follows:

- 20% after successful installation and commissioning of the system.
- 5% after one year of successful operation of the project.
- Balance 5% after two years of successful operation of the project.

The 100 kWp floating solar generation plant, largest of its kind in India, was indigenously developed as a part of ‘Make In India’ initiative, at Rajiv Gandhi Combined Cycle Power Plant (RGCCPP) in Kerala’s Kayamkulam district. These floating platform were indigenously developed by NTPC Energy Technology Research Alliance, the R&D arm of NTPC

Table 2 Solar energy production and water saving potential in Indian major reservoirs

Reservoir	State	Reservoir Area Sq. Km	Floating Solar PV GWp Potential	Water Saving Million Litres Per Year
NagarjunSagar	Andhra Pradesh	284.9	19.943	356125
Sriramasagar	Andhra Pradesh	450.82	31.5574	563525
Srisailam	Andhra Pradesh	616.42	43.1494	770525
Somasila	Andhra Pradesh	212.28	14.8596	265350
ManimataHasdeo	Chhattisgarh	188.47	13.1929	235587.5
Pong	Himachal Pradesh	260	18.2	325000
Salal	J&K	93.56	6.5492	116950
Maithon	Jharkhand	106.19	7.4333	132737.5
Panchet	Jharkhand	153	10.71	191250
Tenughat	Jharkhand	64.8	4.536	81000
Krishnarajasagar	Karnataka	129	9.03	161250
Tungabhadra	Karnataka	378.13	26.4691	472662.5
Bhadra	Karnataka	117.25	8.2075	146562.5
Linganamakki	Karnataka	316.65	22.1655	395812.5
Malaprabha	Karnataka	129.5	9.065	161875
Hidkal	Karnataka	78.04	5.4628	97550
Hemavathy	Karnataka	91.62	6.4134	114525
Supa	Karnataka	123	8.61	153750
Almatty	Karnataka	754.25	52.7975	942812.5
Cheruthoni	Kerala	59.83	4.1881	74787.5
Gandhisagar	Madhya Pradesh	660	46.2	825000
Tawa	Madhya Pradesh	200.55	14.0385	250687.5
Bargi	Madhya Pradesh	267.97	18.7579	334962.5
Indira Sagar	Madhya Pradesh	913.48	63.9436	1141850
Koyna	Maharashtra	115	8.05	143750
Paithan	Maharashtra	398	27.86	497500
Ujjani	Maharashtra	336.5	23.555	420625
Totladoh	Maharashtra	77.71	5.4397	97137.5
Hirakud	Odisha	743	52.01	928750
Rengali	Odisha	378	26.46	472500
Upper Kolab	Odisha	122	8.54	152500
Indravati	Odisha	110	7.7	137500
RanapratapSagar	Rajasthan	198.29	13.8803	247862.5
Mahi Bajaj	Rajasthan	134	9.38	167500
Bisalpur	Rajasthan	218.36	15.2852	272950
Mettur	Tamil Nadu	153.46	10.7422	191825
Rihand	Uttar Pradesh	468	32.76	585000
Matatila	Uttar Pradesh	138.85	9.7195	173562.5
Rajghat	Uttar Pradesh	2453	171.71	3066250
Kangsabati	West Bengal	124.32	8.7024	155400
Total	Potential 909.05 GIGAWATTp		16233187.5 Million Litres	

Fig. 6 India's first floating solar power PV plant at Kolkata[4]

Table 3 Few installation of FSPV plants

Sl. No.	Company Name	Capacity	Location/Features
1	NHPC Ltd.	50 MW	Kerala, India
2	Vikram solar Pvt. Ltd.	10kW	New town, West Bengal, India
3	Kyocera TCL solar	13.4 MW	Yamakura, Japan
4	Balbina hydroelectric plant	350 MW	Brazil
5	Saitama Prefecture, Japan	2786 panels of 255 Wp	43%(0.81 ha) of coverage on water regulation pond, Japan
6	Hyogo prefecture, Japan	3392 panels of 250 Wp	World's 1st floating PV of 37%(0.91 ha)coverage

Development and Future Prospects of FSPV

The world's first floating photovoltaic system was installed in 2007 by SPG Solar on a pond at Far Niente Winery in Napa California.[4] It contains1,000 floating panels linked to 1,300 stationary panels on land to produce a total of 4 MW. In Napa of California most of land used for wine fields, so the Floating solar system is chosen to secure the land which is used for power generation. Fig. 6 shows the picture of world first solar power plant.

Asia pacific is the largest and fastest growing market of floating solar panel followed by Europe, Japan, China and India(some installed plants are given in table 2). A new market opportunity lies in the expansion of floating panel type solar power system in densely populated countries such as China, India, Japan, USA, Korea, Australia, Braziland others where there is shortage of land that can be used for the installation of overland solar panels. As the cost of water surface is much lower than the cost of land the demand for Floating PV is expected to increase and will spread all over the world. In addition arability of the water resources, demand and supply gap of electricity in India and china are also high in comparison to the developed countries which in turn expected to boost the market of floating solar technology. India has taken a challenge of installing of 100 GW capacities of solar power installation and generation by the year 2022.

Andhra Pradesh is also planning to set up a 100 megawatt floating solar power project. It is likely to come up at Penna Ahobilam Balancing Reservoir which has a live capacity of 305 million cubic meters.

The National Hydro Power Corporation (NHPC) has also announced plans to set up 600 megawatts of floating solar power project at the 1,960 MW Koyna hydro power project.

According to media reports, two floating solar PV projects, each having 10 megawatts of capacity, will be set up in the states of Andhra Pradesh and Kerala. Each project is expected to entail an investment of Rs 70 crores ($10.7 million) and will be funded by World Bank. Both these projects will be executed either by the respective state governments or Solar Energy Corporation of India (SECI).

Recommendations

The Government, researchers as well manufacturers should come forward to address the following issues:

- The effect of salt water on the PV structure and the module performance has to be researched
- Development of solar tracking system that can change the tilt and azimuth angle of floating PV system is required
- Most of the projects in existence incorporate rigid crystalline PV modules which are in capable of withstanding harsh water environment therefore research on flexible thin film technology for such harsh condition have to be explored
- Maximum speed of wind, water current, temperature limit, snow load, cyclone and typhone has to be considered while designing the solar panel.
- Remote sensing and GIS based techniques can be used to determine the potential of floating solar PV projects.

Additionally following aspects to be considered related with FSPV plant.

- May create an impact on ecologically protected and susceptible areas.
- Potential reduction in algae growth due to reduced sunlight diffusion and reduced photosynthesis.
- The silicon modules and High-Density Polyethylene (HDPE) thermoplastic floats may affect the quality of water
- Possibilities of electrical accidents owing to underwater cables and have impact on existing ecosystems
- Fishing and other transport activities in water bodies may get affected.
- Biodiversity of aquatic system may likely to get affected

Conclusions

This paper highlights the concept of floating PV system installed on still water bodies such as ponds, lakes, dams and reservoirs. As FSPV panels would be floating on water, they are expected to stay cool and hence generate more power than those set up on land. Undoubtedly, floating solar technology would prove to be an innovative step as it could solve the perennial problem of land. This FSPV technology could be a *game changer* for India. It has the potential to reenergize India's economy by creating millions of new jobs, achieving energy independence, reducing energy deficit and propelling India forward as a *'green nation'*. So, FSPV technology is an attractive option and government should implement it in a well planned way by considering various social, technical and economic issues to utilize the feasible water resources of India. effectively Moreover it will help to meet the solar target and achieving sustainability of power thus ensure sustainable development.

Acknowledgment

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Innovative Technique Implementation on Solar Pump Operation at NLCIL, Neyveli, Tamilnadu

M. Coumarane[1] and V. Manoharan[2]

Abstract Renewable Energy sources are plays vital role in the context of developing clean energy. Global warming and Environment issues are threatening factors in Generation of power from fossil fuel. Solar is kind of renewable energy abundantly available in Earth and is used for producing power and Thermal Energy. The effective way of utilizing the clean energy is also important in the scenario of clean development mechanism. This paper describes an innovative technique implementation to achieve the effective utilizing of Green energy using with Water level control, GPRS/GSM communication and Micro controller mechanism on solar pump operation. Grid-Tied and OFF-Grid solar system concepts are used together at one of the project at NLCIL, Neyveli, Tamilnadu. [1]

Keywords: Renewable Energy–Global warming–Clean Energy–Innovative Technique–Solar pump–Grid Tied–OFF Grid

Introduction

The increasing demand for energy, the continuous reduction in existing sources of fossil fuels and the growing concern regarding environment pollution, have pushed mankind to explore new non-conventional, renewable energy sources for the production of electrical energy . Since, India receives sunlight all 12 months utilizing it in different fields is a wise idea. In the scenario of clean energy generation, PV solar plays a vital role in mass scale of installation in Ground and Roof tops [4]. Solar power meets the requirement of domestic lighting, fan and pumps. In general PV solar systems connected to Grid-Tied or OFF Grid. The integrated Grid-Tied and OFF-Grid operations are rare in installation because it requires intelligent mechanism to control the Grid operation.

E-mail: [1]couma_rane@yahoo.com

[1]Deputy Chief Engineer/ Electrical, Centre for Applied Research and Development (CARD), NLC India Ltd., Neyveli, Tamilnadu

[2]General Manager / Centre for Applied Research and Development (CARD) & Disposal NLC India Ltd., Neyveli, Tamilnadu

PV Panel and Solar Pump–System

The Schematic diagram of PV panel and solar pump is shown in Fig. (1). 10kw PV panel connected to DC Change over switch and connected to Grid Tie Inverter, 10Hp Pump-1 (overhead tank) and 10Hp Pump-2 (Irrigation). This pumps operation carry out in Auto /Manual mode. Auto mode pump operations carry out by Mobile switching with Over Head tank Level switch Control mechanism.

Grid–Tied Solar System

Figure 2 shows that 10kw Roof top solar PV panel mounting arrangement.

Grid-Tied solar Systems generate power when the utility power grid is available. They must connect to the grid to function. These are simplest systems and the most cost effective to install [6]. These systems will pay for themselves by offsetting utility bills in 3–8 yrs. It is a good choice to reduce electric bill and carbon footprint.

OFF–Grid Solar System

2.1 OFF-Grid solar system is generally prepared for remote areas where centralised Grid not extendable. This will be connected to load independently. Battery source used for sharing the load and maintain the system stability in the variation of PV source

Water Pumping System

Figure 3 shows that water pumping system with solar VFD arrangement. Normally VFD electricity supplied by gird or generator directly, that mean is normal VFD using AC power, 3PH or 1 PH. Solar Pump VFD is which getting the input power from PV module and changing it to AC output for pump controlling and pump working [3]. Hard ware is 100% same as normal VFD, the difference between normal VFD and Solar Pump VFD is only about to MPPT Algorithm SOFTWARE. Normally 30% of power saving is achieved by using above VFD mechanism [2]. We can say Solar Pump VFD is VFD based MPPT pump controller. VFD don't have special MPPT control unit. It can be achieved by customized software without any hardware alternative.

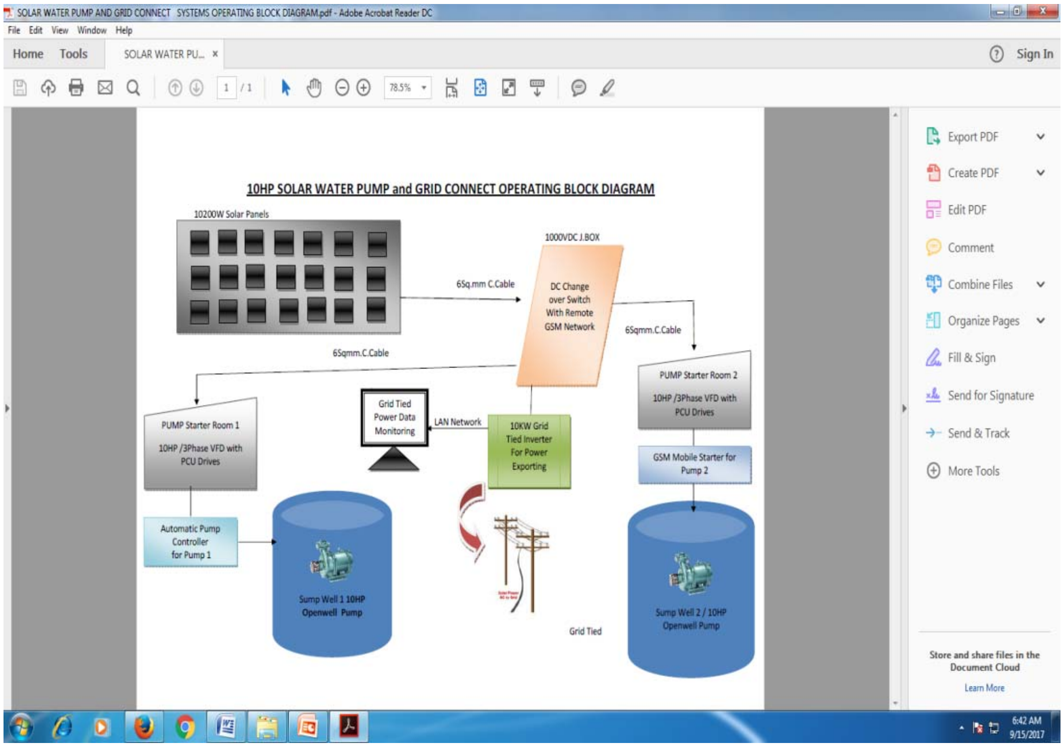

Fig. 1 Schematic diagram of PV solar & pump

Fig. 2 10kw Roof top solar PV panel mounting

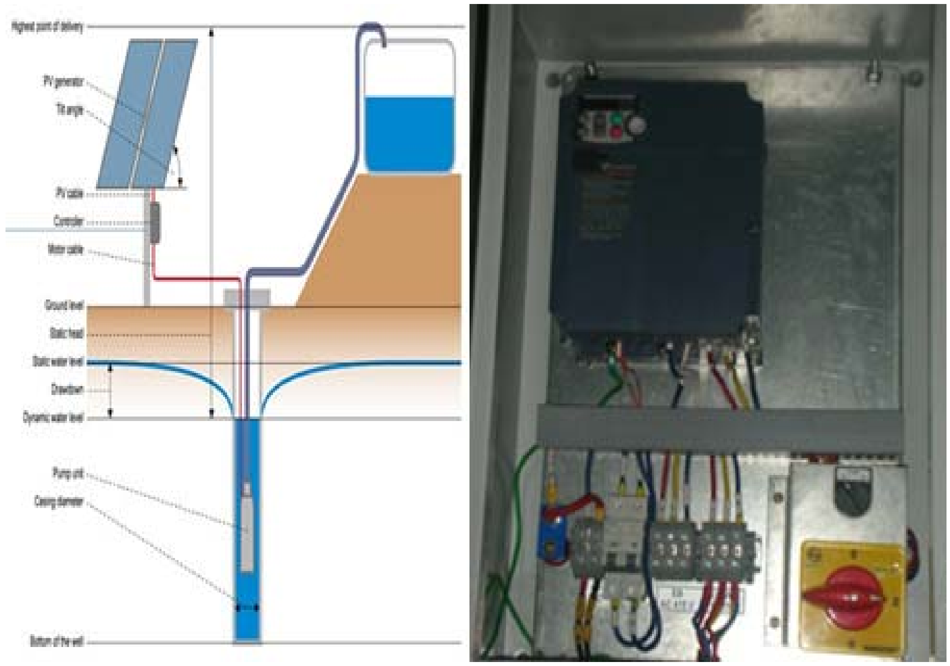

Fig. 3 Water pumping system with solar VFD

Automation and Controller

Grid-Tie operation

In General solar power connected to Grid tie via Inverter. 1phase DC /3Phase AC – Grid tie Inverter takes one minute for synchronizing PV solar power to Grid, matching the voltage and frequency. Symbolic picture representation of synchronization will shows in Inverter LCD display screen during this period. Grid tie mode will be change over to OFF Grid mode in the selection of pump operations by one minute delay. Similarly when the pump gets switched off, the Grid tie Inverter connect the Grid by one minute delay automatically. Power and control Contactor used for the above operation with microcontroller mechanism. It is observed that 40Unit /Day (Average) power generation by 10kw PV solar and it is shared with Grid.

Over Head Tank/ Pump-1 Operation

In case Pump-1 (10HP Sump pump) needs to operate for overhead tank water filling, the pump-1 switched ON by Mobile app, then immediately Grid-tie inverter disconnects the Grid and solar power diverted to solar pump 1 through change over switch to Solar VFD drive. Switching ON operation enabled with making of overhead tank Low level switch and switching OFF operation get automatic by making of tank over flow High level switch. Solar VFD drive converts 1phase PV, DC power to 3 phases AC and varying the frequency according to the available PV power. Solar VFD designed with Safe operation protection of Pump and it will trip the supply in case of very low PV power generation. Pump Water flow will be in proportionate with frequency matching with PV power availability

Irrigation/ Pump-2 Operation

Figure 4 shows that PV Solar and Pump control room. In case Pump-2 (10HP) needs to operate, Pump ON by means of mobile switching and pump gets stop with the initial time set (assigned). Micro controller plays the role of time control action [5]. All status information can be known from the Mobile App.

GSM Module and Micro Controller Application

GSM Module

It is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. GSM networks operate in a number of different carrier frequency ranges, with most 2G GSM networks operating in the 900 MHz or1800 MHz bands. A GSM modem exposes an interface to send and receive messages over the Modem interface [1]. The mobile operator charges for this message sending and receiving as if it was performed directly on a mobile phone. To perform these tasks, a GSM modem must support an "extended AT command set" for sending/receiving SMS messages. Micro controller accesses the GSM communication and all control operation. Fig. 5 shows that Micro controller and GSM communication device.

Fig. 4 10KW PV solar and pump control room

Fig. 5 Microcontroller & GSM module

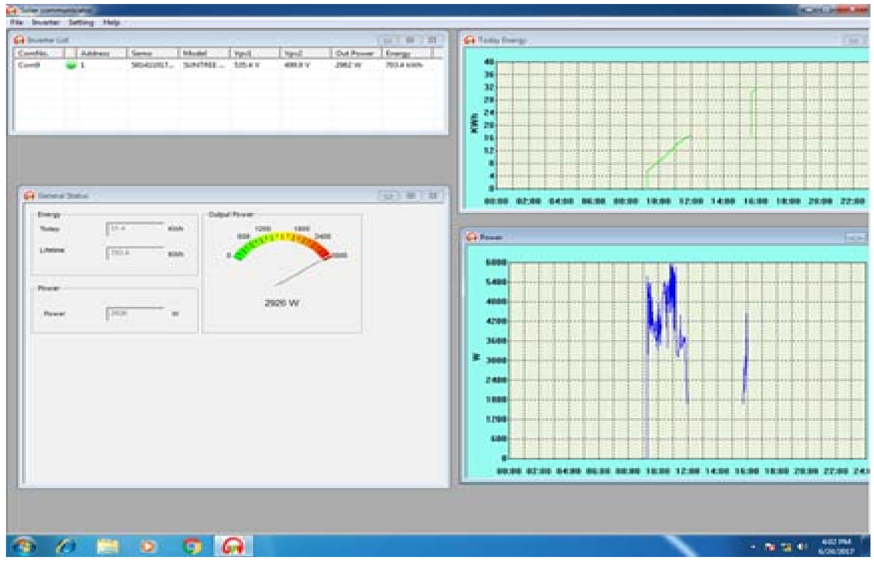

Fig. 6 PV solar parameter display

In the mobile app, Status of the system information, Notification, Individual pump operation and PCU operations are performed via SMS service [3].

PV Solar Power Online Monitoring System

Grid tie Inverter has the feature of software based PV power parameter Data logging and Display system and it can be extended to any pc through RS 485 communication. It is also can extend the service to remote PC if, the system connected in a LAN network. The online display and data logging will be helpful in data analyse and operation study. In general, KW power generation data stored in the Inverter data logger and display the data in hourly and monthly. The instantaneous value of the PV power will be displayed in the screen. Fig. 6 shows that PV solar parameter displays in the computer screen.

Conclusion

The innovative technique adopted in this project, has proven that better result in Grid-Tie, solar pump operation and Energy saving. The effective utilization of solar power is achieved by means of Micro controller, GPRS/GSM based pump ON/OFF operation and Overhead tank Level control mechanism. The ideal wasting of solar power is eliminated by operating both Grid-Tied and OFF- Grid mode of operation with the above control mechanism.

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Memory Efficient Arbitrary Tree Architecture for Wavelet Packet Transform

J. Rejina Parvin[1], S. Elakkiya[2] and Jincy Francis[3]

Abstract In this paper, a design strategy for obtaining memory efficient wavelet packet transform architecture has been derived. The proposed architecture has reduced the number of memory words, using convolution based architecture along with arbitrary tree structure. In traditional DWT architectures the hardware complexity was due to the use of frame buffer between levels which is replaced by line buffer in the proposed architecture thereby reducing the memory complexity of the design. The proposed architecture is best suited for image compression to achieve higher compression ratio by using pipelining between decomposition levels. A detailed description of all the modules used in the proposed architecture is provided in this paper. The synthesis result about the complexity of the architecture has been discussed.

Keywords: Wavelet Packets, Wavelet Tree, Very Large Scale Integration (VLSI)

Introduction

The Discrete Wavelet Transform (DWT) is frequently encountered in wide variety of applications like image processing, image compression, signal analysis [1]. Due to it's remarkable advantages it has been adopted as image compression standard for JPEG 2000. DWT decompose the signals into different subbands with both time and frequency information and facilitate to arrive at a high compression ratio. The wavelet transform puts more emphasis on the low frequencies and obtains the significant information by continuously decomposing the low-frequency component. On the other hand the wavelet packet transform has a more general tree structure. At each level in the tree structure either the high or low frequency or both the components can be decomposed. Such decomposition provides more flexibility for time-frequency tiling and is more suitable for bandpass signals.

Literature survey on the architectures of wavelet transform reveals that earlier works focused on the implementation of common digital wavelet transform or the wavelet packet transform with a predefined wavelet tree. This arise a need for optimizing the wavelet packet tree such that the resulting transform provides the sparest representation of the underlying signal. Our proposed work describes the hardware architecture that provides a dynamic tree structure for the wavelet packet transform operating on 2-D signals.

Furthermore, we provide a memory efficient architecture by reducing the requirement of frame buffers between levels of compression.

The remainder of the paper is organized as follows: The design strategy used for proposed 2-D wavelet packet transform based on parallel data access scheme is discussed in

Section II. Proposed architecture of wavelet packet transform is described in Section III. Hardware complexity and performance of the proposed structure are estimated and compared with existing architectures in Section IV. Conclusions are presented in Section V

Design Strategy

1D DWT forms the basic building block of wavelet decomposition which operates on the input signal $x(n)$ by filtering it using two filters $G(z)$ and $H(z)$, the low pass and high pass filters respectively and then decimating the filtered output by two in order to maintain the same data rate obtained on every clock cycle as shown in Fig. 1. The decimation process is achieved by using multiplexer which selects the output of high-pass and low pass alternatively every clock cycle and thereby forming an interleaved data stream.

E-mail: [1]parvinece@gmail.com, [2]ece08elakkiya@gmail.com, [3]jincyfrncs@gmail.com

[1,2,3]Veltech Dr. RR & Dr. SR University, Chennai, Tamilnadu

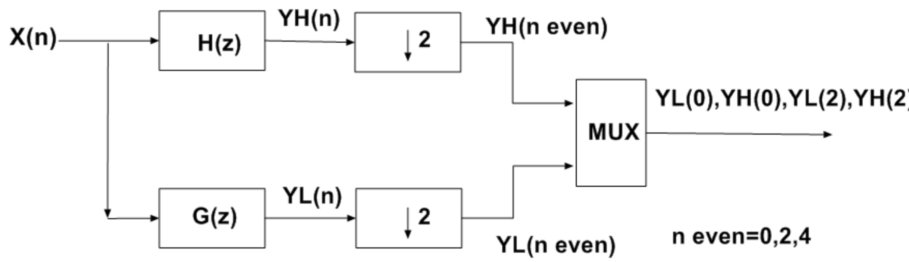

Fig. 1 Wavelet analysis building block

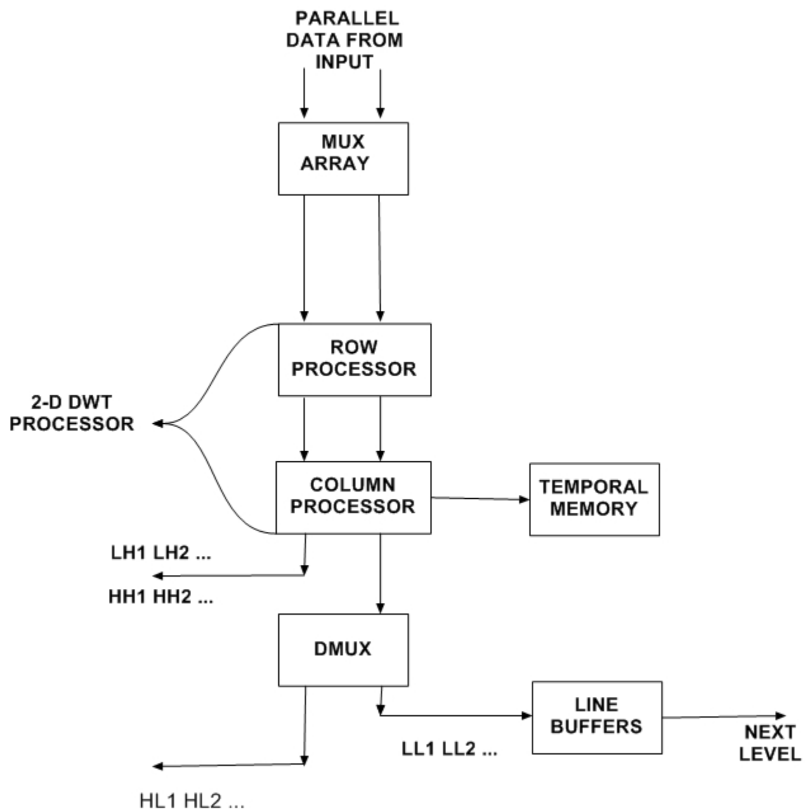

Fig. 2 Folded 2D-DWT using parallel data access

2D-DWT is obtained by performing the 1D-DWT in both row and column transformations. In first stage N rows of the input of dimension NxN is processed. The intermediate result obtained is of dimension (N/2)xN and this is transposed to obtain the columns. In the second stage the columns are processed to achieve the desired 2D-DWT result.

Architectures of 2D-DWT, according to data access techniques are mainly classified into three sets namely block-based architectures, level-by-level architectures and line-based architectures of which block-based architectures are based on processing the data using parallel data-access scheme. Parallel data-access scheme helps to reduce on-chip memory of the folded structure and a brief description about parallel data access has been discussed in this section.

Parallel Data-Access 2D-DWT using Line Buffers

The generic structure of folded 2D-DWT using parallel data-access scheme is shown in Fig. 2. The structure acquires a block of K samples from the input data in every cycle and K is equal to the order of the filter in convolution based techniques. The parallel data fed to the 2D-DWT processor reduces the need of translational memory between row and column processor. Intermediate components of row processor are directly fed to the column processor and there is no need of transposing as the row processor directly generates the intermediate components columnwise.

The LL subbands from the processor is fed as input to the next level of processing using line buffers. The line buffer excludes the use of frame buffer thereby achieving higher memory efficiency.

Wavelet Packet Tree

The wavelet transform puts more emphasis on the low frequencies and obtains the significant information by continuously decomposing the low-frequency component. On the other hand in wavelet packet tree the decomposition is applied to both the low- and high-frequency components. The input is decomposed into its corresponding low- and high- frequency components and the intermediate outputs are further decomposed to their low- and high-frequency components. The process continues as a chain reaction to obtain the complete wavelet packet tree. The output of each node is indexed as [TL, TB] coordinates, where TL is the tree level and TB is the tree branch within that level. The output data sample from a particular node is grouped into frames with frame length F where frame length is the number of samples in the frame. Grouping of frames form the superframe. The frame size is determined based on the signal dynamics and it must be multiples of eight. The frame size is selected based on system dynamics.

Proposed Architecture

The proposed architecture combines the concept of partial tree configuration of wavelet packet transform and the convolution based 2D-DWT Architecture.

Partial Tree Configuration

A partial tree configuration is a structure in which the output samples can be obtained at any node other than the maximum level output nodes. By using partial tree configuration the contents of the superframe is changed. The flexibility of the wavelet packet tree is increased by using this optimization.

For implementing 2D signal analysis the partial tree configuration is grouped consecutive two levels as shown in Fig. 3. To illustrate our proposed packet wavelet structure, we assume the original image size NxN=8x8 and the order of filter to be 4.

Original image:

$$X = \begin{bmatrix} x_{00} & x_{01}x_{02} & x_{03}x_{04} & x_{05}x_{06} & x_{07} \\ x_{10} & x_{11}x_{12} & x_{13}x_{14} & x_{15}x_{16} & x_{17} \\ x_{20} & x_{21}x_{22} & x_{23}x_{24} & x_{25}x_{26} & x_{27} \\ x_{30} & x_{31}x_{32} & x_{33}x_{34} & x_{35}x_{36} & x_{37} \\ x_{40} & x_{41}x_{42} & x_{43}x_{44} & x_{45}x_{46} & x_{47} \\ x_{50} & x_{51}x_{52} & x_{53}x_{54} & x_{55}x_{56} & x_{57} \\ x_{60} & x_{61}x_{62} & x_{63}x_{64} & x_{65}x_{66} & x_{67} \\ x_{70} & x_{71}x_{72} & x_{73}x_{74} & x_{75}x_{76} & x_{77} \end{bmatrix} \quad (1)$$

The input is taken rowwise in blocks of K samples where K is the order of the filter. Each input blocks of K samples has (K-2) overlapped samples from adjacent input blocks. From the input matrix X, extended input blocks are fed to level 1 of architecture. The overlapping will occur as

$$\underset{1}{[x_{00}x_{00}x_{01}x_{02}]}\ \underset{2}{[x_{01}x_{02}x_{03}x_{04}]}\ \underset{3}{[x_{03}x_{04}x_{05}x_{06}]}\ \underset{4}{[x_{05}x_{06}x_{07}x_{07}]}$$

In every clock cycle the input is fed to the processing element (PE) of level1 block-by-block. For the input of size NxN the first level of compression requires (N/2) processing elements. Four data vectors with overlapped inputs will be processed by each of the PE in level 1 as four tap daubechies filter is used. The top level modules and levels of the proposed architecture is shown Fig. 3.

The processing element of each level has the 2D- DWT architecture as shown in Fig. 4. The architecture consists of two subcells one of which acts to be the row processor and the other functions as the column processor. Each subcell consists of a multiplier unit and adder tree circuit. The multiplier circuit is used for interpolating the image signal to the low pass and high pass coefficients of the filter. The filtered signal of the corresponding low and high pass four tap Daubechies filter is added in the adder tree to get the intermediate $[U_L\ U_H]$ matrix components.

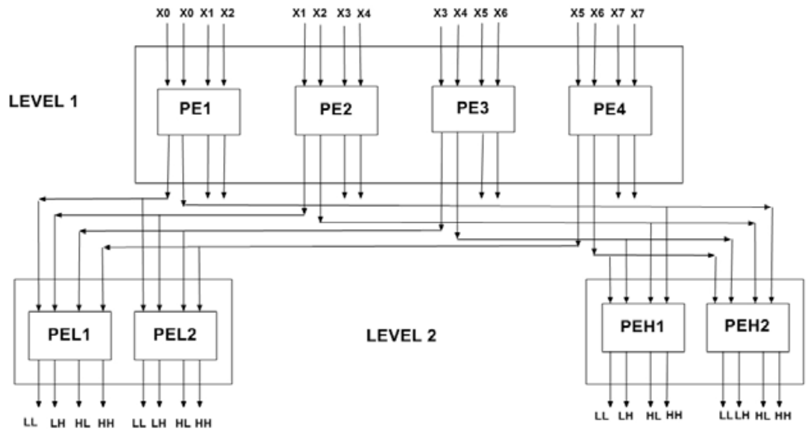

Fig. 3 Top level structure for the proposed architecture

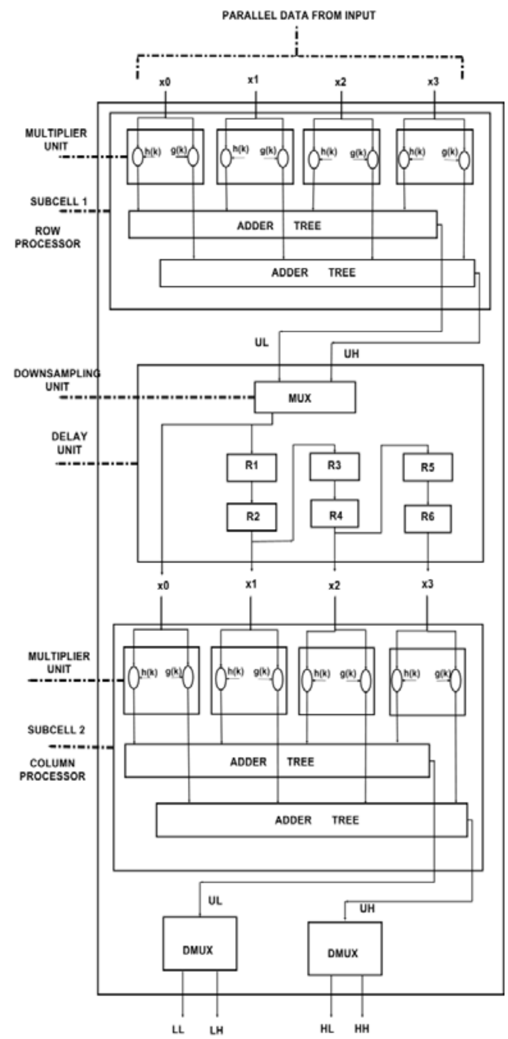

Fig. 4 Architecture of level 1 processing element

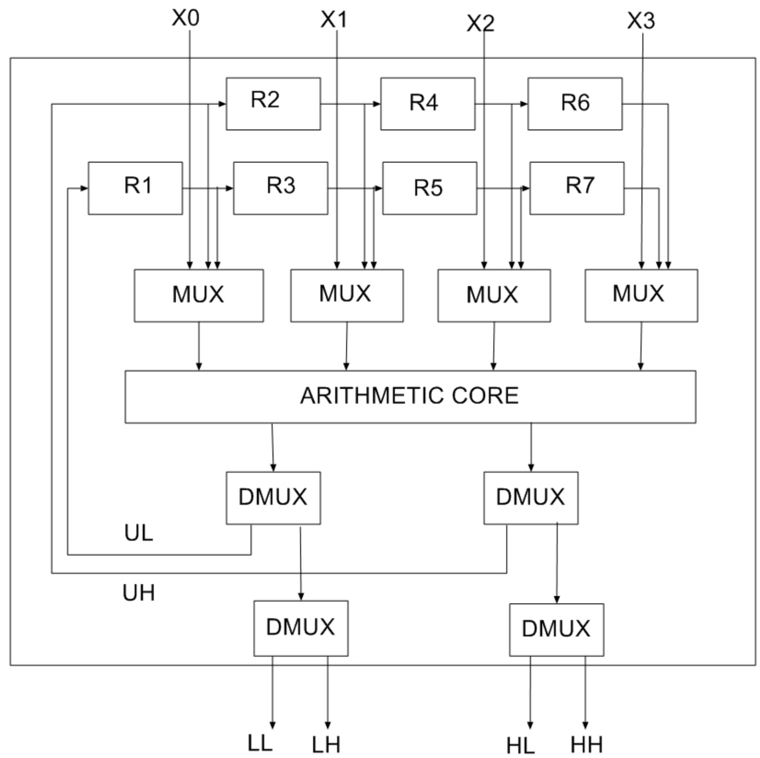

Fig. 5 Architecture of level 2 processing element

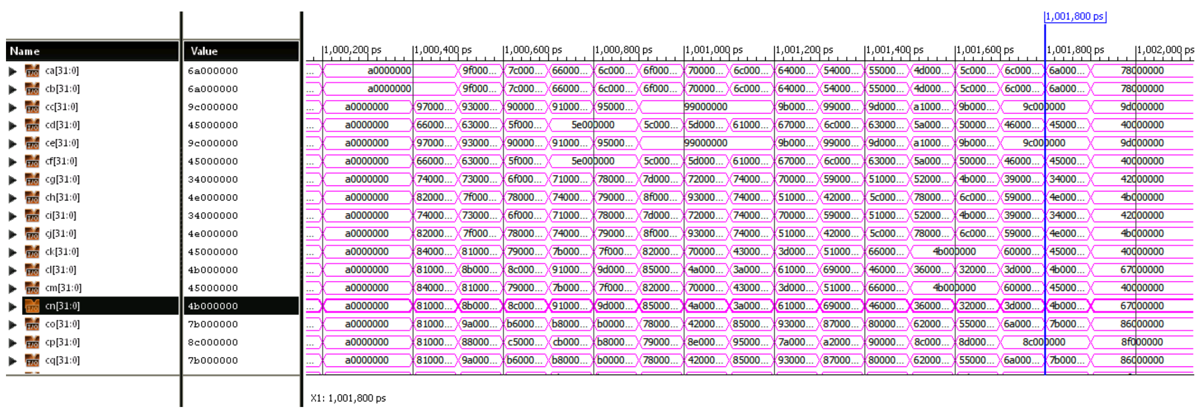

Fig. 6 Overlapped input blocks of input image

In order to achieve compression the obtained [U_L U_H] matrix components should be decimated by the factor two which is done in the delay element by using a multiplexer. The multiplexer chooses the low pass and high pass output alternatively every clock cycle thereby decimating the matrix by two. The output of the multiplexer provides the compressed image of size [M/2 X N]. The delay element also contains a shift register array which is used to delay the multiplexed output for obtaining the same number of input samples for column processing. It also provides the necessary overlapping of samples. The sub cell two is the column processor and it works on the same principle of sub cell one. The output of subcell 2 is the compressed output of level 1 of the proposed architecture and the size of the image is reduced to [M/2 X N/2].

The PE of level 2 has the same structure as that of level 1 PE. In order to reduce the hardware complexity the subcell 2 of PE is removed by making use of the unused cycles when the input to the level 2 from level 1 is unavailable as shown in fig. 5. A single arithmetic core is used which serves as both the subcells . At the first clock cycle when the input is obtained from the level 1 it serves as the row processor and performs the compression. During the second clock cycle when the input is unavailable from level 1 the delayed input samples from the shift register array is taken and processed in the arithmetic core for column processing. The output of level 2 is obtained for every four clock cycles and the size of the obtained compressed output after level 2 is [M/4 X N/4].

Results and Discussion

In order to implement the architecture, all the sub blocks of the architecture are first simulated using VHDL language in Xilinx 13.2 software. Lena image is taken as input and it is sampled to blocks of 4 inputs where each block is overlapped with the previous input blocks by the value of k-2 where k is the order of the filter. Here Daubechies filter of order 4 is taken and hence the input blocks to the DWT architecture is overlapped by 2 values as shown in figure. The hexadecimal values of pixels in the input image is stored in Block RAM using ip core in Xilinx and then processed.

The first level output of 2D packet wavelet transform is a (M/2)x(N/2) compressed output and each output occurs for every 2 clock cycles as shown in fig. 7. During the row processing of the input samples the output obtained is of dimensions (M/2)xN and then during column processing the (M/2)xN is then compressed to the dimensions (M/2)x(N/2).

The second level output is a (M/4)x(N/4) compressed output and each output occurs for every 4 clock cycles.

Conclusion

The proposed architecture is an extension of the architecture of packet wavelet transform of suggested by M. Mansour and M. Ali for compression of 1D signals. The improvement is made by using the proposed architecture for processing the 2D signals. The analysis of hardware complexity proves that the proposed architecture has less multipliers used in comparison with the traditional convolution based architectures for multilevel 2D DWT architectures.

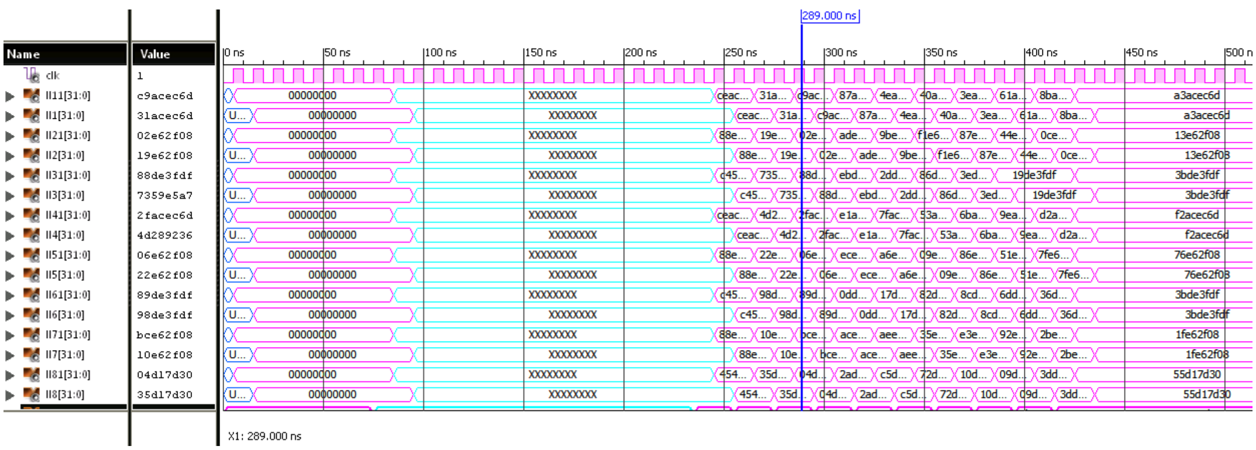

Fig. 7 Level 1 output of proposed architecture of packet wavelet transform

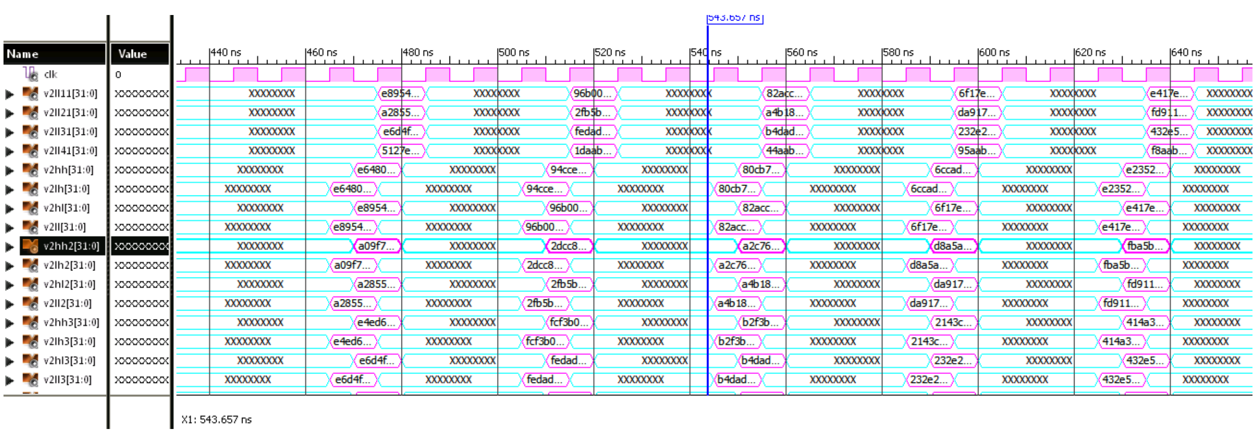

Fig. 8 Level 2 output of proposed architecture of packet wavelet transform

Table 1 Gate count estimate of the asicimplementation

Parameters	1D Structure of M. Mansour and M. Ali	Proposed 2D Structure
Wavelet input sample width	16	32
Wavelet output sample width	19	32
Filter coefficient bit width	16	32
Compiled memory	28000	33000

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Group C

- **Aerospace Engineering**
- **Marine Engineering**
- **Mechanical Engineering**
- **Production Engineering**

Applications of Semantic Web Technologies in Aerospace Domain: Current Issues and Challenges

S.S. Uma Sankari[1], P. Sreenivasa Kumar[2] and C. Geethaikrishnan[3]

Abstract Semantic Web technology offers new techniques and tools for incorporating knowledge modeling and automatic deduction into web. Ontologies are semantic tools and are useful to manage web content effectively. The advantages of semantic (web) technology have been availed in several domains of science and engineering. In aerospace, Launch Vehicle (LV) is a multidisciplinary knowledge based domain. The design, integration and operation of LV call for different types of knowledge that are gained by domain experts, over the years of experience. To establish the feasibility and benefits of semantic technology in LV domain, a knowledge intensive process of mission simulation software development is studied in this paper. Towards the study, LV ontology is developed in which Web Ontology Language (OWL) is used to formalize the declarative knowledge and Semantic Web Rule Language (SWRL) is used to formalize the inference knowledge involved in mission simulation software. Protégé-OWL, a knowledge engineering tool, is used to develop the ontology. Challenges faced during various phases of ontology development are highlighted.

Keywords: Semantic Web Technology, Ontology, Launch Vehicle, Mission Simulation, Model, Module

Introduction

Semantic Web technology, a rapidly evolving technology for the web of data, focuses on describing meaning of web content into machine-accessible form. The approach of dealing with meaning rather than structure enables computer to automatically interpret, extract, process and present web content as per need. With its benefits and features, the said technology has inspired many knowledge intensive domains of science and engineering. However, only limited works are identified in literature on aerospace domain. This paper extends the applications of semantic technology to enhance the process quality in aerospace.

In aerospace, Launch Vehicle (LV) is a multidisciplinary knowledge based domain consisting of heterogeneous subsystems. These subsystems are designed and realized by respective domain experts and integrated by system experts as LV. The knowledge, gained by experts over the years of experience, plays a major role in carrying out LV design, integration and operation.

It is learnt from a literature review that semantic structures are widely used to formalize knowledge in a standard, sharable and machine readable form. Controlled vocabulary, Thesaurus, Taxonomy and Ontology are different kinds of semantic structures 1. Out of all, ontology has all the semantic capabilities of rest of the semantic structures. Also, unlike other semantic structures, ontology can express any number of different types of relations in modeling knowledge.

Ontology is defined as ‘explicit specification of conceptualization’ 2. Borst and Akkermans define ontology as ‘a formal, explicit specification of a shared conceptualization’ 3. In ontology, the knowledge of the chosen domain is formalized by means of a set of classes, properties, functions, axioms and individuals. (Individuals are also called as instances). By defining the knowledge that is explicitly contained in domain, implicit knowledge can be deduced automatically with the help of inference procedures.

With this background, many potential use-cases are identified for adopting semantic technology in LV domain. However, in order to establish the feasibility and benefits of the technology, a knowledge intensive process of mission simulation software development is chosen for the study.

The design and development of a LV ontology to represent the knowledge associated with mission simulation software development and the challenges involved are described in this paper.

E-mail: [1]uma.reachme@gmail.com

[1,2]Artificial Intelligence and Databases Lab, Department of Computer Science and Engineering, Indian Institute of Technology Madras, Tamil Nadu, India

[3]Quality Assurance Mission Division, Indian Space Research Organization, Trivandrum, Kerala, India

The paper is organized as follows: Section 2.0 introduces LV mission simulation software; Section 3.0 describes the design and development of LV ontology; Current issues and challenges faced in applying semantic technology in LV domain and knowledge extraction process are covered in section 4.0 and 5.0 respectively; Conclusions and future works are given at last two sections.

LV Mission Simulation Software

Mission simulation is the process of studying LV performance and behavior through solving numerical models that are constructed to imitate the vehicle subsystems and operating environment. Each one of subsystems that influences the performance of LV is referred as an *aspect* in this study. Each *aspect* can have various characteristics that influence the performance of LV in different manner. Thus, an *aspect* may be classified into many *specific-aspects*. In simulation, each *specific-aspect* is numerically or analytically represented through a model. Mission simulations are carried out using mission simulation software. In the software, each simulation model is coded as a separate module. There is always a need for developing simulation software for various purposes throughout the life cycle of LV.

The current approach of LV simulation software development process consists of six phases: 1. Specification of requirements for developing simulation software by end-user; 2. Identification of LV subsystems/*specific-aspects* based on specified requirements by simulation experts; 3. Selection of required simulation models for the identified subsystems by domain experts; 4. Choosing appropriate software architecture and develop the modules for the selected models with the details of interfaces by software engineer; 5. Development of program through the integration of developed modules by software developers; 6.Testing and evaluation of simulation program by test agency. Thus the development of the software depends on various experts' knowledge gained by their experience and skills. This approach of software development invites many limitations. Out of them, prominent limitation is the dependency on experts.

In order to enhance the existing practices of software development and reduce the dependency on experts, formalization of knowledge involved in simulation software development is required. The aim of the work is to design a LV ontology and the scope of the work is limited to the formalization of declarative knowledge and inference knowledge involved in software development for a two-stage LV. Declarative knowledge describes various concepts of LV simulation such as simulation software requirements, LV subsystems, engineering models and software modules; Inference knowledge describes relationship among these concepts based on a set of principles– such as identification of subsystems/models based on specific simulation software requirements. It is assumed in this work that all the modules of simulation software, available from various design team or experts, are achieved in a centralized repository. The whereabouts (URLs) and details of each module are logically encoded in LV ontology.

In our ontology design, as a result of a detailed study, Web Ontology Language 4-Description Logic (OWL-DL) is chosen to formalize the declarative knowledge and Semantic Web Rule Language (SWRL) is chosen to formalize the inference knowledge 5.

Design and Development of LV Ontology

The steps involved in ontology design process are described as follows: 1. Choose a domain; 2. Enumerate its important terms; 3. Define classes/ class hierarchy; 4. Define properties/ functions/ individuals; 5. Establish restrictions on classes/ properties and individuals as axioms.

Formalization of Declarative Knowledge using OWL

The terms stating the ground facts on simulation software and the relations among them are classified into various ontological elements (denoted in *italics*) such as classes, properties and instances. There are four key classes are defined in LV ontology as: 1. *Simulation_Software_Requirement*; 2. *LV_System_Aspect*; 3. *Engineering_Model* and 4. *Software_Project*.

Simulation software requirements that describes the generic requirements for developing a simulation software, is defined in terms of two sub-components - configuration specification and the simulation requirement. These are defined as two sub-classes. *Configuration_Specification* includes *Stage_Type* and *Propulsion_Type* for each stage. The types of propulsion currently being used in space industry are solid-propellant, liquid-propellant, cryo-propellant and semi-cryo propellant. Two types of propulsion - *solid* and *liquid* - are considered in this study. However, it is to be noted that *cryo* and *semi-cryo*, for simulation purpose, have the same characteristics of liquid stage.

Configuration specification can be *one stage* or *two stage* and each stage can have *solid propulsion* or *liquid propulsion*. Thus, all four possible configurations for a two-stage and eight possible configurations for a three-stage vehicle can be specified. The Descriptive Logic (DL) notation of the designed class: *Simulation_Software_Requirement* is represented as follows.

$\mathit{Simulation\_Software\_Requirement} \equiv \mathit{Configuration\_Specification} \cup \mathit{Simulation\_Requirement}$

$\mathit{Configuration\_Specification} \cap \mathit{Simulation\_Requirement} \sqsubseteq \bot$

$\mathit{Configuration\_Specification} \equiv \mathit{Stage\_Type} \cup \mathit{Propulsion\_Type}$

$\mathit{Stage\_Type} \cap \mathit{Propulsion\_Type} \sqsubseteq \bot$

$\mathit{Stage\_Type(oneStage)}$ $\mathit{Stage\_Type(twoStage)}$ $\mathit{Stage\_Type(threeStage)}$

$\mathit{Propulsion\_Type(solidPropulsion)}$ $\mathit{Propulsion\_Type(liquidPropulsion)}$

$\mathit{Simulation\_Requirement} \equiv \mathit{Degrees\_of\_Freedom} \cup \mathit{Control\_Mode}$

$\mathit{Degrees\_of\_Freedom} \cap \mathit{Control\_Mode} \sqsubseteq \bot$

$\mathit{Degrees\_of\_Freedom\ (threeDOF)}$ $\mathit{Degrees\_of\_Freedom\ (sixDOF)}$

$\mathit{Control\_Mode\ (idealControl)}$ $\mathit{Control\_Mode\ (actualControl)}$

Class: *LV_System_Aspect* describes various *aspects* of LV simulations and defined as subclasses at the same level of generality. *Specific-aspects* for each *aspect* is defined as individuals of classes representing *aspects*. For example, the *Environmental_Aspect* is designed as a subclass and its *specific-aspects* are designed as individuals.

The Third Class: *Engineering_Model* defines mathematical models for *specific-aspects* as individuals of this class. These models are implemented as module in simulation software. Each *specific-aspect* defined in class: *LV_System_Aspect* is linked to its respective models from class:*Engineering_Model* through an object type property *hasModel*. In a similar way, all the *specific-aspects,* defined as individuals of a class, are related with their respective models defined as individuals of another class.

In summary, as part of the ontology design, conceptual taxonomy among the classes is created; subclasses on key classes are defined; object type and data type properties are defined; domain and range restrictions to properties are invoked; cardinality restrictions to object type properties are imposed; instances are populated and are related via defined properties in ontology.

Due to the need of space, design details and DL notations of all the classes are not given here. However, the partial expansion of the developed ontology is depicted in Fig. 1.

Formalization of Inference Knowledge using SWRL

Inference knowledge describes how a problem is solved using knowledge about ground facts of the domain. In this study, it describes the mapping between the combinations of individuals of specific simulation software requirements and the individuals of *LV System Aspects*.

Class: Software_Project describes the specific simulation software requirement and is derived from the *class: Simulation_Software_Requirement* using property restrictions. To define the requirements for any specific project for a two-stage LV, five object type properties are defined as: *hasNumberofStages; hasStage1Type; hasStage2Type; hasDegreesOfFreedom* and *hasControlMode.*

While LV system contains many *specific-aspects*, all these need not be considered for every simulation. Depending on software requirements, only *specific-aspects* that are required are to be considered. Modeling this feature is a significant challenge to be handled in LV ontology design. The significant pieces of knowledge that is required in identifying the *specific-aspects* for simulation have to be collected from experts, assimilated and are to be modeled. Such conceptualized knowledge is depicted in Table 1 along with the terminologies used to describe them.

For instance, the knowledge from system expert, at the first line of Table 1, describes that whatever may be the requirements for a simulation project, the specific-aspect 'gravity' need to be considered for simulation. This is conceptualized by making 'gravity' as an element of a set of Required Specific-Aspect, RSA. In a similar manner, all other lines describe the knowledge accumulated from various experts.

After a detailed analysis, SWRL is chosen to formalize the conceptualized knowledge. The mappings given from Sl.No.1 to 15 in Table 1 are translated into 11 conditions and subsequently implemented as SWRL rules, R1 to R11, as shown in Table 2.

In Table 2, variables ?x and ?y represent any individual of corresponding classes. The rule R1 describes that whatever may be the requirements for a software project, all the individuals of *Environmental_Aspect* (*gravity* and *atmosphere*) will be related to the individual of *Software_Project* through the object type property *hasSpecificAspect*. Thus the individuals of *software_project* class are mapped with individuals of *LV_System_Aspect*. In this manner, all the rules are defined to formalize the inference knowledge depicted in Table 2.

Current Issues and Challenges in Applying Semantic Technology in Aerospace Domain

There exist a number of challenges in applying semantic technology in aerospace domain. As a typical case, the challenges faced during conceptualization and formalization phases of LV ontology development are summarized in Table 3.

Knowledge Extraction from LV Ontology

Having formalized the declarative and inference knowledge, requirements of simulation software are declaratively defined and *specific-aspects*, models and modules required for developing mission simulation software are automatically deduced without experts dependency. This is explained through as example.

An individual representing a new project is populated in LV ontology as highlighted in sub-screen A of Fig. 2 and the specific requirements defined for the project are shown in sub-screen B. The *specific-aspects* automatically deduced for the project by ontology inference process can be seen in sub-screen C. Also, the models available for one of an identified *specific-aspect* and the whereabouts for the module for a model are shown in the sub-screen D & E of Fig. 2 respectively.

This indicates that, from LV ontology, by stating the specific requirements of simulation software, one can deduce automatically the *specific-aspects* required for the software development, the various models available for each *specific-aspect* and the URLs of the validated software modules of the selected models.

Conclusions

Currently, semantic technology has been transformed from a research area into real life applications. In this work, the feasibility and benefits of applying modern semantic technology to represent the multidisciplinary knowledge and employing it to reduce experts' dependency, minimize life-cycle time and enhance the quality of knowledge-intensive processes are studied.

Our work establishes that it is feasible to represent the complex knowledge associated with a launch vehicle in a formal ontology. We feel that this sort of work of conceptualizing, formalizing the multidisciplinary design knowledge associated to a specific field and highlighting the challenges is not reported in a literature. Our study also expresses that it is feasible to formalize the knowledge from other knowledge intensive phases of LV domain.

Future Works

In addition to the identification and retrieval of *specific-aspects*, models and modules based on the specific software requirements, any simulation software for launch vehicle mission consists of two other constituents. First constituent describes the data associated with the software modules. The second constituent is the simulation process which defines the procedure required to be carried out to mimic the behavior of launch vehicle. Knowledge associated with these two constituents can also be conceptualized, formalized as machine readable form. In order to achieve this, the development of *Process Ontology* is in progress.

The completion of these works will facilitate the complete automation of ontology-enabled simulation software generation of launch vehicle missions with any configuration.

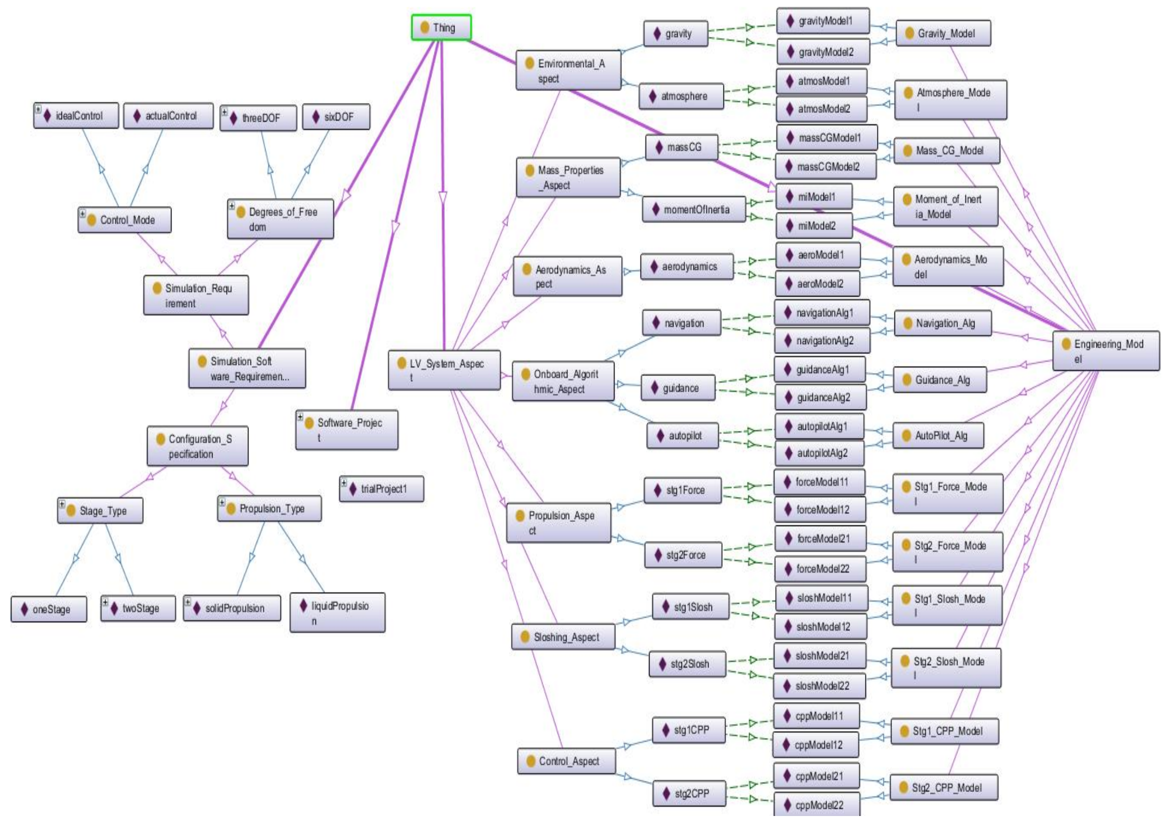

Fig. 1 Partial expansion of LV ontology

Terminologies:
R_i – i^{th} requirement of R, where i =1 to 5
R_1 Number of stages; R_2 Type of stage1
R_3 Type of stage2; R_4 Degrees of freedom
R_5 Control mode; $V(R_i)$- Value assigned to R_i by user

O_{ij} –j^{th} option value for R_i, where i = 1 to 5 and j=1 to 2
O_{11} =1, O_{12} = 2, O_{21} =solid, O_{22} = liquid
O_{31} = solid, O_{32} = liquid O_{41} =3DOF, O_{42} =6DOF
O_{51} =ideal control, O_{52} =actual control
RSA- A set of Required Specific Aspects

Table 1 Significant pieces of inference knowledge from various experts for the identification of *specific-aspects*

System Expert

1. $V(R_i)=O_{ij}:(i=1 \text{ to } 5, j=1 \text{ to } 2) \rightarrow \{gravity\} \in RSA$
2. $V(R_i)=O_{ij}:(i=1 \text{ to } 5, j=1 \text{ to } 2) \rightarrow \{atmosphere\} \in RSA$
3. $V(R_1)=1$ & $V(R_4)$=6DOF & $V(R_5)$=actual control & $V(Ri)=Oij:(i\neq1, i\neq4, i\neq 5, j=1 \text{ to } 2) \rightarrow$ {Stage1 control plant} $\in RSA$
4. $V(R_1)=2$ & $V(R_4)$=6DOF & $V(R_5)$=actual control & $V(Ri)=Oij:(i\neq1, i\neq4, i\neq 5, j=1 \text{ to } 2) \rightarrow$ {Stage2 control plant} $\in RSA$

Vehicle Engineering Team

5. $V(R_i) = Oij:(i=1 \text{ to } 5, j=1 \text{ to } 2) \rightarrow \{massCG\} \in RSA$
6. $V(R_4)$ =6DOF & $V(R_i)=Oij:(i\neq4, j=1 \text{ to } 2) \rightarrow$ {Moment of Inertia} $\in RSA$

Aerodynamics Expert

7. $V(R_i)=O_{ij}:(i=1 \text{ to } 5, j=1 \text{ to } 2) \rightarrow \{aerodynamics\} \in RSA$

Inertial System Expert

8. $V(R_4)$ =6DOF & $V(R_i) = O_{ij}:(i\neq4, j=1 \text{ to } 2) \rightarrow \{navigation\} \in RSA$

Guidance Expert

9. $V(R_4)$ =6DOF & $V(R_i) = O_{ij}:(i\neq4, j=1 \text{ to } 2) \rightarrow \{guidance\} \in RSA$

Control System expert

10. $V(R_4)$ =6DOF & $V(R_i) = O_{ij}:(i\neq4, j=1 \text{ to } 2) \rightarrow \{autopilot\} \in RSA$

Propulsion Expert

11. $V(R_i) = O_{ij}:(i=1 \text{ to } 5, j=1 \text{ to } 2) \rightarrow$ {Stage1 force} $\in RSA$
12. $V(R_1) =2$ & $V(R_i) = O_{ij}:(i\neq1, j=1 \text{ to } 2) \rightarrow$ {Stage 2 force} $\in RSA$

Liquid Stages Expert

13. $V(R_1) =1$ & $V(R_2)$ = liquid & $V(R_i)=O_{ij}:(i\neq1, i\neq2, j=1 \text{ to } 2) \rightarrow$ {Stage1 slosh} $\in RSA$
14. $V(R_1) =2$ & $V(R_3)$ = liquid & $V(R_i)=O_{ij}:(i\neq1, i\neq3, j=1 \text{ to } 2) \rightarrow$ {Stage2 slosh} $\in RSA$

Table 2 SWRL rules implemented to formalize significant pieces of inference knowledge

R1	*SoftwareProject (? x), EnvironmentalAspect (? y) → hasSpecificAspect (? x,?y)*
R2	*SoftwareProject (? x) → hasSpecificAspect (? x, massCG)*
R3	*SoftwareProject (? x), AerodynamicsAspect(? y) → hasSpecificAspect(?x, ?y)*
R4	*SoftwareProject (? x) → hasSpecificAspect(? x, stg1Force)*
R5	*SoftwareProject (? x), hasNumberOfDOF (? x, sixDOF) → hasSpecificAspect(?x, momentOfInertia)*
R6	*SoftwareProject(?x), hasNumberOfDOF(?x, sixDOF), OnboardAlgorithmicAspect(?y) → hasSpecificAspect(?x, ?y)*
R7	*SoftwareProject (? x), hasStage1Type (?x, liquidPropulsion) → hasSpecificAspect(?x, stg1Slosh)*
R8	*SoftwareProject (? x), hasNumberOfDOF(?x, sixDOF), hasControlMode(?x, actualControl) → hasSpecificAspect (? x, stg1CPP)*
R9	*SoftwareProject (? x), hasNumberOfStages (? x, twoStage) → hasSpecificAspect (? x, stg2Force)*

R10	*SoftwareProject (? x), hasNumberOfStages (? x, twoStage), hasStage2Type (?x, liquidPropulsion) →hasSpecificAspect (? x, stg2Slosh)*
R11	*SoftwareProject(?x), hasNumberOfStages(?x, twoStage), hasNumberOfDOF(?x, sixDOF), hasControlMode(?x, actualControl) → hasSpecificAspect(?x, stg2CPP)*

Table 3 Current issues and challenges in ontology development in launch vehicle domain

Ontology Development Phase: Conceptualization of Terms and Relations

Objective:	***Challenges:***	***Way adopted to handle the challenges:***
to make abstract, simplified view of the domain and transfer knowledge between humans and systems	• Sources of knowledge exist in the form of skills, know-how, mental map, etc. Knowledge from these sources is hard to be inseparable. • To understand and capture the domain assumptions made by the experts in view of problem context. • Identifying a right way to model a domain. • As knowledge about the domain changes, to identify a right way to conceptualize the right amount of knowledge • To enumerate a set of important and relevant terms from LV domain, clarify the meaning without loss of information.	• Better communication and technical interaction/interviews with experts • Keeping a drill-down view of domain • Representing different expert's viewpoints of the domain and analyzing its pros and cons. • Improving acquisition, segregation and knowledge classification • Identifying constraints that may limit domain modeling • Aiming for extendable conceptual modeling in view of future growth of the domain in mind. • Endorsement of final concepts by domain experts

Ontology Development Phase: Formalization of Conceptualized Terms and Relations

Objective	***Challenges***	***Way adopted to handle the challenges***
to decide the ontological elements and precisely defining formal semantics of the conceptualized knowledge	• To identify appropriate ontological element to formalize the conceptualized knowledge and finalizing the level of formalization required. • Choosing a correct methodology for developing ontologies • Choosing right language for expressing knowledge and Trade-off between expressivity of representation language and computations involved.	***Details of the domain*** — ***Realized through*** Concrete terms in LV domain — Classes Specialized terms — subclasses Specific value of terms — individuals Characteristics of terms — Property Conditions on terms — Axioms • Setting design principles and guidelines6 • Correct methodology depends on end-use of ontology. LV knowledge is modeled in a way suitable for automating simulation software generation. • Adopting a combined approach based on a ontology language and a semantic rule language (OWL and SWRL) for modeling. • Linking design decisions into requirements specified and identifying design element that affect the goal of the design

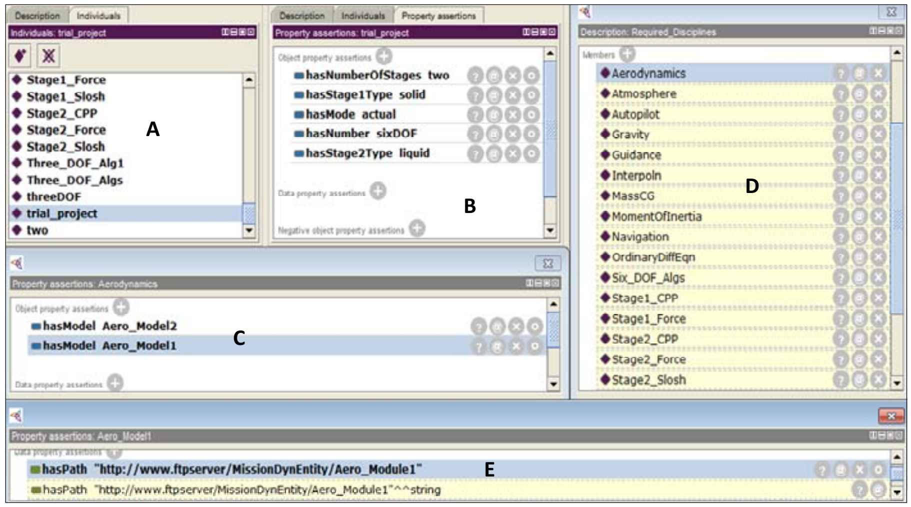

Fig. 2 Knowledge extraction from LV ontology: a typical example

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Computerized Manufacturing Automation; Special Issue of Design and Applications in Robotics

S. Balamurugan[1]

Abstract Robotics & Automation have made great strides in the last two decades and are being successfully deployed in Indian manufacturing Industries especially in Automobile Sector. This paper tries to high light the major issues, critical to successful implementation of Automation and a few thrust areas of activities that need to be looked upon in the immediate future. The paper further lists out the immediate future. The paper further lists out the various levels of automation for the efficient CAD/CAM implementation and analyses the thrust areas of Robotics and its application that utilize the manpower efficiently: Of late, Manufacturing Industry in India has demonstrated their capabilities to deliver quality but there are areas with scope for improvement. This paper is an attempt to highlight various issues during design, development and application of Robotics. The challenge before the Indian Industry is to rise to expectations of their customers by adopting the business practices that can deliver quality.

Keywords: Automation Levels, Robotics Controls, End effectors.

Automated Manufacturing Systems

Automated manufacturing Systems operate in the factory on the physical product. It includes operations like processing, assembly, inspection or material handling. They perform the above operations with a reduced level of human participation or no human participation. In a factory, raw materials flow into one end of the factory and finished products flow out the other end. The main functions in a factory are 1. Business functions 2. Product design 3. Manufacturing planning and 4. manufacturing control. There are many reasons to justify automation like, 1. to increase productivity 2, to reduce labour cost 3. to reduce or eliminate routine manual and clerical tasks 4, to improve safety and quality. Automation is the technology by which a process or procedure is accomplished without human assistance. It is implemented using a program of instructions combined with a control system that executes the instructions. It is involved with technologies like numerical control, industries robotics and programmable logic controllers.

Generally there are five levels of automation and control in manufacturing.

1. *Device Level:* It is the lowest level and includes the actuators, sensors and other hardware components that comprise the machine level. It is also called as control loops of the machine. For example, the feedback control loops for one axis of a CNC machine or one joint of an industrial robot.
2. *Machine Level:* Individual machines are assembled by the hardware. Examples are CNC machine tools and powered conveyors, industrial robots and automated guided vehicles.
3. *System Level:* Here, a manufacturing cell or system is a group of machines or work stations connected and supported by a material handling system, computer, and with appropriate equipment to manufacturing process.
4. *Plant Level:* It receives instructions from the corporate information system and translates them into operational plans for production. It includes functions like order processing, process, planning, purchasing, inventory control, quality control, shop floor control
5. *Enter Price Level:* This is the top most level and consists of the corporate information system. It is concerned with marketing and sales, accounting, design, research and master production scheduling.

Automation consists of technology concerned with the application of mechanical, electronic and computer based systems to operate and control production. The automated elements of the production system can be separated into two categories

1. Automation of the manufacturing system in the factory and
2. Computerization of the manufacturing support systems.

[1]Academic Counsellor,
Indira Gandhi National Open University, New Delhi

In modern production systems, the two categories overlap to some extent, because the automated manufacturing systems operating on the factory floor are themselves often implemented by computer systems. They are connected to the computerized manufacturing support systems and management information system operating at the plant and enterprise levels. The computer integrated manufacturing is to indicate this extensive use of computers in production systems.

Automation offers a feasible solution to improving productivity, Quality and performance. It involves ten strategic for automation and production systems.

1. *Specialization of Operations:* Here we use special purpose equipment designed to perform one operation with the greatest possible efficiency.
2. *Combined Operation:* Production occurs as a sequence of operations. The strategy of combined operations involves reducing the number of distinct production machines or work–stations through which the part must be routed. Here set up time is reduced, material handling effort and non–operation time are also reduce. It is to serve the customers by reducing the manufacturing lead time.
3. *Simultaneous Operations:* It is to reduce the total processing time by combined operations, two or more processing (or assembly) operations are being performed simultaneously.
4. *Integration of Operations:* Here we reduce the number of separate machines through which the product must be scheduled. The strategy is to link several workstations, together into a single integrated mechanism, using automated work handling devices to transfer parts between stations.
5. *Increased Flexibility:* Flexible automation concepts are used to reduce set up time and programming time for the production machine. The aim is to achieve maximum utilization of equipment for Job shop and medium–volume situations by using the same equipment for a variety of parts or products.
6. *Improved Material Handling and Storage:* Automation helps reduced work–in–progress and shorter manufacturing lead times. It benefits the production to large extent.
7. *On–Line–Inspection:* Inspection is incorporated into the manufacturing process, permits corrections to the process as the product is being made. It helps to reduce scrap and brings the overall quality of product.
8. *Process Control and Optimization:* We can have more and desired control schemes to achieve the target. Thus the individual process times can be reduced and product quality improved.
9. *Plant Operations Control:* The previous one was concerned with the individual manufacturing process, this strategy is concerned with plant level. Thus we can achieve a high level of computer networking within the factory.
10. *Computer Integrated Manufacturing (CIM):* It integrates, from factory operations with engineering design to business functions of the firm. Thus CIM involves extensive use of computer applications, data bases and computer networking throughout the enterprise.

Let us see an Automated Turning Operation Issues: Consider an automated turning operation in which a cone–shaped geometry is generated. Here we assume the production system is automated and a robot is used to load and unload the work unit. The work cycle consists of the following steps: 1, load work piece 2, position cutting tool prior to turning 3, turn 4, reposition tool to a safe location at end of turning and 5, unload finished work piece. Now let us identify the activities and process parameters in each step of the operation.

Solution: In step (1) the activities consist of the robot manipulator reaching for the raw work part, lifting and positioning the part into the chuck jaws of the lathe, then removing the manipulator to a safe position to await unloading. The process parameters for these activities are the axis values of the robot manipulator (which change continuously), the griper value (open or closed) and the chuck jaw value (open or closed).

In step (2) The activity starts with the movement of the cutting tool to a ready position. The parameters are X–and Z–Axis position of the tool.

Step (3) It involves the simultaneous control of three process parameters: Rotational speed of the work piece (rev/min), feed (mm/rev) and radial distance of the cutting tool from the axis of rotation. Radical Distance is to be changed continuously at a constant rate for each revolution of the work piece. And for a good finish on the surface, the rotational speed must be continuously adjusted to maintain a constant surface speed (m/min) and for equal feed marks on the surface the feed must be set at a constant value.

Steps (4) and (5) involve the reverse activities as step (2) and (1) respectively and the process parameters are the same.

Control Systems

The Basic elements of an Automated System are, the power to accomplish the Automated process, program of Instructions and Control System. Industrial control is defined here as the automatic regulation of unit operations and their associated equipment as well as the integration and coordination of the unit operations into the production system. We have two basic types of control;

1. Continuous control, in which the variables and parameters are continuous and analog and
2. Discrete control, in which the variables and parameters are discrete, mostly binary discrete. The industrial controllers are designed with the capability to receive, operation and transmit both types of signals and data.
   - Control of the output of a chemical reaction that depends on temperature, pressure, and input flow rates of several reactants. All of these variable and/or parameters are continuous.
   - A robot loads a work part into the fixture and the part is sensed by a limit switch. Sensing the parts presence is the event that alters the system state. The event driven change is that the automatic machining cycle can now commence.

Numerical control (NC) is another form of industrial computer control. The NC requires the controller to execute not only sequence control but geometric calculations as well. Closely related to NC is industrial robotics, in which the joints of the manipulator (robot arm) are controlled to move the end–of–arm through a sequence of positions during the work cycle. As in NC, the controller must perform calculations during the work cycle to implement motion interpolation, feedback control and other functions. In addition a robotic work cell usually includes other equipment besides the robot, and the activities of the other equipment in the work cell must be coordinated with the robot. Inter locks are used to achieve this co ordination.

In industrial control systems, an actuator is a hardware device that converts a controller command signal into a change in a physical parameter. An actuator is a transducer, because it changes one type of physical quantity, say electric current, into another type of quantity, say rotational speed of a stepping motor.

Robots are capable to respond to sensory inputs, communicate with other machines and make decisions. These capabilities permit robots to perform a variety of useful tasks.

End Effectors

It must be custom–engineered and fabricated for each different application. The two categories of end effectors are grippers and tools. The grippers are used to grasp and manipulate objects during the work cycle. There are five important types employed in industrial robot application.

1. *Mechanical Grippers:* Dual grippers, Interchangeable fingers, Sensory feedback, multiple fingered grippers, Standard gripper products.
2. *Vacuum Grippers:* used to hold flat objects
3. *Magnetized Devices:* for holding ferrous parts
4. *Adhesive Devices:* To hold flexible material like fabric

Tools are used where the robot must perform some processing operation on the work part, here the robot must be able to transmit control signals to the tool for starting, stopping and regulating its actions. Sometimes, rapidly changing tools are provided in the robot for the work cycle. For example several sizes of routing or drilling bits must be applied to the work part.

Sensors in Robots

Sensors used in industrial robotics can be classified as 1, internal 2, external. Internal sensors are those used for controlling position and velocity of the various joints of the robot. These sensors form a feedback control loop with the robot controller. External sensors are used to co ordinate the operation of the robot with other equipments in the cell. They are simple devices like limit switches. It determines the position of a part in a fixture or to indicate that a part is ready to be picked up at a conveyor. Other more advanced sensor are:

1. *Tactile Sensor:* to determine whether contact is made between the sensor and another object. Touch sensors indicate about the contact has been made with the object. Force sensors indicate the magnitude of the force with the object. It is useful in a gripper to measure and control the force that is applied to grasp an object.
2. *Range Sensor:* Its is used to indicate the actual distance of the object
3. *Optical Sensors:* Photo cells and photometric devices are to detect the presence or absence of objects.
4. *Machine Vision:* It is for inspection, parts identification, guidance and other users.

Industrial Robot Applications

Industrial Robot applications in various manufacturing process are as follows:

1. *Die Casting:* Peripheral operations performed by the robot include dipping the parts into a water bath for cooling.
2. *Metal Machining Operations:* The change in shape and size of the part before and after machining presents a problem in end effectors design and dual grippers.
3. *Forging:* The hammering action and the risk of damage to the die or end effectors are significant technical problems. Forging and related processes are difficult because of the severe conditions under which the robot must operate.
4. *Press Working:* In these applications, the robot loads the blank into the press, the stamping

operation is performed and the part falls out the back of the machine into a container

5. *Spot Welding:* In car body fabrication, the end effectors is the spot welding gun used to pinch the car panels together and perform the resistance welding process.
6. *Continuous Arc Welding:* The cell consists of the robot, the welding apparatus (power unit, Controller, Welding tool and wire feed mechanism) and a fixture that positions the components for the robot. The fixture is mechanized with one or two degrees-of-freedom so that it can present different portions of the work to the robot for welding.
7. *Inspection:* The robot manipulates an inspection device, such as a mechanical probe, to test the product. The end effectors attached to the robot's wrist is the inspection probe. To perform the process, the part must be presented at the work station in the correct position and orientation and the robot manipulates the inspection device as required.

Conclusions

Indian robotics & Automation Industry continues to have remarkable growth despite various impediments. In the 1960's onwards universities and private companies have spent a lot of their time on design and development of Robotics and today giant corporations express vivid interest in this field and actively participate in their development. Now institute professionals are working on the next generation of Robotics for various technological and research purposes Our country has to concentre in this field and continue research for Nano Satellities technology (Aero space Industry) and manufacturing Industries for our advancement.

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Evolution of Automatic Gauge Control Philosophy for Flat Rolling in Single Stand Mills

Amitabh Kumar Sinha[1]

Abstract During the course of author's working in Steel Industry, world of automatic gauge control changed from Mechanical Screw Down Control to Hydraulic AGC. This led to evolution of different control philosophies depending upon available sensors, required and possible response time as well as customer expectations and quality concerns. The control system also changed from available sophistication in automation e.g. from operational amplifiers and potted logic blocks of 70's to Micro Processor and PLC based system including higher levels of process controls. The paper sums up the control strategies used from 1970's till now for single stand steel mills, though some old methods may be still prevalent due to other considerations such as cost. The present study ignores effect of rolling speed, roll deformation, roll coolant etc on AGC.

Initially mechanical screw down with large size DC motors were used for AGC control with a selsyn or pulse encoder as position sensor and load cells as roll force sensors. Basic parameter for control was back tension which was a fastest controlled parameter at that time. Roll gap was changed only if permitted change in back tension was not sufficient to get a desired thickness control. Once hydraulic roll cylinders were available for Automatic Gauge Controls, the scenario changed from tension control to direct roll gap control since faster control of cylinder position was possible. With improvement of Gauge measurement and other sensors and advent of micro-processors and PLC the control philosophy constantly changed and methodology of mass flow were also used. In multi stand mills one stand was used as reference mill and other stands will have speeds as per reduction in each stand since speed ratio will correspond to thickness reduction as per constant mass flow. For constant mass flow, hinv1=houtv2, i.e. hout = hinv1/v2, for a given constant. These principles are explained in the following articles in some detail with electro mechanical explanations as per authors' experience in design and commissioning of such mills.

Keywords: AGC, Mass Flow, Screw Down, Mills

AGC Through Control of Back Tension

Before Hydraulic AGC Cylinders became a standard fixture in flat rolling mills, electrical DC motors were used to adjust top rolls for roll gap adjustment. Different systems from Ward Leonard to SCR's controlled bridge rectifiers1 with or without circulating current were used to fasten the response of screw down motor controls. However considering the slow response of such motorized screw downs roll gap adjustment was used only as coarse adjustment and alternative method was needed for fine gauge control. The fastest means was to control the back tension. Rolling tension moves the neutral plane of rolling forward or backward and thus changes the specific rolling pressure. This reduces rolling force for same reduction of the strip. Tension Fz changes the roll force needed for same reduction in following manner (simplified formulae):

$$P_m = Pm1\ \{1-(\alpha_0+\alpha_1)/k\} \qquad (1)^2$$

Where Pm = specific rolling pressure, Pm1 =mean specific pressure with zero tension, α0 & α1 are entry and exit stress due to tension on the strip in kg/mm2 for a given reduction, k= A constant.

This leads to following equation

$$R_a = R_f(1-k1*F_z) \qquad (1_a)^4$$

Where Ra is actual roll force, Rf is roll force for same reduction with tension zero and k1 is a multiplication factor.

Now we know that $t2 = s + Ra/mm$

(ie loaded gap = no load gap+ mill stretch)- Gage meter principle[3]

Where t2= output thickness, s= unloaded gap in the mill and mm= mill modulus.

Thus replacing Ra from first equation we get:

$$t2 = s + (Rf*(1-k1*Fz))/mm \qquad (2)$$

E-mail: [1]amit1950@yahoo.co.in

[1]MECHONIAN'S Rolling Mill Consultancy, Ranchi

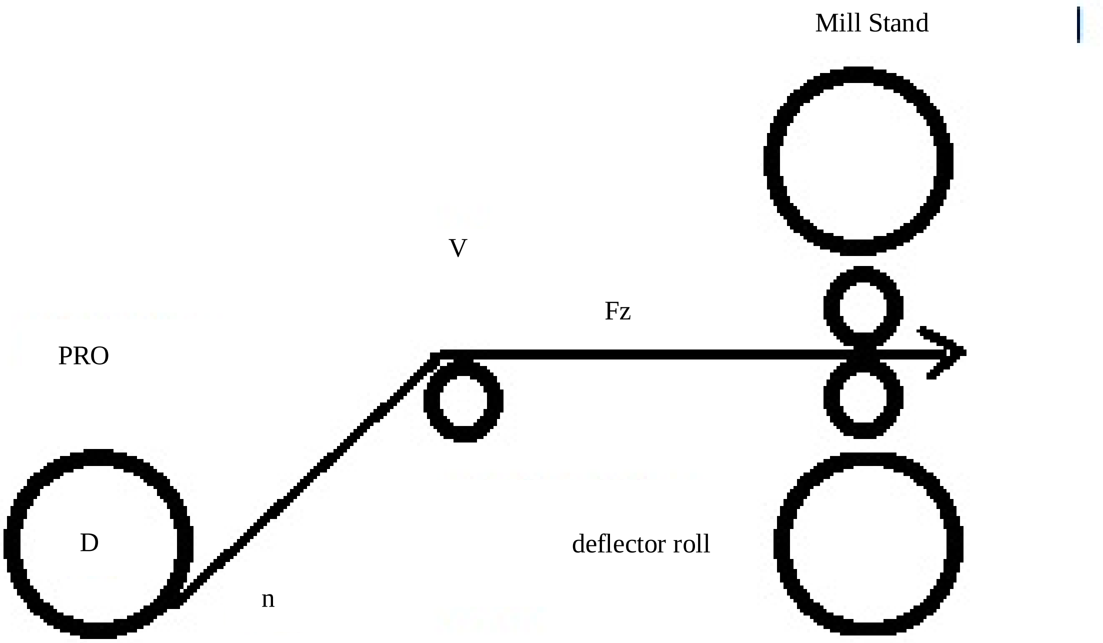
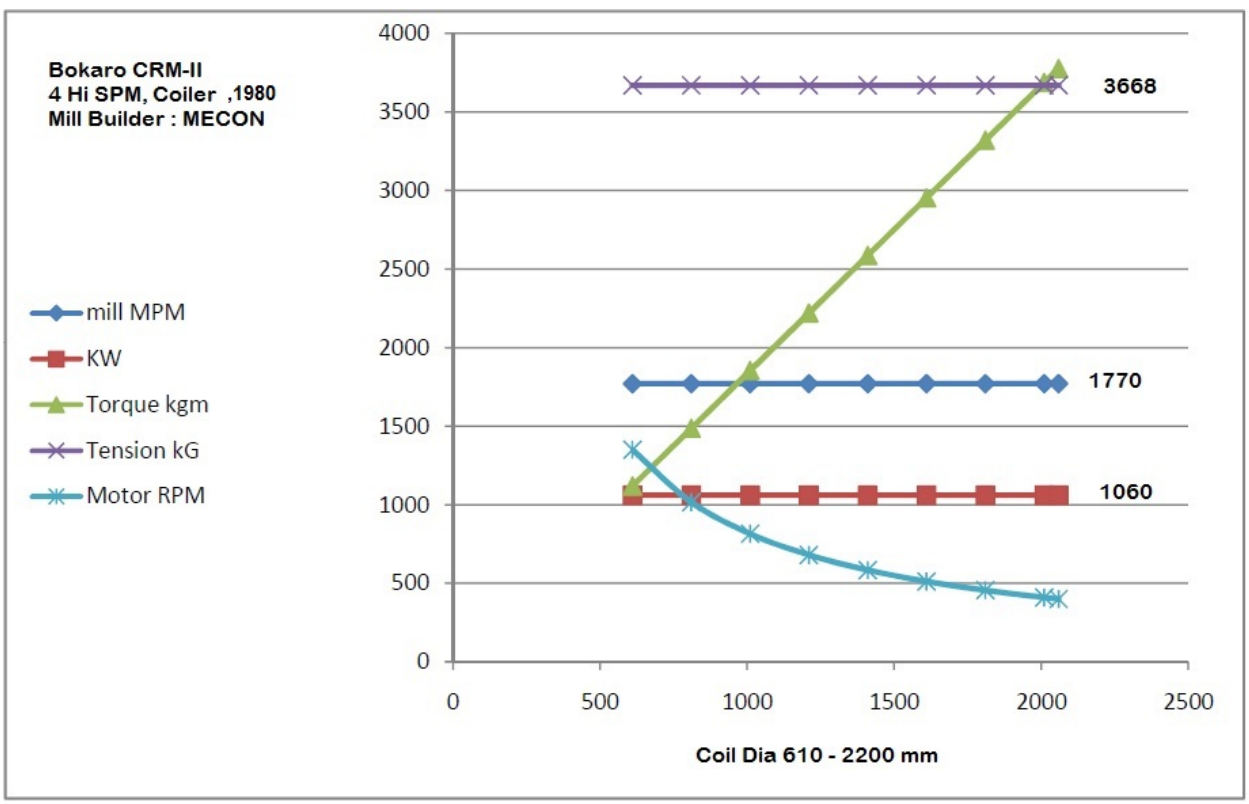

Mill Stand
V
Fz
PRO
D
deflector roll
n

Fig. 1


Bokaro CRM-II
4 Hi SPM, Coiler ,1980
Mill Builder : MECON
mill MPM
KW
Torque kgm
Tension kG
Motor RPM
3668
1770
1060
4000
3500
3000
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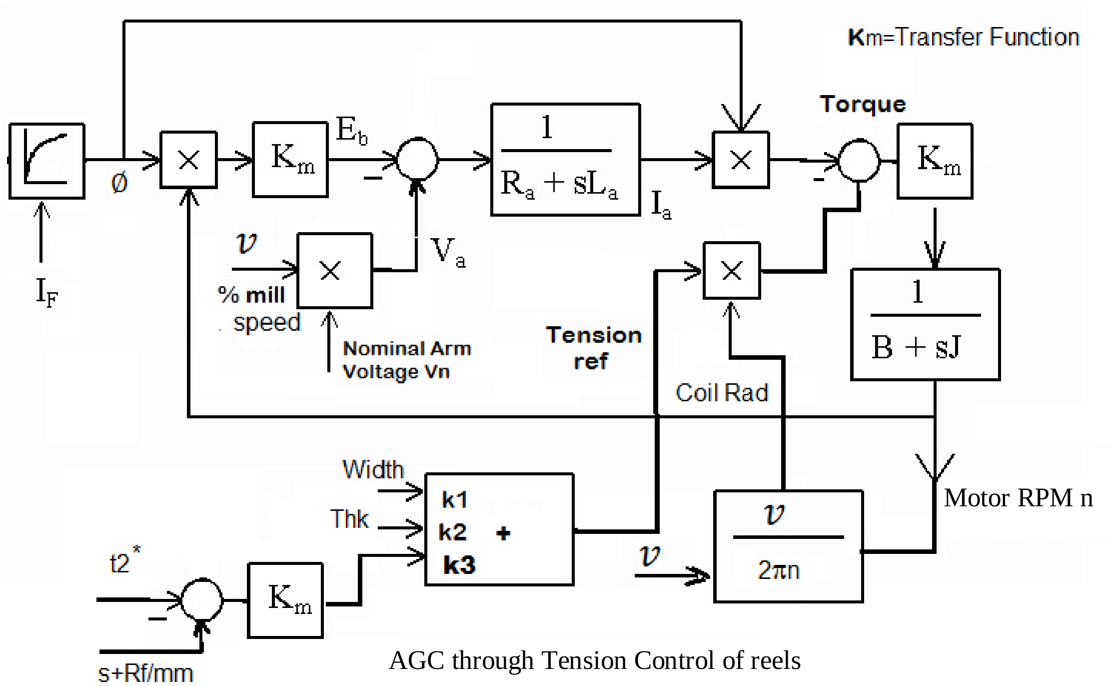
Coil Dia 610 - 2200 mm

Fig. 2



AGC through Tension Control of reels

Fig. 3

Thus first fixing a calculated roll gap then manipulating back tension Fz as required up to a set limit for fine control, and then changing roll gap as coarse control allowing some more correction in Fz fast gauge control was achieved.

Earlier tension control of Pay off reel or tension reel was controlled using field control of DC motor since SCR for armature control of such powerful motors were not available then. This type of tension control was known as "Tension Control" as opposed to torque control now applied. This control works with following principle:

n = reel rpm in MPM (measured by motor tacho / GR)

v = material speed in meter /min (measured by deflector roll tacho)

$v = \pi * D * n$ ie $D = v//\pi/n$ (3)

Torque $T = Fz * D/2$ ie $Fz = T * 2/D$ (4)

Since $\propto Ia * \emptyset$, $T \propto Ia * If$ (5)

Where $Ia =$ motor armature current and $If =$ Motor field current. It follows

$Fz = 2 * k2 * Ia * If/D$ Where $k2$ is a constant (6)

For field control $n \propto 1/\emptyset$ and $\emptyset \propto If$ where $\emptyset$= Field Flux, ie $n = k3/If$ (7)

For a given fixed mill speed v, $D * n = D * k3/If$

Hence if If/D is kept constant $Fz \propto Ia$ (8)

For keeping tension to a set value the motor has to run in constant power mode, where entire motor control is in field weakening range–keeping motor voltage constant. Base speed of motor is available at max OD of the coil and top speed at the ID of the coil. Motor current is adjusted as per tension required. We know motor power is proportional to tension x mill speed, Hence keeping motor power constant results in constant tension and if motor voltage is constant this means keeping motor current constant.

The above calculations and control block diagram are shown in the graph below (fig-2).

AGC Through Calculated Roll Gap

During late 70's after hydraulic AGC were introduced and became popular the faster controls directly of roll gap became possible and full dependence on tension control was not needed. However measuring out going thickness was not very fast and was not predictable accurately when material was in bite. This led to using the calculated roll gap for control of thickness using roll position control, roll force control & mill modulus to generate the calculated loaded roll gap and hence output gauge. Finer roll gap correction was done using feedback from X-Ray or isotope type thickness. Gauge Difference from set value was corrected using faster AGC position control and more accurate gap measurement using LVDT, relative and absolute position sensors or other position sensors. Use of hydraulic AGC cylinders with position sensors called for a procedure named calibration of the mill and position controller. This was required since the top level of bottom roll changed from campaign to campaign due to various factors including roll turn downs.

Calibration of Position Control

In this write up I assume that mechanical screw down for moving the rolls to compensate for roll turn downs for keeping pass line, are mounted at the top of the mill where as hydraulic cylinders are mounted in the bottom. Process as per author's experience is given below:

1. Top motorized screw down is moved down to bring the rolls to pass line keeping it parallel as far as possible.
2. Bottom rolls are lifted under roll force mode with kissing roll force reference differential roll force reference as zero.
3. Rolls will rise to touch to top rolls and touch either on drive or operator side as per skew due to error in parallel position of top rolls.
4. Roll force will develop and rise up to the set value. Differential roll force also will rise since the rolls touches only on one side. Differential roll force controller comes into action to achieve the set value of zero, thus ensuring the rolls touch both side with equal force.
5. The above roll position is registered as kissing position or unloaded zero gap position. Rolls are rotated at small speed.
6. Total roll force is then raised to another set value called the calibration roll force.
7. Though the rolls are still touching but position sensors will read another position due to mill stretch and this is also registered. The difference in the two registered position divided by roll force gives mill stretch coefficient ie mill modulus "mm"
8. Mill calibrated signal lights up.

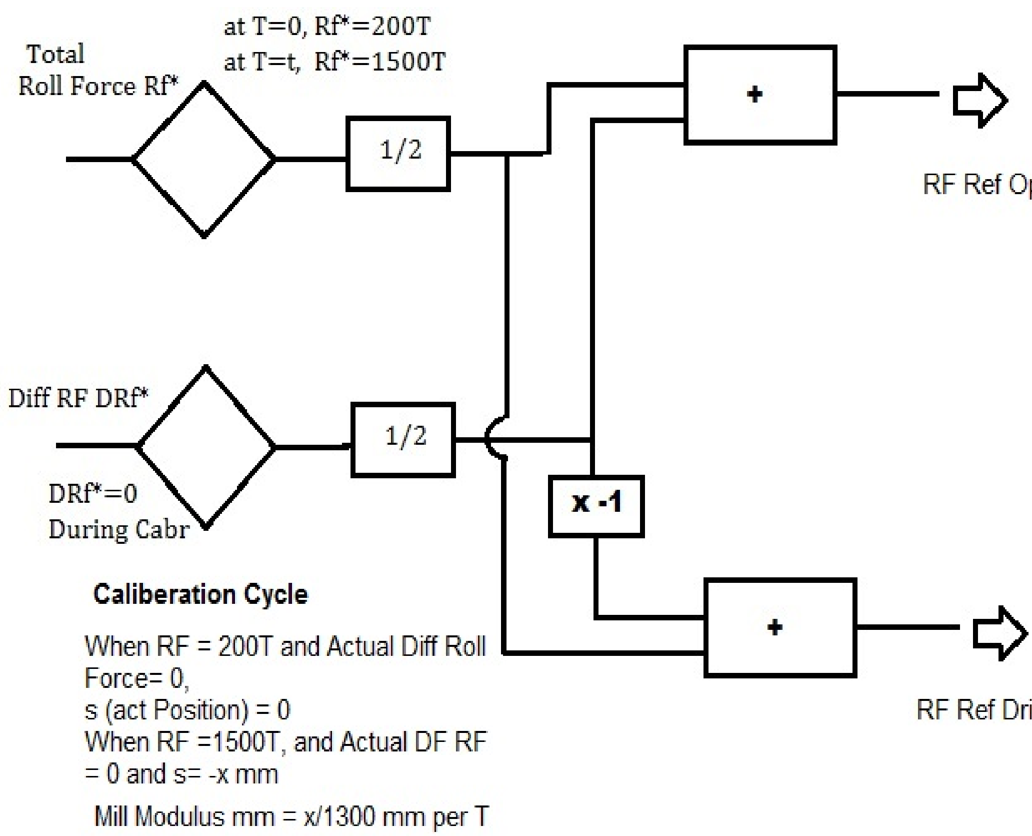


Fig. 4

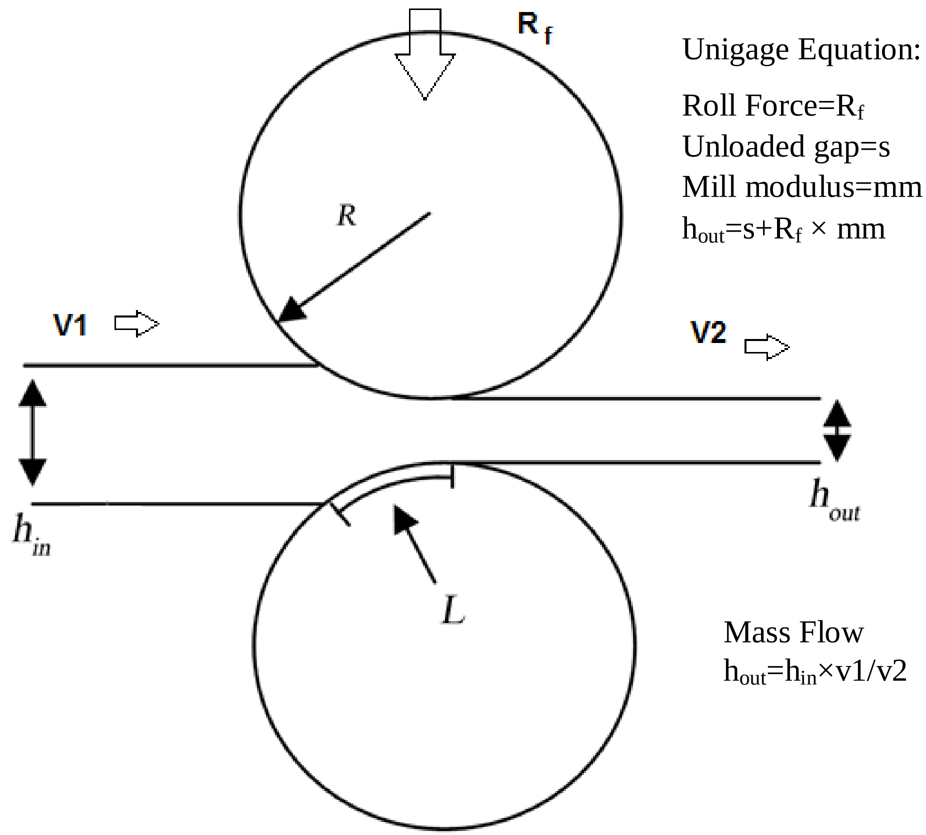

Rf
Unigage Equation:
Roll Force=Rf
Unloaded gap=s
Mill modulus=mm
hout=s+Rf × mm
R
V1
V2
hin
hout
L
Mass Flow
hout=hin×v1/v2

Fig. 5

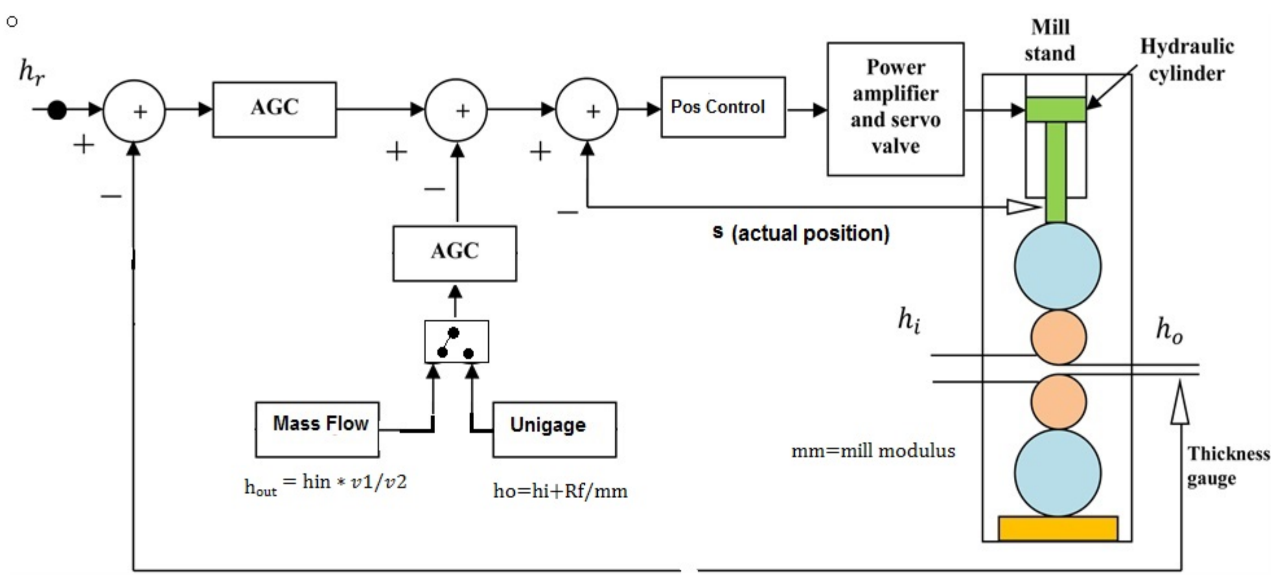

hr
AGC
Pos Control
Power amplifier and servo valve
Mill stand
Hydraulic cylinder
AGC
s (actual position)
hi
ho
Mass Flow
Unigage
hout = hin * v1/v2
ho=hi+Rf/mm
mm=mill modulus
Thickness gauge

Fig. 6

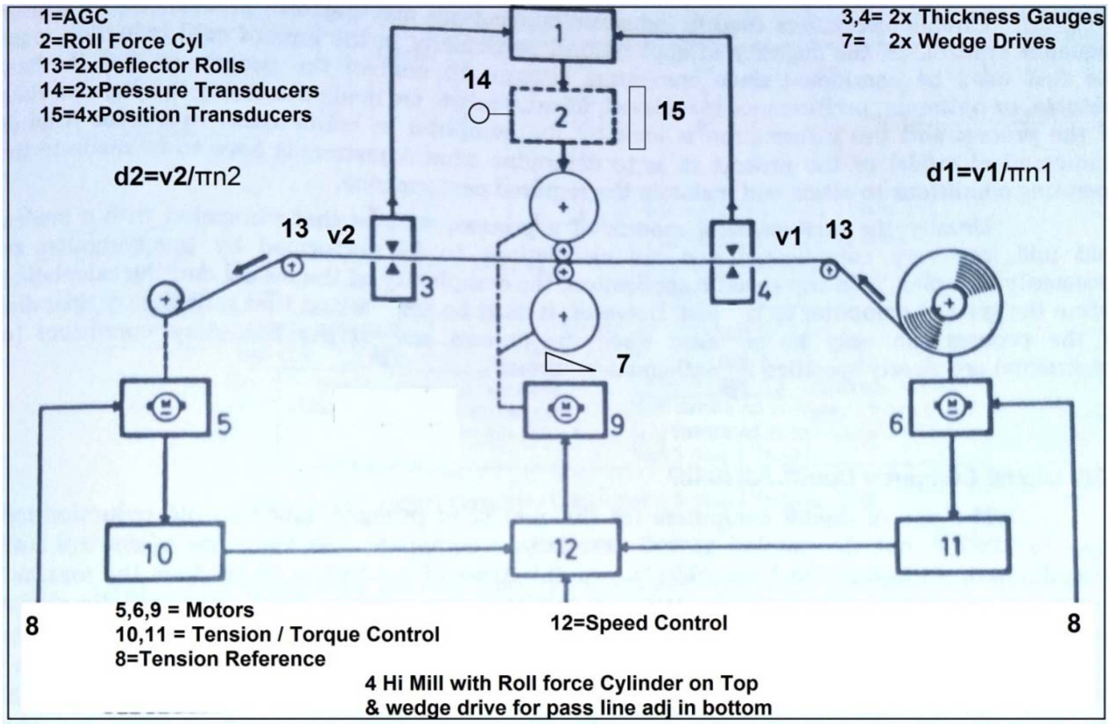


Fig. 7

Mass Flow Principle

With the advent of faster non-contact thickness gauges, AGC suppliers introduced a another method of measuring loaded roll gap or output thickness by using a simple principle that mass remains constant. Thus if entry side thickness is h_{in} and entry material speed is $v1$, exit side thickness is h_{out} and exit side material speed is $v2$ then considering that there is no change in width of material,

$$h_{in} * v1 = hout * v2, \text{ thus } h_{out} = \text{hin} * v1/v2 \quad (9)$$

Thus if we are able to measure entry and output material linear speed and entry side thickness we have quite accurate and fast value for exit thickness, thus accurate AGC was possible with this calculated output thickness with over all vernier correction from exit thickness gauge. See figure-4.

Null Setting for Moog Servo Valves

In the various mill stands commissioned by the author Moog Servo Valve of 72 series are used for control of Hydraulic Force Cylinders. These valves have certain amount of flow even with zero control current. This flow will either make to top and bottom roll come together or separate from each other and may move with a skew (unparallel movement) when the power to the Moog Valves are powered off. If the rolls do come together the chance is that they will move and raise the roll force to unsafe values. Hence to have safe operation it is imperative that top and bottom rolls move away from each other with near equal speed or in parallel motion. The Moog Valve are provided with a "Null flow screw" and the manufacturer has provided 2^5 methods to adjust in the catalogue n namely mechanical and electro-magnetic. Author did come across a much simpler procedure which however needed the position control commissioned and working. The procedure is very simple where in the rolls are separated to a fixed gap and the control system will keep the rolls at this gap – not affected by the null flow. Now the null screws on both drive side and operator side servo valves are adjusted one by one such that direction of control current is for same as for gap "closing" and is 2-4 % of full flow. Care is taken that this null current is same for both operator and drive side. Thus once the power is off the roll gap will "open" with almost parallel movement of rolls.

Conclusion

With the use of Hydraulic AGC cylinders and fast and accurate position sensors and thickness gauge Automatic Gauge Control for flat mills have undergone sea change from controls through back tension to actual position. Temper passing in Cold Mill with constant roll force has also become feasible. In India Hydraulic AGC were introduced in late seventies and now is a standard fixture in flat rolling mills.

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Evolution of Maritime Life Saving Appliances Boats & Rafts

S. Rengaraju[1]

Abstract Life saving appliances is in various natures according to the Locations, atmospheric and weather conditions, in addition depending on the personnel who are intend to use. For example inland (on shore) and offshore, Tropical and winter climate, Working plats and heights, Open air and enclosed spaces and so on. Here we deal with Offshore in water especially in water like sea and oceans. Here we discuss about the evolution of life saving appliance especially LIFE RAFT powered by possible use of various conventional renewable energy and risks involved

Abbreviations: SOLAS-Safety of Life at Sea, IMO-International Maritime Organization, LSA-Life Saving Appliance, GI-Gas Inflation, HRU-Hydrostatic Release Unit, DOT-Department of Trade, SEP-Survival Equipment Pack, CG-Coast Guard

Introduction

Lifeboats are the most important life-saving equipment among the safety gears onboard a ship. They are used at the time of extreme emergencies for abandoning a ship. Lifeboat launching is by way of mechanical assistance carried out in a faster way with the help of the davits on which it is secured on the sides of the ship.

During abandoning the ship when an extreme emergency arises, for example Flooding and sinking due to dangers like Grounding, Big Fires, Collision etc., Life boat is one of the most important device for saving the lives on board ships

Under SOLAS and LSA codes a lifeboat must carry all the equipments described, which are surveyed and ensured for the survival at sea. This includes rations, fresh water, first aid, compass, distress signaling equipments like rocket etc. A ship must carry one rescue boat for the rescuing purpose, along with other lifeboats. One of the lifeboats can be allotted as a rescue boat. Where there are if more than two or more lifeboats are available onboard a ship, there is no need to have separate Rescue boat. Right from the age of sail ships boats were often used as life saving appliances to meet the emergency situation. The vessel Titanic was capable of carrying 3330 persons but all life boats put together were able to carrying capacity of only 1060 persons.

The Titanic vessel sank in the year 1912. After this incident requirement of many more life boats to meet the number of passengers, restricted the deck space less available for movement of the personnel on board. Collapsible life boats were introduced to save space. People surviving in open life boats were less. So enclosed, unsinkable and self righting boat was manufactured in Delanco, New Jersey in 1944 and these life boats were driven by sail as well as motors.

Unsinkable wooden life raft (balsa) was built in United States; these were used for briefly in 1943 till bigger life boats were introduced. Enclosed life boats being are fitted in modern ships because of superior protection from rough seas, heat and in cold. Merchant ships are fitted with life boats on both sides ie Port and Starboard, this serves the purpose in case of vessels listing to one side ie -a life boat is always available for use. Life boat capacity is specified and listed in the ships Safety equipment certificate. Details of the boat are found in Form E of the certificate. Some ships are fitted with only one free fall life boats at the Stern side, Rescue boats introduced in 2006, if it is required to save only very few persons.

Open Lifeboat

Lifeboats which are not having roof are called Open type Lifeboats. They are generally moved in the water with the help of Oars. This practice of using Oars exists right from the ancient days including Catamaran which was used for transporting personnel and goods from one place to another place,

Diesel engine may also be installed for the propulsion purpose. Presently open Life boats are getting obsolete

E-mail: Rengaraju.s@ametuniv.ac.in

[1]Department of Marine Engineering, AMET University

because of the strict safety regulations. But still in some older ships it is available. In open life boats water ingress is very much possible due to rain or bad weather etc.

Closed Lifeboat

Closed lifeboats are very popular in these present days on board ships. Since they are enclosed which saves personal and property from exposure to sea water, rain, sun, strong wind and rough weather.

Moreover, the water tight integrity is very high in this type of lifeboat and it can also get upright on its own if toppled over by waves. Further classifications of closed lifeboats are as fallows 1.Fully enclosed Life Boats and 2.Partially enclosed life boats.

Free fall life boat

Free fall lifeboat is similar to an enclosed lifeboat but there is difference in launching them, compared to the conventional type of enclosed life boats. Life boats are built in an aerodynamic design so that in can penetrate in to water without getting damaged, when they are launched from on board ships.

There is a wide discussion in the maritime industry regarding free fall life boats, since there were few accidents where life of personal's involved.

The International Convention for the Safety of Life at Sea (SOLAS) makes it a requirement for merchant ships to have life-rafts on each side of the ship, sufficient for all the personnel on board the ship. Irrespective of the personnel boarded on the ship, the approved capacity of Lifeboats must be available onboard the ship. However, if the lifeboats are "easily transferable", viz. Life rafts substitutes the Life boats, hence number of life boats carried on board ships are reduced. They can be stored in convenient locations in between the port and starboard Life boat decks etc,. Life rafts are designed and provided with automatic inflating devices

Ocean Life Rafts

Life Rafts used in the more expensive life rafts are much stronger in construction, some are having Inflatable Double floors which can preserve heat, Rain water catching device and additional Safety features. Rafts of this type are intended to keep the crew afloat and alive for long periods of time in open water and rough seas. The supplies which are stored inside the life raft will still be fairly basic but more comprehensive than in cheaper rafts. The supplies are included with the following items: 6 Leak Stoppers, Rescue Quoit, Bailer, Sponges, Repair Kit, Survival Manual, 1 Heliograph Mirror, Signal Tables, 3 Hand Flares, 1 SOLAS Rocket, Anti seasickness Pills, Sea Anchor & Swivel, Whistle, Seasickness Bags, Knife, 2 Paddles, Bellows, 2 Torches.

Life Rafts used in coastal zones are designed to use for short periods and moderate sea or weather condition. Rescue services are likely to be deployed rapidly, and crew recovered quickly. Life rafts of this type are typically constructed with lighter material, it will have only single floor. Cheaper ones will have single inflatable tube. Minimal storage. Flares, Bailer, Sea anchor, Repair kit, Air pump, Paddles, Rescue quoit, Anti sickness pills, Drinking water, Torch

Disposable Battery used for light inside and outside for signaling, left one in the picture is one time use, required change with maximum of 24hours usage.

Case Study

A Coast Guard report on the 2015 sinking of the cargo ship *El Faro* calls for 31 safety improvements to the U.S. maritime fleet, from eliminating open lifeboats and requiring new high-water alarms to improving marine hurricane warnings.

Their report calls for a review of lifeboat standards with an eye to upgrading all vessels to the modern Safety of Life at Sea (SOLAS) enclosed lifeboats.

MBI chairman Capt. Jason Neubauer told reporters at a press conference Sunday in Jacksonville.

Had the *El Faro* carried those escape craft, "our survival expert said the crew could have had a chance,"

DAG HANSSEN on OCTOBER 3, 2017 4:58 PM :- No kidding the crew would have had a chance with modern lifeboats. Perhaps they would get seasick and would have bounced around for a while, but survival would have been likely. Cheap Pos Company tried to save money on 1910 vintage life boats.

PATRICK BOYLE on OCTOBER 4, 2017 2:07 PM:- I agree with MBI Chairman Capt. Jason Neubauer, had the El Faro carried modern SOLAS lifeboats the crew would have had a chance.

Ships that carry open lifeboats in the US Merchant fleet are few in numbers; it would not be overly burdensome to refit them with survival craft that would give the crew a fighting chance in the event of ship abandonment.

Fig. 1

Table 1

Modern fully enclosed Life boat on the *Caroline Delmas*

Freefall Lifeboat of the *Spring Aeolian*

Life boat on a oil Rig

Description	Life Boat	Life Raft
Motor	Modern boats have	Usually not
Davits	Large Life boats use	Few are used
Launching	Require Human to launch	Not necessary
Launching time	More	Less
Inflation system failure	Not applicable	Yes
Equipments carried	More	Much less
Easily transferable	No	Yes
No of boats/Rafts	Cannot reduce, it is fixed	Can be reduced as per requirement
Weight	Heavy, (free fall boats are much heavier &stronger)	Light
Instant launching	Freefall boats	Yes
Engine failure	Not failsafe	Not applicable
Hydrostatic Release mechanism	Yes	Available
Structure	Rigid	Generally collapsible
Fibre glass heavy duty canister	Stored openly on deck	Used for storage
Self righting	Yes	No

Fig. 2

Fig. 3 Coastal life rafts

Fig. 4 Battery for Life raft

Fig. 5 Inflatable Life raft

Using Conventional Energy in Rafts, Life Rafts, Life Boats and their Risks

Solar Energy

Risk of raining, rough weather or stormy weather Solar cells may not be able to function, Also requires larger area of canopy exposed to sky. At night times solar cells not of any use. Requires storage battery for nighttime power consumption

Wind Energy

Risk of Stormy wind can break the pole which is fitted with rotor. Also there is short fall in wind energy leads to short in power production.

Wave energy

Risk of stormy weather breaking the turbine machinery if not fitted properly without the consideration given for this point. Waves in deep sea can vary but rare phenomenon of absolute still water. Because of this reason it is more suitable for coastal and deep sea sailing

Conclusion

Life saving appliances, Life boats and Life rafts in deep sea has gone through lots of changes in terms of safety and reliability of usage and brought down many risks. Evolution of changes improved in its design including the manning and materials used. Use of renewable energy in Life saving appliances will become one day reality which will reduce the replacement of storage battery frequently for powering.

Accidents can be prevented by taking precautions and common sense by adhering to the reality and circumstances. Maintaining equipments in good working order and also crew fitness

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Lean Six Sigma Model in Chennai Automotive Industry

E. Bhaskaran[1]

Abstract Lean Six Sigma Model is an important innovation tool in improving the competitiveness of Industries of Chennai Automotive Cluster. The Objective is to analyses 7 wastes, 5 Six Sigma Tools (DMAIC) and to develop Lean Six Sigma Models using 15 steps for the Automotive Components Manufacturing Industry at Chennai. The 15 steps in Lean Six Sigma Model are analyzed in detail. The Problems are Defined(D) using (1) Project Critical to Quality (CTQ) using VOC and QFD Analysis(2) Outline Business Standards Centre, (3) High Level Process Map using SIPOC and (4) Change Management Strategy like Shareholder analysis. It is Measured (M) using (5) CTQ Characteristics like Process Map; Fish bone diagram / Cause Effect Diagram, Failure Mode Effect Analysis (FMEA) and calculating Risk Priority Number (RPN), (6). Outline Performance Standard, (7). Develop a Data Collection Plan, and (8) Validate the Measurement System. It is further Analyzed (A) using (9) Process's Current capability, (10) Performance Objectives and (11) Sources of variation. The Improvement(I) done using (12) Vital Implementable Solution tools like Kaizen, 5S audit, Waste Elimination etc., The Control (C) Measures used are (13) Validate measurement system analysis using Cross Cross Functional Resources, (14). Determine the process Capability using DPMO and Z score and (15) Implement Process Control using SPC like C Chart to analyses before and after Lean Six Sigma. To conclude, before Lean Six Sigma implementation the Z score is 4.7 and after Lean Six Sigma Implementation the Z score is improved to 5.13for DOL Components.

Keywords: Lean Six Sigma Model, Automotive Cluster.

E-mail: [1]e.bhaskaran19@bsnl.in

[1]Deputy Director of Industries and Commerce,
Department of Industries and Commerce,
Government of Tamil Nadu, Guindy, Chennai, India

Introduction

Six Sigma enhances quality and accuracy of processes by reducing variation and Lean focuses faster response times by eliminating waste (Muda), overburden ("Muri") and unevenness in workloads ("Mura").

Lean principles will help 7 wastes to be eliminated as shown in fig. 1.On the other hand, if the goal is to reduce defects in manufacturing, 5 Six Sigma tools will be used as shown in fig. 2.

The complete Lean Six Sigma Model of 15 steps is given in Fig. 3.

Technical Survey

The study, explores the hypotheses that implementing effective total quality management (TQM) programs improves the operating performance of firms [1] and twelve key to successon Six Sigma [2]. The Ford didn't stop with the assembly lines but also improved the product with innovative new substances. [3]In the technical score and ranking of auto component manufactures, there is significant increase in technical efficiency after the Cluster Development Approach (CDA. [4]There is increase in technical efficiency of Chennai auto cluster and Chennai auto components cluster [5]. The technical efficiency of Lean Manufacturing Companies also increases significantly[6]. Lean Six Sigma (LSS) effort has three distinct phases as shown in fig. 3. First Phase Quality Leader will be trained, second phase, champions are trained, third phase Black and Green Belts are trained and start executing the projects.[7]. Inclusive growth and sustainable developmentstudy reveals thatinefficient Automotive Component Cluster (ACC) should increase their turnover and exports, as decrease in no. of enterprises and employment is practically not possible. [8]the inefficient Textile Cluster shouldincrease their Sales /turnover and

Exports, as decrease in number of enterprises and Employment is practically not possible. [9]. For sustainable development, the cluster should strengthen infrastructure, technology, procurement, production and marketing interrelationships to decrease costs and increase productivity and efficiency to compete in the indigenous and export market.[9][11].

The Quantitative, Qualitative and Impact Assessment prove that there is increase in productivity and decrease in cost. [13][14][15]. The study on CNSL Processing Plant proves that there is need on formation of Cluster to implement Lean Six Sigma activities. [17]

The Automotive Component Industry under study, got funds under Lean Manufacturing Competitiveness Scheme which comes under National Manufacturing Competitiveness Programme (NMCP) of Government of India where Tripartite Agreement between National Productivity Council (NPC), Consultants and Cluster Unitsoccurred [10] [12] and there is need for study on Lean Six Sigma Implementation in Automotive Component Industry.

Objective

The objective is

1. To analyses about 7 wastes in Automotive Components Manufacturing Industry at Chennai.
2. To analyses 5 Six Sigma Toolsin Automotive Components Manufacturing Industry at Chennai.
3. To develop Lean Six Sigma Models using 15 steps for Automotive Components Manufacturing Industry at Chennai.

Methodology

The methodology adopted is the researcher interacted with one of the partners and collected the primary data and secondary data of Automotive Component Manufacturing Industry at Ambattur, Chennai. The data and the picture collected areanalyzed using 15 Lean Six Sigma Tools as shown in Table 1.

Fig. 1 Lean manufacturing

Fig. 2 Six sigma (DMAIC)

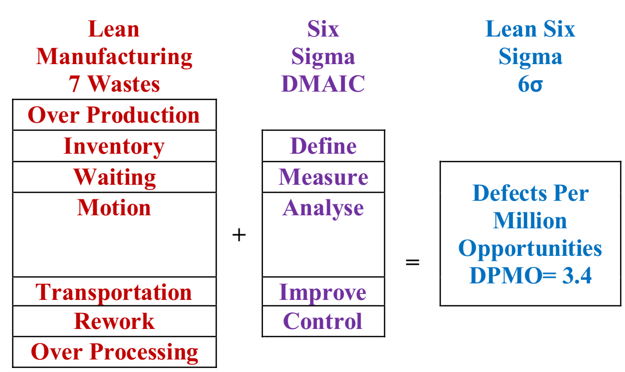

Fig. 3 Lean six sigma model

Source: Developed by Researcher

Fig. 4 Automobile components

Table 1 Lean six sigma model

Step	**Description**	**Deliverables**		**Tools**	
Define					
1	Project Critical To Quality (CTQ)-Project Y	1.1	Identification of an opportunity	1.1	UNIDO-Subcontracting Exchange.
		1.2	Identification of the customer	1.2	UNIDO-Subcontracting Exchange.
		1.3	Define CTQ	1.3	VOC
2	Outline Business Centre	2.1	Develop team charter	2.1	Business 4 Block and Project Milestone
3	Process Mapping	3.1	Define team charter	3.1	SIPOC & Product Synchronization
4	Change Management	4.1	Create a shared vision & gain consensus from stakeholders	4.1	Stakeholder Analysis
Measure					
5	Define CTQ Characteristics	5.1	Link customer CTQ to measurable process characteristics	5.1	X- functional Process Map Total Product Cycle time Fishbone FMEA
6	Outline Performance Standards	6.1	Define defect and specification limits for Project Y	6.1	Setup Time
7	Data Collection	7.1	Develop a data collection plan	7.1	No of defects
8	Validate Measurement System	8.1	Ensure reliable and accurate data	8.1	Repeatability and Reliability

Step	Description	Deliverables	Tools	Step	Description
Analyze					
9	Baseline Process Capability	9.1	Graphical representation of capability	9.1	Histogram, run chart, box plot and Parento
		9.2	Continuous normal data analysis	9.2	Normality Plot, z table, data indicators
		9.3	Discrete data analysis	9.3	
		9.4	First-pass yield calculation	9.4	First-pass yield
10	Define Performance Objective	10.1	Develop attainable goals	10.1	Benchmarking
11	ID Sources of Variation		Prioritize List of Xs		
		11.1	ID Process inefficiencies (cycle/time/capacity)	11.1	VA / NVA, SOE, takt time, effective hours
		11.2	Graphical analysis (optimization / quality)	11.2	Correlation and Scatter Plot
		11.3	Numerical analysis	11.3	Hypothesis Testing
Improve					
12	Identify Vital Xs & Implementable Solutions	12.1	Workflow redesign (CT / Standardization)	12.1	Kaizen, 5S, NVA / Waste elimination, line balancing
		12.2	Variable relationship (quality / optimisation)	12.2	Regression
Control					
13	Validate MSA on Xs	13.1	Measurement system is adequate for Xs	13.1	MSA
14	Determine Process Capability	14.1	Determine post improvement capability	14.1	DPMO / Z score
15	Implement Process Control	15.1	Develop and Implement control plans	15.1	Control Plan, risk management, SPC Charts

Source: Developed by Researcher

Lean Six Sigma Implementation Define (D)

One unit in Ambattur, Chennai is manufacture of automobile components as shown in Fig. 4.

Automotive Component Industry

The Automotive Component Manufacturing Industries has Direct Online Supplier (DOL). The organization have 120 trained employees, manufactures Precision Industrial Components and dispatch 12 million precision parts every year.

Machinery

The List of Machineries available are shown in Table 2 and Fig. 5

The Lean Six Sigma Model developed by researcher for this Automotive Components Manufacturing Industry is given in Table 1 where there are 15 steps involved in the implementation of LSS.

Step 1: Critical to Quality (CTQ): The first step is CTQ where Global OEMs are identified as an opportunity. The OEMs like TAFE, Greaves Cotton India Limited and Brakes India Limited are identified as customers. The CTQ is defined by way of Voice of Customers (VOC) or Needs and Wants of Customers by way of QFD analysis as shown in Fig. 6.

Y = F(x),

Where Y= Customer CTQ or the thing to improve with Lean Six Sigma.

F(x) = internal process (es) that directly affect the customer CTQ.

Table 2 List of machineries

Sl. No.	Description	Quantity
1	CNC Turning Center	22
2	Polygon Turning	3
3	VMC	2
4	Center Less Grinding	3
5	Surface Grinding	2
6	Single Spindle Automat	18
7	Thread Rolling	4
8	Bundle Cutting	2
9	Drilling	12
10	Tapping	3
11	Lathe	3

Fig. 5 List of machineries

Step 2: Outline Business Centre

Table 3 Information

Project Title	**Decreasing OEMs Response Time**
Champion	Sales Manager
Internal Leader	Black Belt
Key Stakeholder(s)	Operations Manager, Sales Team
Location(s)	Chennai Operations.

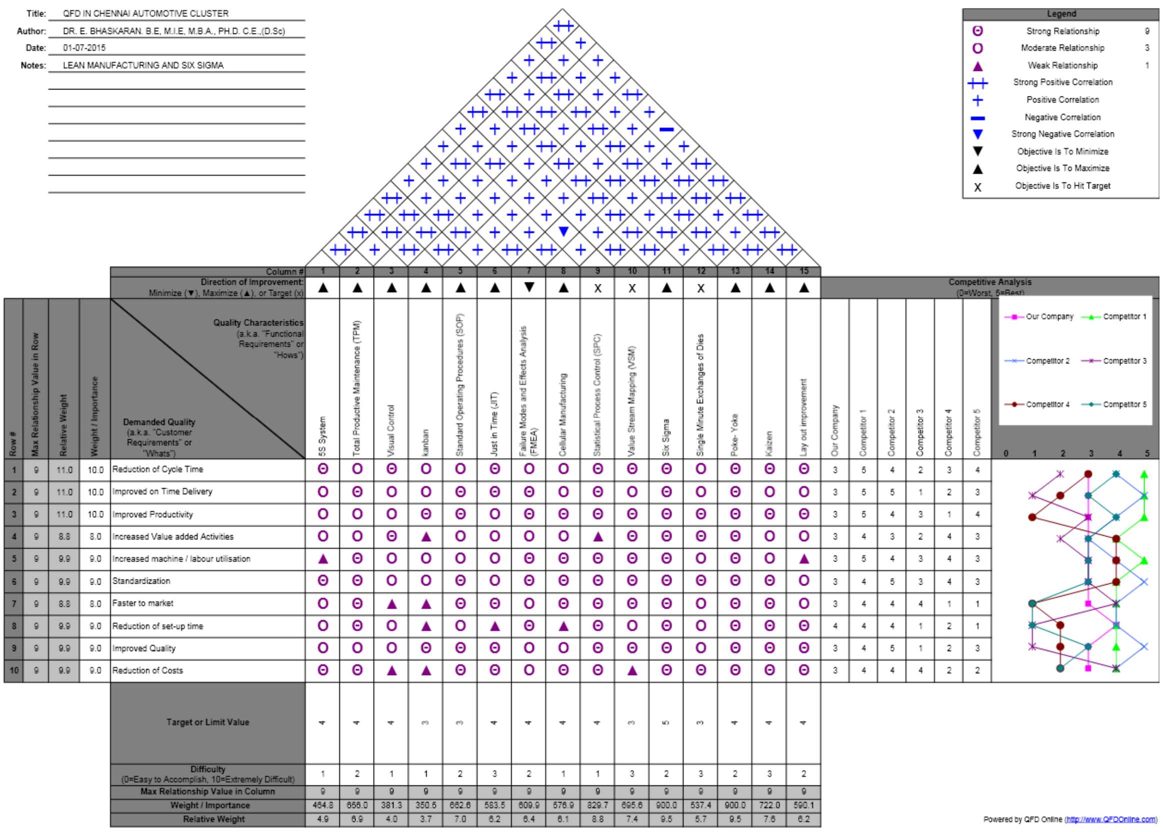

Fig. 6 Quality function deployment (QFD)

Source: Developed by researcher

Step 3: High-Level Process Map

For standardizing a process or reduce its cycle time.

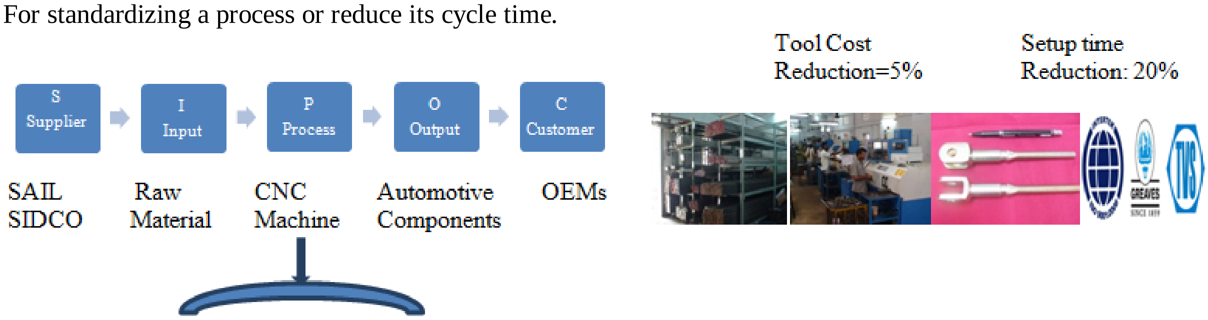

Fig. 7 SIPOC overview and product synchronization map (PSM)

Step 4: Change Management Strategy

	Threat	Opportunity
Short Term	Lost clients- now	Customer loyalty
	Loss of trust	Become number one
	Poor funds flow	Comprehensive solution
	Lost profitability	Competitive advantage
	Increased application inventory	Establish trust- keep it
	Higher installation cost	Retain good people
	Pain in everyone's job	Positive impact on the future of the business
Long Term	Loss of future sales / customers	Incremental business
	Lost of trust / confidence	Delight customers
	Damage to reputation	Employee satisfaction
	Affect the organisation's business	Better funds flow
	Could affect jobs	Sales tool-positive advantage
	Lost market position	Be creative thinkers

Partners	Strongly Against	Moderately Against	Neutral	Moderately supportive	Strongly supportive
1					
2					

Measure (M)

Step 5: Define the CTQ Characteristics Process Map

Y = F(y),

Where Y= What OEMs wants.

F(y) = the process with highest impact on the customer want.

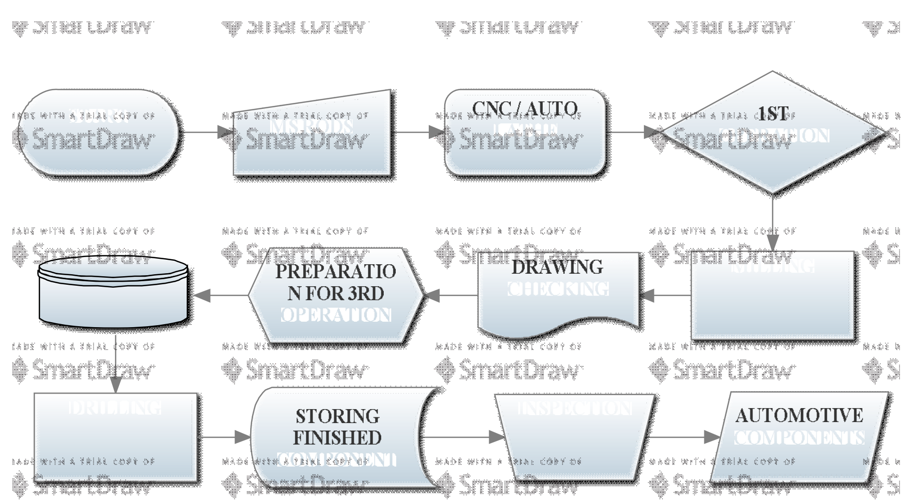

Fig. 8 Auto components manufacturing process map

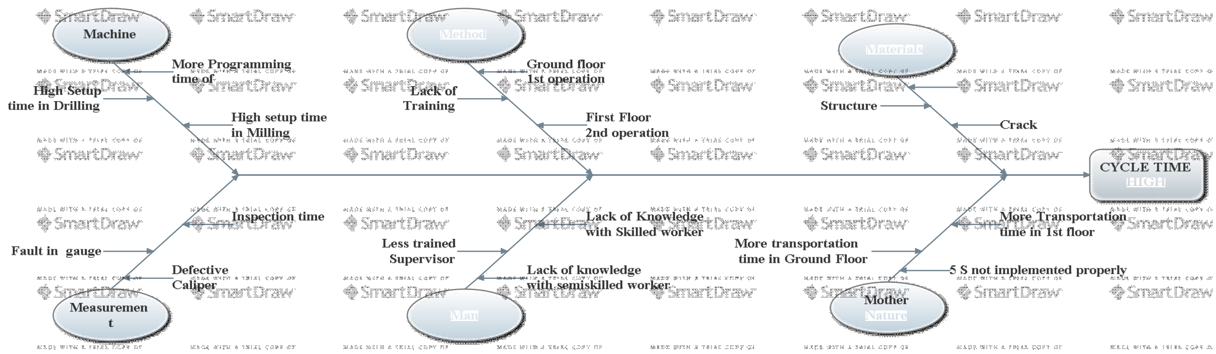

Fig. 9 Fishbone diagram/ cause and effect diagram

Table 4 Fmea

Process Name: Set up Time **Prepared by: Researcher** **Page_____ of ______**

Responsible FMEA Date (Orig)_________ (Rev)____________

Process Step	Potential Failure Mode	Potential Failure effects	Severity	Potential causes	Occurrence	Current Controls	Detection	RPN	Action Recommended
Bringing tool	Tool brought after starting setup change	Cycle Time High	7	Setup time high	1	Tool to be brought before starting setup change	9	63	Single Minute Exchange of Dies (SMED)
Bringing drawing from QC area	Drawing brought after producing first piece	Defects in product	9	Dimension vary	1	Drawing to be brought before starting set up change	9	90	Drawing to be visualized or made visual control
Bringing raw material from store	Raw material brought from store after starting set up change	Cycle Time High	10	Setup time high	2	Raw material to be from brought store before starting set up change	10	200	Raw material to be brought earlier
Bringing measuring instrument from QC area	Vernier brought after producing first piece	Process time high	10	Waiting time high	3	Measuring instrument be brought before starting setup change.	10	300	Vernier to be brought before production.

*Risk Priority Number (RPN) = Severity * Occurrence *Detection =7*1*9 = 63*

Failure Mode Effect Analysis (FMEA)

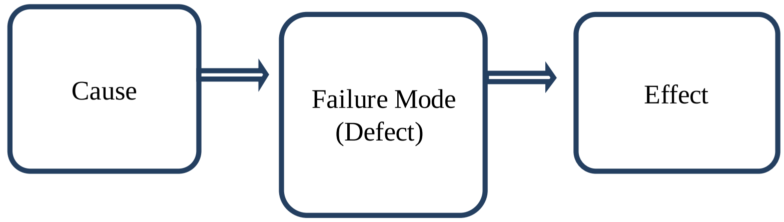

Fig. 10 FMEA

Step 6: Outline Performance Standard

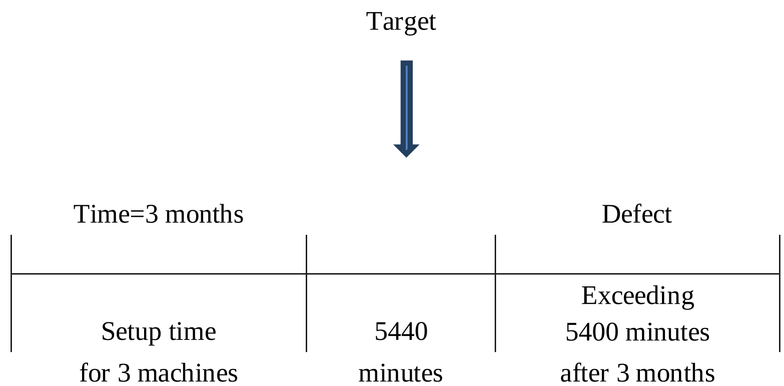

Fig. 11 Set up time

Step 7: Develop a data collection plan

Table 5 Data collection for process xs and ys

Process Input (Xs)	Process	Process Outputs (Ys)
Study on Setup time for 3 machines 6800 minutes	1 month Study	After study it is reduced to 5400 minutes
Reducing cutting tools cost	7 months study	After study it is reduced to 1/3 rd per year

Step 8: Validate the Measurement System

Fig. 12 Validation

Accuracy	=	2 defects / 10 pieces = 80%
Repeatability	=	agreement within machine operator / total units
	=	9/10= 90% for machine operator 1.
	=	7/10 = 70% for machine operator 2.
Reproducibility	=	agreement between machine Operators / total units.
	=	7/10= 70%

Analyse (A)

Step 9: Baseline the Process's Current Capability

Fig. 13 Process current capability

Step 10: Performance Objectives for the Process

Table 6 Process boundaries

Inscope	Outscope
Retail Sales	Assembly
Weekday operations	3 shifts / round the clock
Older machines	Expansion / Diversification
National Operations	International Operations

Step 11: Identify sources of variation

Supplementary Resources

Fig. 14 IT Data collection

Improve (I)

Step 12: Vital Xs and Implementable Solutions.

The 5 S audit were conducted it is revealed that score improved from 39 scrore to 76 Score.[6]

Fig. 15 ISO 9001: 2000 and 2008 certification and certificate of membership with AIEMA

Source: Developed by Researcher

Fig. 16 Quality, cost and delivery certification from m/s. cotton greaves limited

Fig. 17 Business growth and ppm certification from m/s. sundaram fasteners limited

Fig. 18 Challenge and quality vision

Control (C)

Step 13: Validate measurement system analysis on the Xs.

Support and Resources

Core Cross-Functional Resources

1. Lending Sales Manager: Outline OEMs needs.
2. Lending Sales Rep: Provides OEMs data.
3. Lending Operations Supervisor: Process expert.
4. Six Sigma Black Belt: Six Sigma Expert

Step 14: Determine the process Capability
SIX SIGMA CERTIFICATION
DPMO= (Total Defects / Total Opportunities)* 1,000,000

Table 7 Six sigma calculation

Before	**After**
Units = 1,000,000	Units= 1,000,000
Total number of defects= 687	Total number of defects= 142
DPMO= (687 / 1,000,000)* 1,000,000= 687	DPMO= (142 / 1,000,000)* 1,000,000= 142
Z score (using Z table) = 4.7 sigma	Z Score (using Z table) = 5.13 sigma

Step 15: Implement Process Control
LCL = C bar–3* SQRT(C bar) = 9.37
HCL = C bar+ 3* SQRT(C bar) = 38.82

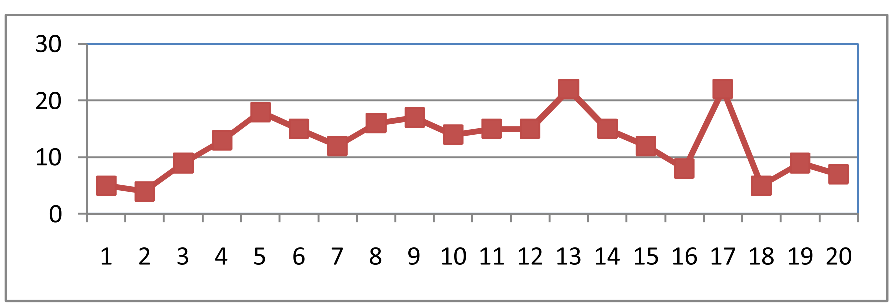

Fig. 19 C Chart before lean six sigma

LCL = C bar–3* SQRT(C bar)= -1.86
HCL = C bar+ 3* SQRT(C bar) = 3.38

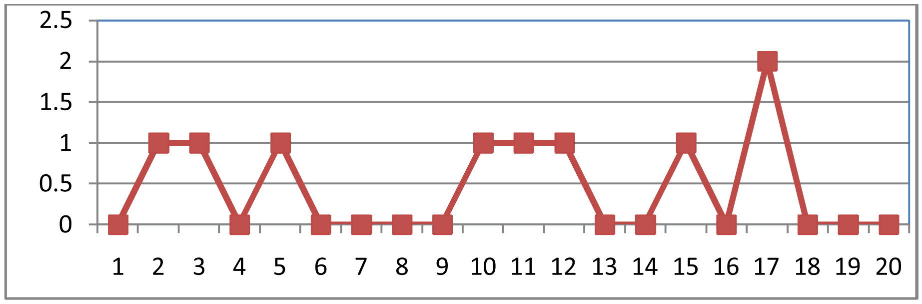

Fig. 20 C Chart after lean six sigma

Table 8 PPM and sigma

Item Code	Direct on Line (DOL) Components	PPM	Sigma
50–004–75	Plug Relief Valve	189	5.1
500–051–97	Terminal Cable Sleeve with Bracket	495	4.8
500–6141–52	Pin-Governor Lever	76	5.3
540–6045–38	Rocker Fulcrum	141	5.1
560–9680–013	Relief Valve Body	704	4.7
9–7626–043	Plain Washer 14.5x40x7	8	5.8
Total		1613	30.8
Average		268.83	5.13

Greaves Cotton Limited
Light Engines Unit – II
Ranipet – 632 403.

Date : 01.07.08

INDIA INDUSTRIES

I. DOL – COMPONENTS:

The following are the DOL-Components declared for DOL-Supplies with Self Certification as Per our Quality Agreement Dated 24-03-08

DOL Components

SI.No	ITEM CODE	ITEM DESCRIPTION	PPM STATUS
1	500-004-75	PLUG RELIEF VALVE	189
2	500-051-97	TERMINAL CABLE SLEEVE WITH BRACKET	495
3	500-6141-52	PIN-GOVERNER LEVER	76
4	540-6045-38	ROCKER FULCRUM	141
5	560-9680-013	RELIEF VALVE BODY	704
6	9-7626-043	PLAIN WASHER 14.5X40X7	8

D.KRISHNAN
DY.MANAGER- SUPPLIER ENGG.

Fig. 17 The quality management system is applicable to ferrous and non-ferrous machined components

Conclusion

The Lean Six Sigma Model is an important innovation tool in improving the competitiveness of Industries of Chennai Automotive Cluster. The Objective is to analyses 7 wastes, 5 Six Sigma Tools (DMAIC) and to develop Lean Six Sigma Models using 15 steps for the Automotive Components Manufacturing Industry at Chennai. The 15 steps in Lean Six Sigma Model are analyzed in detail. The Problems are Defined (D) using (1) Project Critical to Quality(CTQ) using VOC and QFD Analysis (2) Outline Business Standards Centre, (3) High Level Process Map using SIPOC and (4) Change Management Strategy like Shareholder analysis. It is Measured(M) using (5) CTQ Characteristics like Process Map; Fish bone diagram / Cause Effect Diagram, Failure Mode Effect Analysis (FMEA) and calculating Risk Priority Number (RPN), (6). Outline Performance Standard, (7). Develop a Data Collection Plan, and (8) Validate the Measurement System. It is further Analyzed (A) using (9) Process's Current capability, (10) Performance Objectives and (11) Sources of variation. The Improvement(I) done using (12) Vital Implementable Solution tools like Kaizen, 5S audit, Waste Elimination etc., The Control (C) Measures used are (13) Validate measurement system analysis using Cross Cross Functional Resources, (14). Determine the process Capability using DPMO and Z score and (15) Implement Process Control using SPC like C Chart to analyses before and after Lean Six Sigma. To conclude, before Lean Six Sigma implementation the Z score is 4.7 and after Lean Six Sigma Implementation the Z score is improved to 5.13 for DOL Components.

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Multi Response Optimization of Cold Rolling Mill Process Parameters using Taguchi's Approach and Utility Concept

Vivek Anil Vaidya[1] and Atul C. Waghmare[2]

Abstract Cold rolling process is to successively reduce the thickness of the metal strip and/or impart the desired mechanical and micro structural properties. Thickness variation and flatness are the important quality characteristics of metal strip while rate of production and power consumption are the important productivity characteristics of cold rolling process. In the age of cut throat competition among the cold rolled product producers, the manufacturer are in search of optimization techniques which involves multiple response characteristics. Taguchi Techniques is generally applied for optimizing the Process parameters of single objective optimization. A single setting of process parameters is optimal for single characteristics but same optimal setting may results in non-optimal results for other characteristics. Under such condition Multi Objective optimization can be the solution to optimize multi response simultaneously. This paper, Multi Performance Characteristics based on Taguchi's design of approach and Utility concept is used to optimize rolling parameters, namely, exit tension, entry tension, Rolling speed and Roll Bending Pressure. A L_{27} orthogonal array was selected and total 27 experiments were conducted in Single stand reversing cold rolling Mill after selecting control factors and its levels as a case study. Interaction plot shows no interaction among the control parameters. The ANOVA carried out which shows the mill speed is most significant control factor. The Prediction model was developed at 95% confidence level. The optimal values obtained using the multi characteristics optimization Model using Taguchi and Utility concept have been validated by confirmation experiment.

E-mail: [1]vivek.vaidya67@gmail.com, [2]dratulwaghmare@rediffmail.com

[1]Department of Mechanical Engineering, Bapurao Deshmukh college of Engineering, Wardha, India

[2]Department of Mechanical Engineering, Umred college of Engineering, Umred. Nagpur, India

Keywords: Optimization, Cold rolling, Taguchi method, orthogonal array& Utility concept.

Introduction

The cold rolling of metals provides flat product such as sheet, strip and foil with good surface finishes and increase mechanical strength with close control of product dimensions [1]. Tandem type rolling mills used for larger scale production, whereby the strip undergoes a single pass through a train of rolling stands before being wound into coil form. The single stand type rolling mills are usually operated as “reversing” mills, whereby the strip is successively wound and unwound in coil form as it is repeatedly passed back and forth through the single mill stand. Reversing mills are generally used for smaller scale production of the cold rolled products.

Fig. 1 shows schematic representation of single stand 4HI Cold rolling mill configuration consists of two work rolls and two back up rolls. The back up rolls provides rigid support to to prevent work roll bending & flexure. There are two hydraulic Jacks mounted on top of the housing on either side which provide rolling force of back roll housing and adjust roll gap. The strip coil fed to mill via tension reel on either side of mill stand. As the strip exists the mill stand it wound tight on tension reel on other side which is and expanding mandrel that maintain contant tension during rolling process while reel on entry side maintain back tension during rolling.

Since rolled metal strip is used in many applications requiring strict adherence to tolerances, such as in the aerospace, automotive, construction, container, and appliance industries, it necessary to optimized rolling parameter in order to obtain productivity and quality metals. Various Process models for cold rolling mills have been intensively developed by researcher, hoping to increase quality of steel strip and productivity of rolling processes.

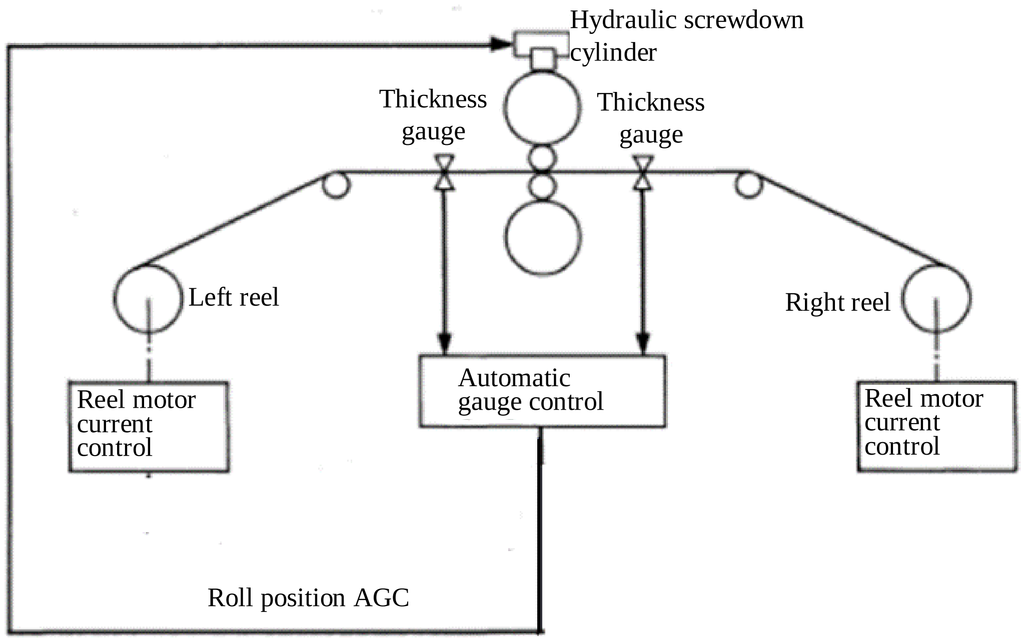

Fig. 1 Schematic representation of Single stand 4 HI reversing cold rolling mill

Table 1 Material data

#	Parameters	Unit
1.	Input thickness	2.15 mm
2.	Output thickness	0.38 mm
3.	Total Reduction	82.32%
4.	No. of Pass	8 Pass
5.	Material	ST29DC(Low carbon steel)
6.	Width of coil	1200 mm
7.	Weight of coil	20 MT

Table 2 Pass schedule

Pass No.	Entry Thk	Exit Thk	Reduction	Exit Tension	Entry Tension	Rolling Speed	Roll Bending pr.
	mm	mm	%	Kg	Kg	mpm	bar
1	2.150	1.735	19.302	12200	2000	300	80
2	1.735	1.400	19.302	12200	7200	500	80
3	1.400	1.130	19.302	12200	7200	600	80
4	1.130	0.912	19.302	12200	7200	600	80
5	0.912	0.736	19.302	10682	7121	600	80
6	0.736	0.594	19.302	8600	5734	600	80
7	0.594	0.479	19.302	4617	5772	600	80
8	0.479	0.387	19.302	3718	4647	600	80

Experimentation and Data Analysis

In accordance with the steps that are involved in Taguchi's Method, a series of experiments were conducted on low carbon steel in 4HI cold rolling Mill at JSW Steel coated Product, Kalmeshwar Nagpur, India as a case study.

Table 2 shows the material data for input material and output desired, depend on input and output data a roll pass schedule prepared. The basic procedure for the scheduling of cold rolling mills is usually based on past experience, on trials or on rules of thumb [4]. Table 1 shows the typical pass schedule as per Experience operator. Our experimentation was done for optimization control factors for 2^{nd} pass.

Identifying the Control Factors and Their Levels

The factors and their levels were decided for conducting the experiment, based on a "brain storming session" and by Fishbone diagram of cause and effect study that was held with a group of people and also considering the guide lines given in the operator's manual provided by the manufacturer of the rolling mill.

The factors and their levels are shown in Table 3.

Identifying Performance Characteristics

For evaluating the performance of single stand cold rolling mill process, the following output characteristics were selected.

1. One of the quality characteristics of rolled strip is Thickness variation, % of total rolled strip length under specified acceptable limit. Maximizing %
2. Strip flatness measured in I value Minimizing Strip flatness I value
3. Minimizing power consumption in rolling.
4. Maximizing Production rate.

Select a Suitable Orthogonal Array and Construct the Matrix

There are four control factors with 3 levels in our experiment. The suitable orthogonal for experimentation for this project selected is $L_{27}(3^{13})$ from standard orthogonal array. The experimental layout with the selected values of the factors with four response is shown in Table 5.

Optimum Parameter Setting

The optimum parameter setting for each performance characteristics were evaluated by Taguchi Method of optimization using following criteria.

Taguchi's S/N Ratio for (NB) Nominal-the-best.

$$\eta = 10\log_{10}\frac{1}{n}\sum_{i=1}^{n}\frac{\mu^2}{\sigma^2} \tag{1}$$

Taguchi's S/N Ratio for (LB) Lower-the-better

$$\eta = -10\log_{10}\frac{1}{n}\sum_{i=1}^{n}y_i^2 \tag{2}$$

Taguchi's S/N Ratio for (HB) Higher-the-better

$$\eta = -10\log_{10}\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_i^2} \tag{3}$$

The optimum setting parameter for thickness variation and production rate calculated by using equation (3) whereas for flatness and power consumption optimum setting calculated using equation (2).

Utility Concept

The performance of a product is evaluated on various quality characteristics. The evaluations of different characteristics are combined to give a composite index. Such a composite index represents the utility of a product and is the sum of utilities of each of the quality characteristics. The joint utility function can be expressed [9]:

Table 3 Factors and there levels in design of experiment

#	Process Parameter	Parameters Designation	Units	Leve 1	Level 2	Level 3
1.	Exit tension	A	kgs	11000	11600	12200
2.	Entry tension	B	kgs	6000	6600	7200
3.	Mill speed	C	MPM	400	500	600
4.	Bending Pr.	D	kg/cm2	70	80	90

Table 4 Orthogonal array with four multiple response

RUN	TEXT	TENT	MS	BP	THKV	FLT	PC	PR
	Kg	Kg	mpm	Kg/cm2	%	I Value	KWhr/ Ton	Tons/Hr
1	11000	6000	400	70	72.13	23.96	7.93	24.89
2	11600	6600	500	80	75.62	25.74	8.18	27.54
3	12200	7200	600	90	79.21	27.49	8.32	30.52
4	11600	6600	600	90	74.95	28.47	8.11	30.54
5	12200	7200	400	70	81.13	22.16	8.51	24.52
6	11000	6000	500	80	71.12	26.64	7.88	27.77
7	12200	7200	500	80	79.88	24.76	8.38	27.52
8	11000	6000	600	90	70.45	29.37	7.82	30.77
9	11600	6600	400	70	76.63	23.06	8.22	24.66
10	11600	7200	400	80	78.87	24.04	8.50	24.60
11	12200	6000	500	90	77.38	31.96	8.13	28.99
12	11000	6600	600	70	70.95	21.27	7.87	29.24
13	12200	6000	600	70	75.21	25.69	7.92	30.49
14	11000	6600	400	80	74.37	24.94	8.21	24.74
15	11600	7200	500	90	77.38	26.56	8.30	27.72
16	11000	6600	500	90	73.12	27.54	8.08	27.74
17	11600	7200	600	70	75.21	20.29	8.08	29.22
18	12200	6000	400	80	78.87	29.44	8.34	25.87
19	12200	6600	400	90	80.63	30.26	8.46	25.96
20	11000	7200	500	70	73.62	19.44	8.13	26.30
21	11600	6000	600	80	72.71	27.49	7.83	30.69
22	11000	7200	600	80	72.95	22.17	8.07	29.30
23	11600	6000	400	90	76.13	31.16	8.17	26.19
24	12200	6600	500	70	78.12	23.94	8.26	27.34
25	11600	6000	500	70	73.38	24.76	7.90	27.69
26	12200	6600	600	80	77.45	26.67	8.20	30.34
27	11000	7200	400	90	76.13	25.76	8.33	24.92

Table 5 Optimal setting of process parameters and optimal values of individual productivity characteristics

Productivity Characteristics	Optimal Setting of Process Parameter	Significant Process Parameter (at 95% Confidence Level)	Predicted Optimal Value of Productivity Characteristics
Thickness variation %	A3,B3,C1,D3	A, B, C, D	80.57
Flatness I value	A1,B3,C3,D1	A, B, C, D	19.15
Power consumption KWHr/ Ton	A1,B1,C3,D1	A, B, C, D	7.73
Production rate Tons/ Hr	A3,B1,C3,D3	A, B, C, D	31.49

$$\mathrm{U}(x_1, x_2, x_3, x_n) = f[U_1(x_1), U_2(x_2), U_n(x_n)] \quad (4)$$

Where $U_i(x_i)$ Utility of ith attribute

In linear case, the function becomes:

$$\mathrm{U}(x_1, x_2, x_3, x_n) = \sum_{i=1}^{n} W_i\, U(x_i) \quad (5)$$

where Wi is the weightage assigned to the attribute i and the sum of the weightages for all attributes is equal to 1.

If the composite measure (the overall utility) is maximized, the quality characteristics considered for evaluation of utility will automatically be optimized (maximized or minimized whatsoever the case may be).

Determination of Utility Value

To determine the utility value for a number of quality characteristics, a preference scale for each quality characteristic is constructed. Later these scales are weighted to obtain a composite number (overall utility). The weighting is done to satisfy the test of indifference on the various quality characteristics. The preference scale should be a logarithmic one [10]. The minimum acceptable quality level for each quality characteristic is set out at 0 preference number and the best available quality is assigned a preference number of 9. If a log scale is chosen, the preference number (Pi) is given by:

$$P_i = A \log \frac{x_i}{x_i'} \quad (6)$$

Where,

x_i–any value of quality characteristic or attribute i

x_i'–minimum acceptable value of quality characteristic or attribute i

A–a constant

At optimum value (x_i') of attribute i, the preference number, Pi = 9, therefore:

$$\mathrm{A} = \frac{9}{\log \frac{x_i^*}{x_i'}}$$

The next step is to assign weights or relative importance to the quality characteristics. This assignment is subjective and based on experience. Moreover, it depends on the end use of the product or it may depend on the customer's requirements. The weightage should be assigned such that the following condition holds

$$\sum_{i=1}^{n} W_i = 1 \quad (7)$$

The overall utility can be calculated as:

$$U_j = \sum_{i=1}^{n} W_i\, P_i \quad (8)$$

Multi-Characteristic Optimization of Productivity Characteristics

The optimal setting of process parameters and the optimal values of strip thickness variation (THKV), strip flatness(FLT), power consumption(PC) and Production rate (PR) (optimized individually using Taguchi's approach) have been established. The summary results are reproduced in Table 5.

Preference Scale Construction

Thickness variation within acceptable (Thkv)

x*–optimum value of Thkv (when optimized individually)

x* = 80.57% (Table 5)

x'–minimum acceptable value of material removal rate

x' = 70.45% (assumed)

Using these values and Eqs. 3 and 4, the following preference scale for thickness variation

has been constructed:

$$A = \frac{9}{\log \frac{X^*}{X'}} = \frac{9}{\log \frac{80.57}{70.45}} = 154.39$$

$$P_{Thkv} = 154.39 \log \frac{X}{71}$$

Strip Flatness I value (Fltv)

x*–optimum value of Thkv (when optimized individually)

x* = 19.15 (Table 3)

x'–Maximum acceptable I value

x' = 31.96 (assumed)

Using these values and Eqs. 3 and 4, the following preference scale for flatness as been constructed:

$$A = \frac{9}{\log \frac{X^*}{X'}} = \frac{9}{\log \frac{19.15}{31.96}} = -40.46$$

$$P_{Fltv} = -40.46 \log \frac{X}{25}$$

Power consumption KWHr per Ton of coil produced (PC)

x*- optimum value of PR (when optimized individually)

x* = 7.73 KWhr /Tons (Table 3)

x'–Minimum acceptable of PR

x' = 8.51 KWHr/ Ton (assumed)

Using these values and Eqs. 3 and 4, the following preference scale for power consumption

has been constructed:

$$A = \frac{9}{\log \frac{X^*}{X'}} = \frac{9}{\log \frac{7.73}{8.51}} = -215.569$$

$$P_{pc} = -215.569 \log \frac{X}{8.51}$$

Prduction rate Tons per Hr (PR)

x*–optimum value of PR (when optimized individually)

x* = 31.49 Tons per Hr (Table 3)

x'–Minimum acceptable value of Production rate

x' = 24.52 Tons per Hr (assumed)

Using these values and Eqs. 3 and 4, the following preference scale for production rate

has been constructed

$$A = \frac{9}{\log \frac{X^*}{X'}} = \frac{9}{\log \frac{31.49}{24.52}} = 82.83$$

$$P_{PR} = 82.83 \log \frac{X}{24}$$

1. Weightage of quality characteristics

It has been assumed that the quality characteristics are equally important and hence equal weightage has been assigned. However, there is no constraint on weightage and it can be any

value between 0 and 1 subjected to the conditions specified.

W_{Thkv} = 0.25 (Weightage for Thickness variation)

W_{Fltv} = 0.25 (Weightage for Flatness I value)

W_{PC} = 0.25 (Weightage for Power consumption)

W_{PR} = 0.25 (Weightage for Production Rate)

2. Utility value calculation

The utility value of each machined part has been calculated using the following relation:

$U(n) = P_{Thkv}(n)\ X\ W_{Thkv} + P_{Fltv}(n)$ X W_{Fltv} + $P_{pc}(n)$ X W_{PC} + $P_{PR}(n)\ X\ W_{PR}$

where,

n–trial number, n = 1, 2, 27

The utility values thus calculated are given in Table 6

Table 6 Utility database on all performsnce characteristics

RUN	U_{thkv}	U_{fltv}	U_{pc}	U_{pr}	UI	UI_SN
1	1.580	5.062	6.620	0.544	3.451	10.760
2	4.748	3.803	3.758	4.182	4.123	12.304
3	7.861	2.645	2.159	7.875	5.135	14.211
4	4.155	2.030	4.524	7.901	4.653	13.354
5	9.464	6.435	0.026	0.002	3.981	12.001
6	0.635	3.199	7.152	4.482	3.867	11.748
7	8.423	4.485	1.411	4.154	4.618	13.290
8	0.003	1.483	7.947	8.172	4.401	12.872
9	5.638	5.735	3.244	0.209	3.707	11.379
10	7.570	5.004	0.108	0.119	3.200	10.103
11	6.291	0.000	4.246	6.028	4.141	12.343
12	0.477	7.152	7.351	6.337	5.329	14.533
13	4.387	3.835	6.774	7.843	5.710	15.132
14	3.631	4.358	3.371	0.326	2.921	9.311
15	6.291	3.252	2.394	4.414	4.088	12.230
16	2.494	2.615	4.807	4.442	3.590	11.101
17	4.387	7.981	4.871	6.310	5.887	15.398
18	7.570	1.443	1.915	1.933	3.215	10.144
19	9.050	0.960	0.577	2.057	3.161	9.997
20	2.951	8.736	4.230	2.522	4.610	13.274
21	2.120	2.645	7.814	8.078	5.164	14.260
22	2.341	6.424	5.000	6.408	5.043	14.054
23	5.199	0.445	3.815	2.375	2.959	9.422
24	6.929	5.077	2.761	3.920	4.672	13.390
25	2.732	4.485	7.020	4.378	4.654	13.356
26	6.355	3.177	3.519	7.665	5.179	14.285
27	5.199	3.790	2.012	0.584	2.896	9.236

Determination of Optimal Settings of Process Parameters

The data (utility values) have been analyzed both for mean responses (mean of utility at each level of each parameter) and signal to noise ratio. Since utility is a higher-the-better (HB) type of quality characteristic, the signal to noise ratio for HB has been used. The S/N ratios are also given in Table 6. The mean responses and main effects (in terms of utility value) are given in Table 7. The average value of S/N ratios and S/N main effects are given in Table 7.

The results of ANOVA for Multi Response Utility Index S/N Ratio indicate that MS (Mill speed) is the most significant (80.28%) Cold rolling parameters in affecting the Utility Index followed BP (13.54%) and TENT and TEXT and are very less significant. Based on the above discussion and the main effect plot of S/N ratio, the optimal cold rolling parameters are the EXT at level 3 (A3 = 12200), ENT at level 3 (B3= 7200), MS at level3 (C3=600) and BP at level 1 (D1 = 70) or A3B3C3D1 in short.

The predicted optimal utility based on THKV, FLT, PC and PR is calculated as (Ross 1996, page 185):

$$\mu_{UI} = Y_{UI} + (A1 - Y_{UI}) + (B1 - Y_{UI}) + (C3 - Y_{UI}) + (D1 - Y_{UI}) \quad (9)$$

$Y_{UI} = 4.235$

$= 4.235 + (4.424 - 4.235) + (4.384 - 4.235) + (5.167 - 4.235) + (4.667 - 4.235) = \mathbf{5.937}$.

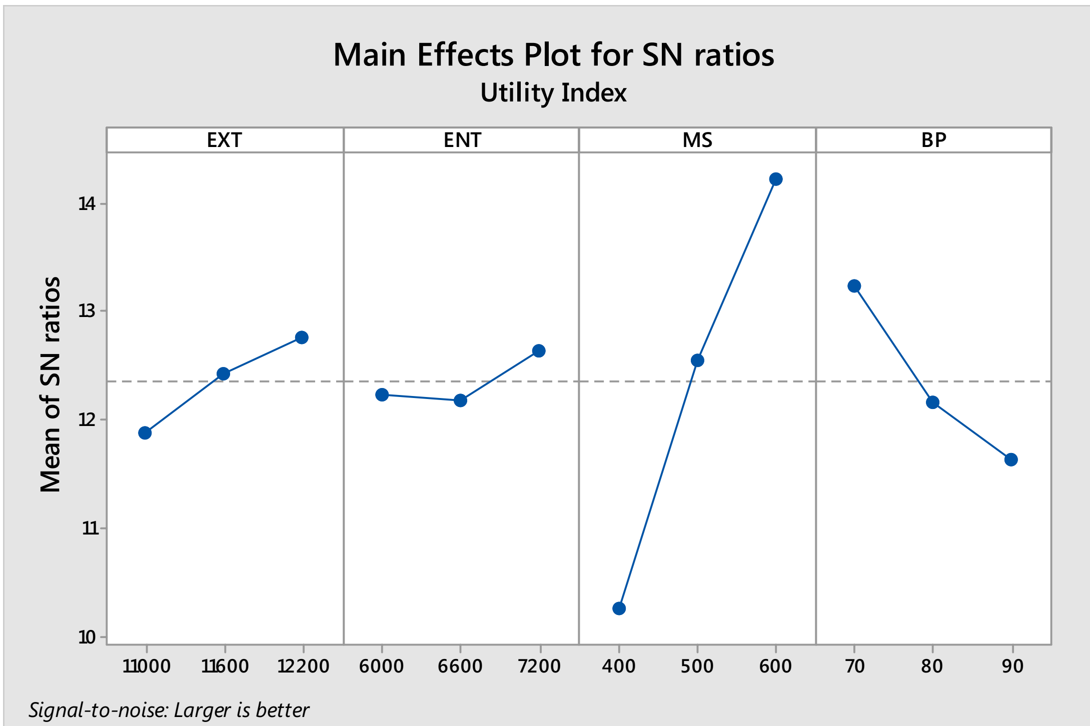

Fig. 2 Main effect plot for S/N ratio UI

Table 7 Response table for s/n ratio utility index

	Control Factors			
	TEXT	**TENT**	**MS**	**BP**
Levels	**A**	**B**	**C**	**D**
1	11.88	12.23	10.26	13.25
2	12.42	12.18	12.56	12.17
3	12.75	12.64	14.23	11.64
Delta	0.88	0.46	3.97	1.61
Rank	3	4	1	2

Table 8 Average values of response at optimal level for utility index

Process Parameters	Utility Index	S/N_Ratio
A3	4.424	12.75
B3	4.384	12.64
C3	5.167	14.23
D1	4.667	13.25

Table 9 Anova for s/n ratio of utility index

Factors	DOF	Sum of Square	Mean Sqaure	F- Value	P-Value	% Contribution
TEXT (A)	2	3.5383	1.7692	27.94	0.001	3.97
TENT (B)	2	1.1648	0.5824	9.2	0.015	1.31
MS (C)	2	71.5694	35.7847	565.19	0.000	80.28
BP (C)	2	12.0749	6.0374	95.36	0.000	13.54
AxB	4	0.1763	0.0441	0.70	0.622	0.20
AxC	4	0.0637	0.0159	0.25	0.899	0.07
AxD	4	0.1857	0.0464	0.73	0.601	0.21
Error	6	0.3799	0.0633			0.43
Total	26	89.153				

Table 10 Result of confirmation test

	Unit	Predicted Result	Actual Results	Error in Prediction
Factor Level		A3B3C3D1	A3B3C3D1	
THKV	%	78.21	78.35	
FLT	I	21.46	21.5	
PC	KWHr/ Ton	7.21	8.23	
PR	Tons/ Hr	29.52	29.56	
Utility Index		5.937	6.301	6.13%

For the 95% confidence interval, CI is calculated as below:

$$CI = \sqrt{\frac{F_{\propto}(1,f_e)\,V_e}{n_{eff}}} \qquad (10)$$

The specific values as required are:

f_e–error; DOF = 6 (Table 9)

V_e–error variance is 0.0633 (Table 9)

$N = 81$: $n_{eff} = 81/27$ (calculated), $R = 3$

$F_{0.05}(1.6) = 5.99$; (tabulated value from F-Table)

$CI = 0.42$

The 95% confidence interval of the population is:

$[\mu_{UI} - CI] < \mu_{UI} < [\mu_{UI} + CI]$

$5.517 < 5.937 < 6.35$

Confirmation Experiment

Table 9 represents confirmatory result and it can be concluded that the overall utility index for optimal parameters is near to the predicted value of optimal UI. UI of the actual result is Within confidence interval shows the error of 6.13%.

Conclusion

The following conclusions have been drawn.

1. A simplified model based on Taguchi approach and utility concept has been developed for determining optimal settings of the process parameters for multi-characteristic product. The model has been

used to predict optimal settings of process parameters for combined quality characteristics. The predicted optimal values of the quality characteristics have been verified by rolling the coil at the optimal settings recommended by the model.

2. The percent contribution of the significant process parameters towards the utility index of the selected response of cold rolling are (Table 10):
   Mill Speed: 79.86 %, Exit Tension: 3.87 %, entry Tension: 1.5 %, Roll Bending Pressure:13.94 %, interaction between exit tension and Entry tension: 23.317 %, interaction between exit Tension and Mill speed: 18.541 %, interaction between Exit Tension and Roll bending Pressure: 3.005 %.
3. The optimal levels of various cold rolling process parameters for optimization of utility based on Thickness variation, Flatness, Power consumption and Production rate are A3B3C3D1 in short.
4. The predicted optimal range of utility based Thickness variation, Flatness, Power consumption and Production rate are within, at 95 % confidence level.
5. The optimal values obtained using the multi-characteristic optimization models have been validated by confirmation experiments.
6. The model can be extended to any number of quality characteristics provided proper utility scales for the characteristics are available from the realistic data.

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Optimize the Drying Mathematical Models of Stripped Mullet and Grey Mullet for a Hybrid Solar Dryer

T.K. Chand[1], M.K. Mohanty[2] and R.C. Mohanty[3]

Abstract The present investigations deal with the comparative study of Stripped Mullet and Grey Mullet which were investigated experimentally by analyzing on a hybrid solar dryer in addition to regression study of kinetic drying of them. The drying experiments of samples (fish) were conducted in Bhubaneswar, India during a month of January to March 2016.The test were conducted from 9:00 a.m. to 5:00 p.m. and observed the variation in the mass of the samples and other drying parameters such as temperature, relative humidity, air flow rate, solar radiation in every one hour of interval. A Statistical analysis has been carried out with data analysis in Microsoft excel software to developed mathematical models and compare the drying parameters like R^2, MBE, RMSE, χ2, EF. The samples used in this experiment were "Stripped Mullet" and "Grey Mullet" having zoological name Juvenile Mugil and Mugil Cephalus respectively under the same family of Mugilidae. Newton's mathematical equation was found to be the best fit model for explaining the drying curves of the samples with observed values of R^2 were 0.985 and 0.995 for Stripped Mullet and Grey Mullet respectively.

Keywords: Regression, R^2, MBE, RMSE, χ2, EF

Introduction

Sun drying is the old traditional procedure for preservation of agricultural products, marine products in the tropical region. It is also economical and environmentally friendly methods to improve the shelf life of the products. Sun drying having draw back like undue exposure to rain, contamination by wind borne elements, exposure to ultraviolet rays, apart from these products can be deteriorate by insects, rodents, pests. Sun drying fall short of meet international standards, required hygienic conditions and hence sun drying lack of effective preservation [1]. As use of electricity is not affordable for small-scale farmers and fishermen, they have no other option than depends on renewable energy source like solar energy for drying the products. So the basic principle adopted here is drying the products inside the solar dryer by effective use of renewable solar energy. Solar dryer develops the higher temperature, lower relative humidity, low moisture content and hence minimize the spoilage of products during the drying process [2]. The solar drying technology has been steady evolution from natural convection types to forced convection types for last four decades and still it needs to improve further [3–10].Various researchers has been designed, constructed and test the solar dryers, while some researchers has carried out exergy and energy analysis, drying analysis and simulation [3,5-7,9-10].Solar drying relies on the sun as its source of energy. The design of the many solar dryers are simple in construction and user friendly to dry the products by enhancing the solar radiation. The basic technology behind the solar dryer is to increase the air temperature of the drying chamber and consequently decreases the value of relative humidity which helps in enhance the drying rate and so decreases the drying time and lower moisture content of the products. In the drying method the water content of the product decreases which prevents microbiological infestation and hence improve the shelf life [11-16]. The physical and chemical stability of the products are improved by drying as because of reduction in volume, weight and transportation cost [11, 17-19]. Drying of the product takes place inside a closed environment, hence it has some advantages like optimum control over the drying parameters, reduce the environmental hazards. The solar dryer can be designed either on the mode of the natural convection or forced convection of air flow [20]. In case of forced convection mode, a required capacity of fan or blower is/are fixed in the drying chamber to circulate the air in the system to remove the moisture that comes out from the product. Moisture from the product can be removed by direct heating mode, indirect heating mode and mixed mode [20-21]. In case of direct heating, solar radiation directly passes through a glass cover and falls on the dying bed where necessary heat can be generated by absorbing in the

E-mail: [1]tapas_chand@rediffmail.com, [2]mohanty65@gmail.com, [3]rcmohanty@cutm.ac.in

[1,3]Centurion University of Technology and Management, Bhubaneswar, India

[2]Orissa University of Agriculture and Technology, Bhubaneswar, India

absorber material. In case of indirect mode, instead of direct heating of the product, the solar energy first fall on a separate solar collector to increase the temperature of the air, then heated air passes to the drying bed. In case of mixed mode, the heating of the product takes place by combination of direct and in direct modes. It has been found in the literature review that India receives the solar radiation on a average of 5 kWh/m^2 over a period of 300 sunny days per year [22]. Odisha an eastern state of India having geographical coordinates 17° 49' North - 22° 34' North Latitude and 81° 29' East-87° 29' East Longitude receives daily solar radiation between 5.4 to 5.6 KWh /m^2. NASA data (Annexure I) shows that average solar radiation falls for all the district of Odisha is almost 5 kWh/m^2 which is very favourable condition for commercial exploitation [23].

Methodology

Brief Description about Hybrid Solar Dryer

The experiments were conducted in the hybrid solar dryer at Department of Farm machinery and Power, College of Agricultural Engineering and Technology (CAET), Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India. The capacity of the dryer is 5 kg with three number of drying trays inside the dryer. The essential components of the dryer are drying chamber, transparent glass plate mounted over the drying chamber, drying trays, absorber plate made with G.I. plate, coated with special black chrome paint, thermocol material and glass wool are used as an insulator to restrict the heat loss from the chamber. A twelve volt photo-voltaic panel is provided to receive solar energy and converts to dc current for energize the blowers provide in the back side of the dryer. A chimney is provided to create natural draught for easy removal of moisture from the drying chamber that comes out from the product to be dried. A burner is provided in the bottom part of the dryer which can be used to raise the temperature of the air by burning the bio mass to dry the product during night time or when solar radiation is negligible particularly in rainy days. The area of the glass plate is 1.54x0.85 square meter with a value $\alpha\tau = 0.85$. Thermocouples are provided in different locations to measure the temperature of drying air.

Experimental Procedure for Load Test

The latitude and longitude for test centre are 20.29^0 N, 85.83^0 E. The marine fishes were caught from Chillika Lake, which has the largest costal area of Odisha for fish production. The fishes were treated with the brine solution at strengths of about 80 to 100% for 15 to 20 minutes. The fishes were soaked in the brine solution and were turned in every 5 minutes for homogeneity. Prior to loading of the samples inside the dryer, they were put on a screen for removal of excess water which renders in drying. A sample was then taken from the lot for measurement of initial moisture content of the fish.

Drying Parameters

Moisture Content

Moisture content of the sample can be evaluated either on wet basis or dry basis techniques. In the current research study, moisture content (M_{db}) was evaluated on dry basis method. The sample was kept in an electrical oven which was maintained at a temperature of 105^{0}C for 24 hours to achieve constant weight of the sample. The initial and final mass of the sample were measured with electronic balance for better accuracy. The formula for (M_{db}) has given in equation (1)

$$M_{db} = \left(\frac{W_I - W_O}{W_O} \right) \times 100\ \% \qquad (1)$$

Moisture Ratio

$$MR = \frac{M_t - M_e}{M_I - M_e} \qquad (2)$$

M_e Value is negligible as compared to M_t and M_I [24], hence the equation (2) can be reduced to equation (3)

$$MR = \frac{M_t}{M_I} \qquad (3)$$

Drying Rate

The drying rate (DR) has direct relationship with difference in moisture content and equilibrium moisture content.

$$DR = \frac{M_{t+dt} - M_t}{dt} \qquad (4)$$

Mathematical Model

In the present research study some important mathematical models were reviewed that has been discussed by various researchers and detailed analyses were carried on Newton and Henderson & Pabies models on aforesaid samples to evaluate drying parameters to optimize the mathematical model statically [25,26-38].

$$\chi^2 = \frac{\sum_{i=1}^{N} \left(MR_{\exp,i} - MR_{pre,i} \right)^2}{N - z} \qquad (5)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} \left(MR_{\exp,i} - MR_{pre,i} \right)^2}{N}} \qquad (6)$$

$$EF=\frac{\left[\sum_{i=1}^{N}\left(MR_{exp,i}-MR_{exp,mean}\right)^2\right]-\left[\sum_{i=1}^{N}\left(MR_{pre,i}-MR_{exp,i}\right)^2\right]}{\left[\sum_{i=1}^{N}\left(MR_{exp,i}-MR_{exp,mean}\right)^2\right]} \quad (7)$$

Regression Analyses

Solar Drying (Stripped Mullet)

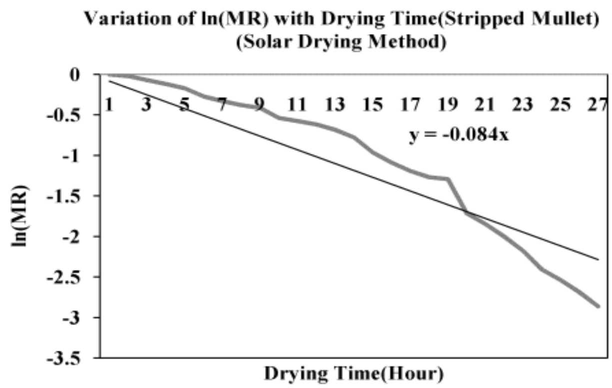

Fig. 1

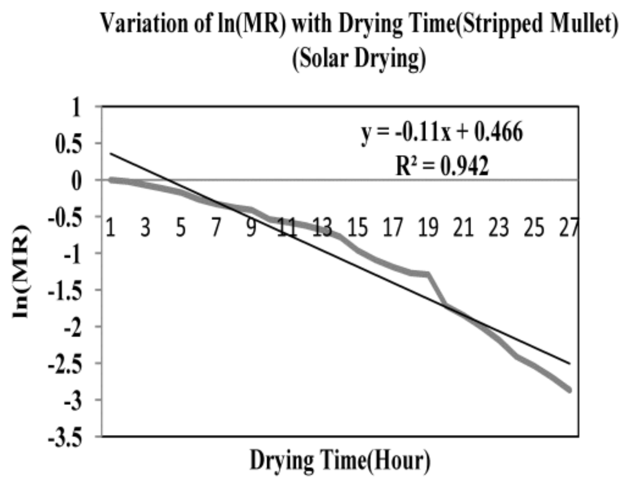

Fig. 2

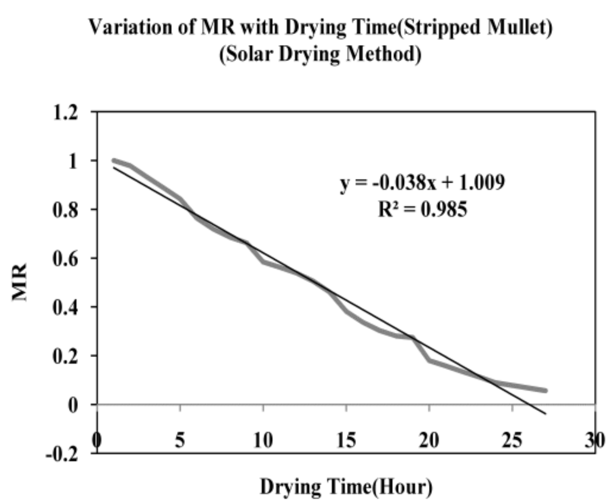

Fig. 3

Solar Drying (Grey Mullet)

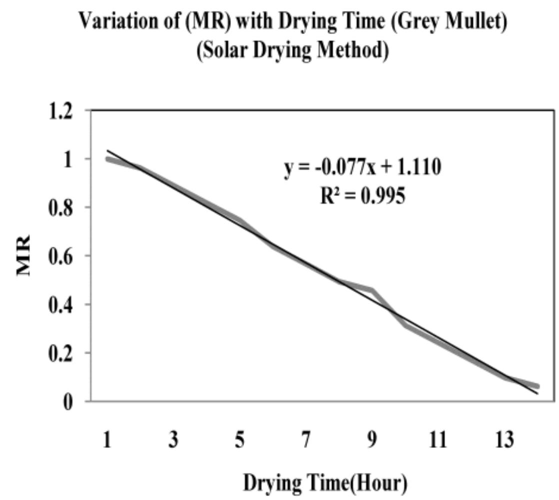

Fig. 4

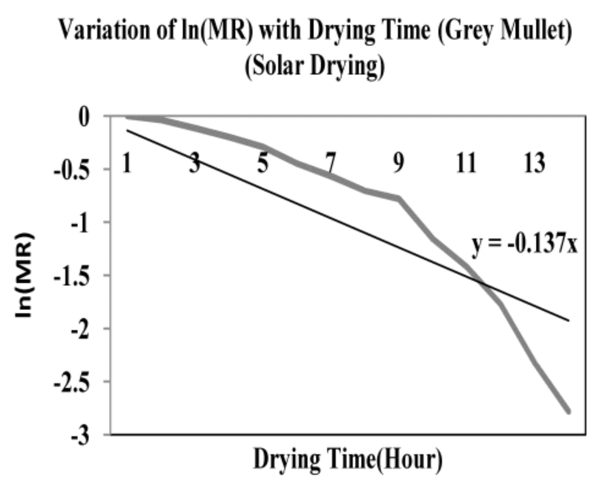

Fig. 5

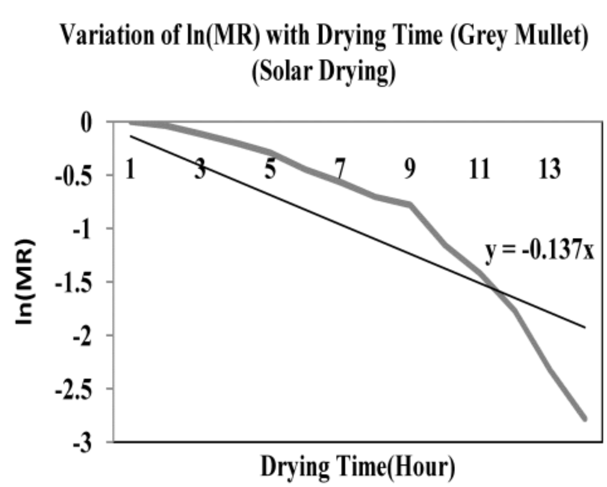

Fig. 6

Table 1

Name of the Samples				
Samples/ Parameters	**Stripped Mullet**		**Grey Mullet**	
Name of the Model	**Newton**	**Henderson & Pabies**	**Newton**	**Henderson & Pabies**
R^2	0.985	0.942	0.995	0.889
k	0.084	0.11	0.137	0.2
a	-	1.59	-	1.8
MBE	0.00014	0.0160469	0.00044	0.0268191
RMSE	0.01165	0.1266763	0.02108	0.0312889
χ2	0.00141	0.0173306	0.00048	0.0312889
EF	98.5351	81.476788	99.5405	72.264835

Results

Regression methods were carried out on the experimental data in Microsoft excel software and plots the graphs for stripped Mullet (Fig. 1, Fig. 2 & Fig. 3) and Grey Mullet (Fig. 4, Fig. 5 & Fig. 6) respectively for the evaluation of drying parameters and compare the mathematical models which is shown in Table 1.

Conclusion

The present research work was to developed the best mathematical drying model of two marine fishes (Stripped Mullet & Grey Mullet) using a solar dryer for producing best quality dried products at low investment and transfer the drying technology to small- scale fishermen to improve their living status in the coastal region of Odisha, India. The dried product was produced in a short period of time and simultaneously quality also improved in this controlled drying process.

The coefficient of determination (R^2) was one of the primary drying parameters for evaluating the best statistical model for fish drying. Some other drying parameters like model efficiency (EF), reduced chi-square (χ^2), and root mean square (RMSE) are also helpful for selecting the drying curves. As literature review shown that higher the R^2 value and lower the $\chi^2$and RMSE values, the better is the goodness of fit [39], So Newton mathematical model were best fit model for both the samples that were taken for investigation. Same solar dryer can be installed as per the geographical coordinates in different locations to get maximum availability of solar insolation and drying can be done effectively

Acknowledgment

I would like to acknowledge my parents, elder brother and my son who was supported me both morally and technically at each and every step duing my research work.

Nomenclature

R^2=Coefficient of Determination
MBE =Mean Bias Error
RMSE=Root Mean Square Error
χ2=Reduced-Chi Square
EF=Model Efficiency
W_I=Initial weight of the sample.
W_O =Weight of bone dried sample
M_t =Moisture content of the sample at any instant of time
M_I =Initial Moisture Content
M_e =Equilibrium Moisture Content
t=Time
k,a = Drying Constants
dt= Time Interval
α =Absorptivity of the glass material
τ =Transitivity of the glass material

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Prediction of Surface Roughness in High Speed Turning of Ti-6Al-4V using Adaptive Neuro Fuzzy Inference System

Abhishek B.[1], Grynal D'Mello[2] and Srinivasa Pai P.[3]

Abstract High speed machining plays a very important role in manufacturing processes. Surface roughness is very important in machined products, as it determines its quality. Ti-6Al-4V is one of the widely used titanium alloy in aerospace and medical applications, because of its high corrosion resistance, high strength, hardness and biocompatibility. In this work, attempt has been made to determine the effect of cutting speed, feed, depth of cut, tool wear and vibrations of cutting tool on surface roughness of turned Ti-6Al-4V alloy. The experiments have been carried on a CNC lathe with uncoated carbide inserts. Surface roughness has been evaluated using two parameters namely Ra (arithmetic average surface roughness) and Rt (maximum peak to valley height of profile in the assessment length). Adaptive Neuro Fuzzy Inference system (ANFIS), was used to build the predictive model for prediction of surface roughness. Comparison of predicted values against the experimental values are done and the model is found to be reliable with around 90% accuracy.[1]

Keywords: ANFIS, Ti-6Al-4V, Surface Roughness

Introduction

Among various factors influencing productivity of machining processes, surface roughness is considered as the most important factor. If a good quality surface finish is not obtained, then it might affect the life of the component. Problems like friction and, difficulty of fit might occur because of bad surface finish. The factors which affect the surface roughness are combination of machining parameters, material properties of workpiece and cutting tool and, cutting conditions. In high speed turning operation, the surface roughness is mainly dependent on machine speed, depth of cut, feed rate, tool wear and, machine vibrations. Small change in the factors mentioned above greatly influences the surface roughness [1]. There is a need to understand the influence these various factors on surface roughness. There are several modelling techniques available and there have been several efforts to model the surface roughness [2,3]. Benardos *et al.* has presented a review of different approaches used for predicting surface roughness, which include Artificial Intelligence approach and under this technique include artificial neural network (ANN), expert systems and, fuzzy logic [4].

In aerospace, automobile and bio-medical applications, Ti-6Al-4V is extensively used. Because of its high thermal conductivity, corrosion resistance and, reaction with cutting tool inserts, it is considered as a difficult to machine material [5,6].

Surface roughness modelling in turning is a complex process. There have been several efforts, which include use of artificial intelligence (AI) to regulate the CNC machining parameters [7]. The study demonstrated that the use of AI would be suitable for predicting the surface roughness. Karayel Durmus demonstrated the prediction of surface roughness in CNC lathe by using ANN [8]. Lambert and Sundaram predicted surface roughness using Response Surface Methodology (RSM) [9]. Jean-Philippe and Chen Lu [10] examined three variables in turning process using RBF neural network to predict the surface roughness. Reddy B. *et al.* [2] worked on the construction of prediction model for surface roughness during machining of aluminium alloys using ANFIS. The performance was compared with Response Surface Methodology (RSM) technique. The ANFIS results were superior than RSM. Nikos Tsourveloudis [3] compared the performance of RSM and ANFIS for estimating the surface finish of the Ti-6Al-4V alloy during turning operations. It was found that feed rate is a dominant parameter influencing surface roughness. Ibrahem Maher *et al.* [11] used ANFIS to predict surface

E-mail: [1]abhishek.bolar@gmail.com, [2]grynal@nitte.edu.in, [3]srinivasapai@rediffmail.com

[1]M-Tech Scholar, Department of Mechanical Engineering, NMAMIT, Nitte, India

[2]Asst. Professor, Department of Mechanical Engineering, NMAMIT, Nitte, India

[3]Professor, Department of Mechanical Engineering, NMAMIT, Nitte, India

roughness in CNC end milling of brass. ANFIS model with gbellmf MF achieved a prediction accuracy of 97.25%. Grynal D'mello et al [1] compared three modelling techniques namely ANN, RSM and ANFIS to predict surface roughness during high speed turning on mild steel. Cutting speed, feed and vibration parameter were used as the input parameters and R_a was the output parameter. The evaluation of the models was done on the basis of R^2 (coefficient of regression). ANFIS was found to be a better modelling technique with a R^2 of more than 0.9, when compared to other two techniques.

The use of ANFIS in modelling surface roughness in titanium based alloys is rather limited. Hence in this paper, attempts were made to model surface roughness during high speed turning of Ti-6Al-4V. Cutting experiments were conducted at different feeds and cutting speeds with a constant depth of cut. Cutting tool vibrations were measured online using accelerometer which is mounted on the tool holder and surface roughness and tool wear were measured offline. The cutting conditions along with the vibration parameter and tool wear have been used to predict surface roughness using ANFIS. The vibrations of cutting tool and tool wear have not been considered in previous studies as these two parameters are considered as uncontrollable.

Experimental Details

Experiments were carried out on a CNC lathe (HMTStallion 100 SU make) with spindle speed in the range of 100–3500 rpm as shown in fig. 1. Using a tri-axial accelerometer (Model 65–10 Isotron) the vibration signals were recorded. With a cellophane tape, tri-axial accelerometer is fixed close to the cutting zone on the tool holder. The feed, speed and depth of cut are captured in three different directions. For further analysis the vibration signals sensed were sent to a PC through a DNA-PPCx using LABVIEW software. The machining was carried out for a length of one machining pass. After every pass the tool insert is removed and its flank wear (VB_{max}) is measured using Mitutoyo make Tool maker's microscope (TM505/510). There are two micro metres. One in the x direction and another in y direction, with a least count of 0.005mm and the eyepiece have 15X magnification. The experiments were continued, till the flank wear on the insert reached 0.4mm, which is as per the ISO 3685, 1993 standard [12]. Surface roughness after each turning pass is measured using Taylor Hobson Taly Surf 50 which is a contact type stylus instrument. While measuring the two surface roughness parameters R_a (arithmetic average) and R_t (maximum peak to valley height of the profile in the assessment length), a sampling length of 2.5mm has been considered. The workpiece is kept on a V block and surface roughness along the circumference of the workpiece at three different locations is measured and mean value has been calculated.

Work material Used

In this study, work piece of grade 5 titanium alloy (Ti-6Al-4V) in the form of a bar with length 20 mm and diameter of 50mm is used, which is held in a three jaw chuck during machining.

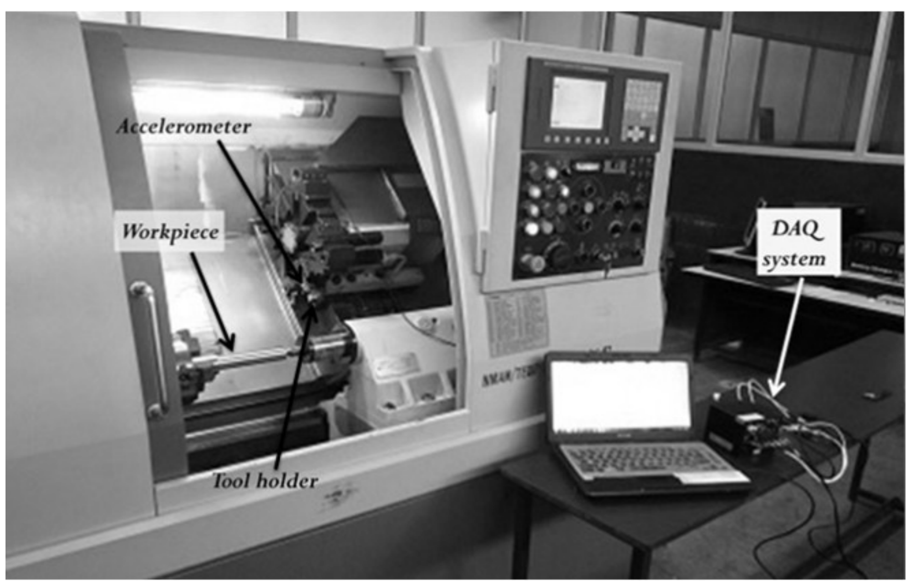


Fig. 1 Experimental setup

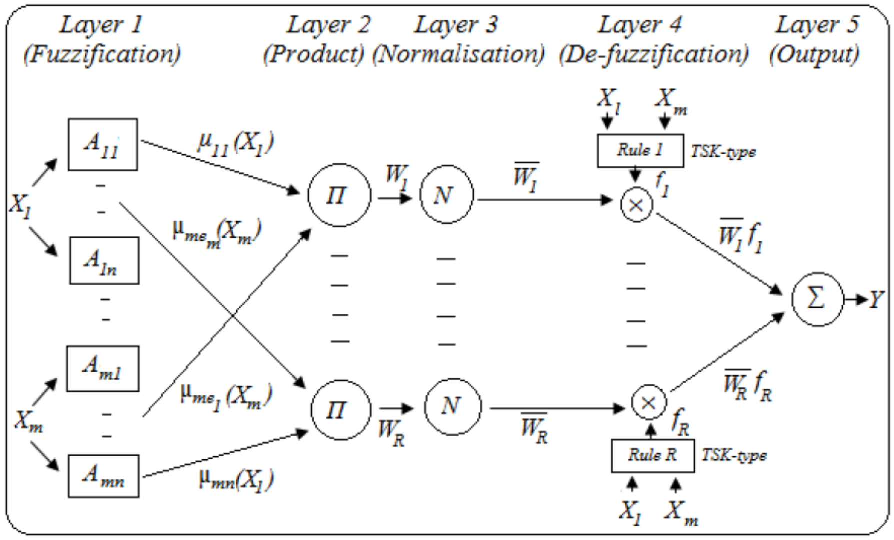


Fig. 2 Basic structure of ANFIS [21].

Cutting Tool Material

Experiments were carried out using uncoated carbide inserts. The specifications of the inserts are:883 with MR4 chip breaker, CNMG 120408 (SECO make). The tool geometry of the insert is: back and side rake angle -6^o, end cutting edge angle 5^o and tool nose radius of 0.8mm. The tool holder used is PCLNL 2020 (SECO make).

ANFIS

Introduction

ANFIS is a combination of artificial neural network and fuzzy systems such that neural network is used to decide the parameters of the fuzzy system. The fuzzy inference system (FIS) effectively identifies and controls complex linear systems [13]. Fuzzy logic is extensively used because of its capability to find answers even when suitable mathematical models are unavailable [14]. With the convenience of rule based fuzzy system and the learning capacity of neural network, the neuro fuzzy systems can construct a mechanism to insert past observations into the grouping process and can enhance its performance. In neural network, the system is built by training. However, in neuro fuzzy scheme, the system is constructed by fuzzy logics and it is fine tuned using training algorithms for neural network. The MATLAB ANFIS GUI toolbox [15] is used to build the FIS and the MF parameters can be selected using either a back propagation algorithm, or with a least squares method [16]. During setting up of initial MF parameters, data from previous experiments can be considered [17, 18].

ANFIS Architecture

To facilitate learning and adaptation, the fuzzy Sugeno models are included along the frame work of adaptive systems [19]. The mathematical relation between the input and output data in ANFIS is given by using hybrid learning method, to choose the best distribution of membership functions [20]. Five layers are used to model the fuzzy inference system. The inputs for layers in consideration are taken from the nodes in the preceding layers. The ANFIS structure of a system is shown in Fig. 2, which has m inputs each with n membership functions (MFs), a fuzzy rule base of R rules and one output (Y).

For learning, Sugeno type FIS, between training and adaptation with a network containing 5 layers is used. In layer 1, number of nodes (N) is the product of numbers of inputs (m) and MFs (n), for each input the number of nodes is given by N=mXn. Number of nodes in layers 2–4 are based on the number of rules (R) in the fuzzy rule base.

Layer 1: (Fuzzification Layer)

In this layer the inputs X_i are converted into grammatical labels with a scale of membership. The node $_{ij}$ output is given by:

$O_{ij} = \mu_{ij} (X_i)_j$

where,

i=1,2,…m

j=1,2,…n

μ_{ij} is the j^{th} MF for the input X_i

Several types of MFs can be used. In this study a generalized bell–linear membership function has been selected by trial and error, which is given in equation (1):

$$\mu Ai\,(x) = \frac{1}{1+\left|\frac{x-c_i}{a_i}\right|^{2b_i}} \quad (1)$$

where, $\{a_i, b_i, c_i\}$ are the parameters set. The bell shaped function differs as the values of a_i, b_i and c_i vary.

Layer 2 (Product Layer)

Every node in this layer is a fixed node denoted by Π, whose output is the product of all the incoming data:

$$Ok^2 = Wk = \mu_{Ak}(X)\mu_{Bk}(Y) \quad (2)$$

Where, node number k = 1,2

Layer 3 (Normalized Layer)

The W_k (normalized weighing factor) for the k^{th} rule is represented by the output of each node k and it is given by equation (3):

$$O_k^3 = \overline{W}_k = \frac{W_k}{W_1+W_2+\dots+W_R} \quad (3)$$

k=1,2, R

Layer 4 (De-Fuzzification Layer)

Every node k in this layer is an adaptive node with a node function

$$O_k^4 = W_k f_k, \quad (4)$$

Where, f_k =parameter set of W_k

Layer 5 (Output layer)

The only node in layer 5 is a fixed node labelled ∑, which determines the overall output (Y) as the sum of all input signals as given in equation (5).

$$O_k^5 = \sum_{k=1}^{R} W_k f_k \quad (5)$$

Anfis Modelling

The flow chart of ANFIS training and modelling process is shown in Fig. 3.

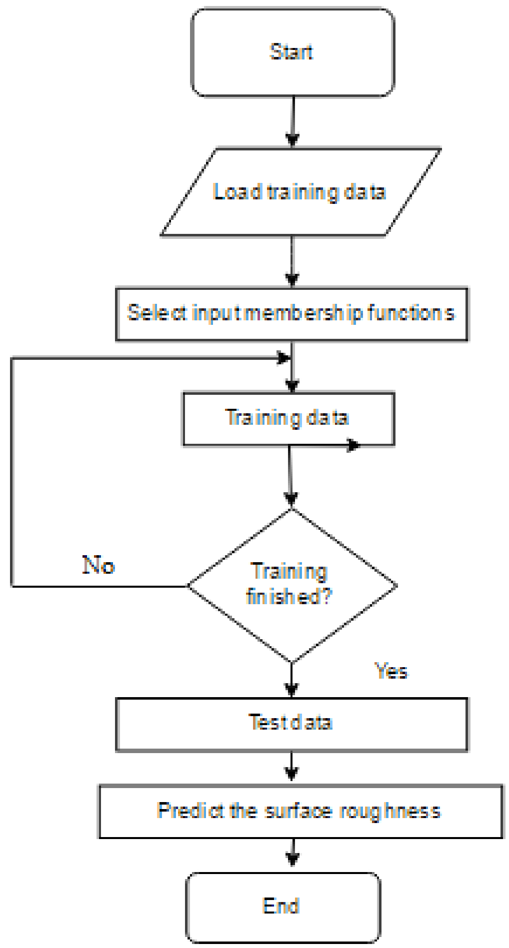


Fig. 3 Flow chart for ANFIS model

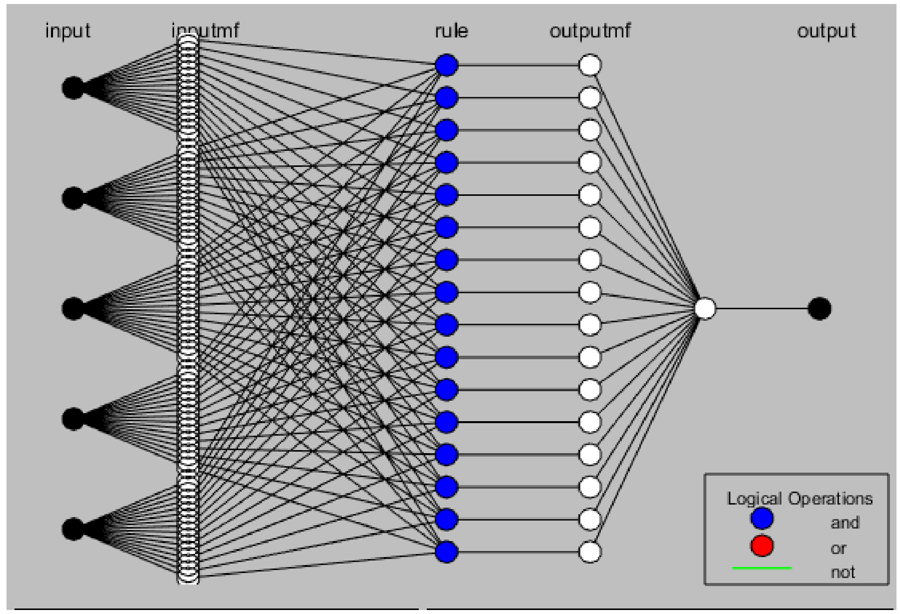


Fig. 4 ANFIS structure

Table 1 Training error for R_a

SI. No.	No. of Epochs	Error	Membership function
1	30	0.03951	gbellmf
2	30	0.05413	trimf
3	30	0.06031	trapmf
4	30	0.05652	gaussmf
5	30	0.5324	gauss2mf
6	30	0.04988	pimf
7	30	0.04913	dsigmf
8	30	0.04845	psigmf

Table 2 Training error for Rt

SI. No.	No. of Epochs	Error	Membership function
1	30	0.052755	gbellmf
2	30	0.078546	trimf
3	30	0.069987	trapmf
4	30	0.064785	gaussmf
5	30	0.059456	gauss2mf
6	30	0.055756	pimf
7	30	0.053124	dsigmf
8	30	0.052985	psigmf

Table 3 R^2 and prediction accuracy value for ANFIS model

Parameters	R^2	Prediction Accuracy for Test Data
R_a	0.905	92.2%
R_t	0.784	84.9%

ANFIS Model for R_a

Parameters namely cutting speed, feed rate, depth of cut, wear of tool and vibrations of cutting tool are given as inputs and R_a is the output. Among 289 data sets obtained for different cutting parameter combinations set during experimentation, a total of 246 data sets have been selected randomly for training and the remaining 43 data sets are used for testing the developed model. Subtractive clustering method in MATLAB GUI is used to train the FIS. The trained ANFIS structure is shown in the Fig. 4.

FIS system is generated using different MFs. The error drops with increase in the number of epochs and after 9 epochs, it almost remains constant at 0.03951.

ANFIS Model for R_t

The same inputs used in the previous case are used for model development and R_t is the output. The model for R_t is trained similarly as in the previous process. In this case, the error drops from 0.065 to 0.052 in about 7 epochs, beyond which it remains constant.

Results & Discussion

The performance evaluation of the model developed for R_a and R_t has been done based on R^2 and prediction accuracy was calculated based on MSE.

R_a

For R_a, least training error of 0.03951 with prediction accuracy of 93.1% is obtained using 'gbell' MF during training. This trained model is tested using test data for validating the performance of the model. Training error for other MFs is given in Table 1. The average percentage deviation of test data for surface roughness prediction using ANFIS for Ra was found to be 7.79% and prediction accuracy was found to be 92.2%. The predicted and experimental values are almost close, with deviations observed for higher and lower values of R_a.

R_t

For R_t, least training error of 0.052755 and prediction accuracy of 90.9% is obtained using 'gbell' membership function. The training error for other MFs is given in Table 2. The average percentage deviation of test data set used for the surface roughness prediction using ANFIS model for R_t was found to be 15.09% and prediction accuracy was found to be 84.9%. The deviation is more between experimental and predicted values in this case. The R^2 values and prediction accuracy on test data are shown in Table 3. A plot of experimental values versus predicted values for test data is shown in fig. 5.

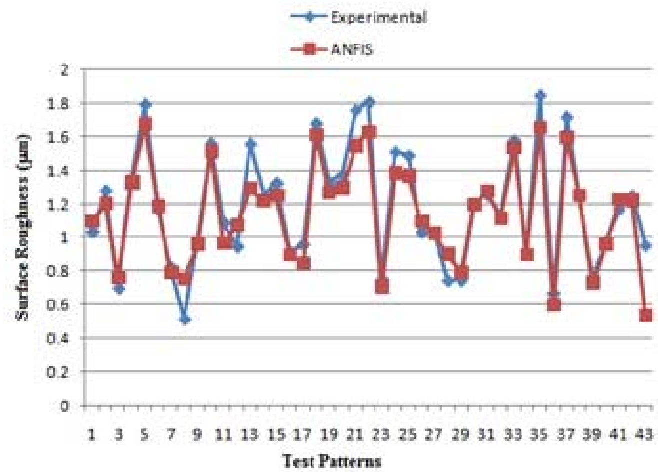
The prediction accuracy and R^2 values are lower for R_t than for R_a. The machining of titanium alloys generates lot of tool vibrations during cutting, which influences the surface roughness, particularly in terms of chatter. The effect of this chatter is more reflected in the R_t value than of $R_{a/}$

Conclusions

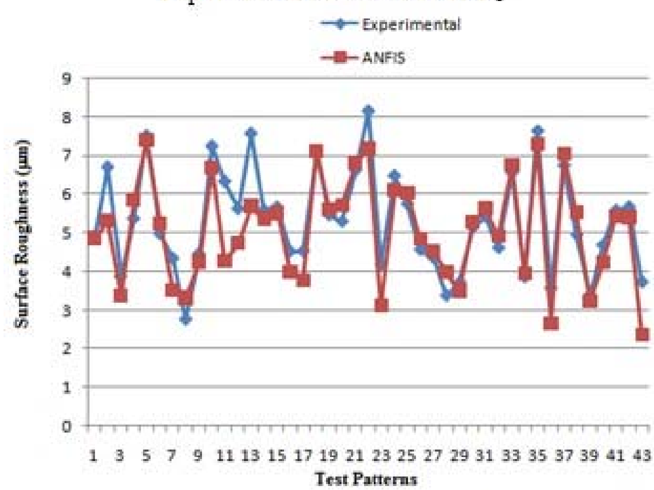
An adaptive neuro fuzzy inference system is used for predicting surface roughness during high speed turning operations on Ti-6Al-4V alloy. Five parameters namely feed, cutting speed, depth of cut, wear of tool and cutting tool vibrations have been used as the inputs and surface roughness parameters namely R_a and R_t are the outputs. Most of the modelling efforts make use of only R_a. There are very few efforts in modelling R_t. Two different models have been developed. The conclusions obtained from this study are as follows:

- The ANFIS model for test data, predicted the surface roughness with an accuracy of 92.2% for R_a and 84.9% for R_t. The modelling effort includes the use of parameters namely speed of cutting, feed rate and depth of cut and wear of tool and vibrations of cutting tool, which are uncontrollable parameters and are generally the ouputs of a machining process.
- The ANFIS model for R_a gives better performance than R_t, because the effect of cutting tool vibrations on R_t is more dominant than R_a. Also the values of R_t are greater than 1, which results in poorer performance of the model. A similar observation was made in [22].
- It is observed that ANFIS model gives better prediction accuracy for R_a when compared to R_t.

The accuracy of the model built can be further improvised by optimising the membership functions in ANFIS by using GA.



Experimental vs Predicted data for R_a



Experimental vs Predicted data for R_t

Fig. 5 Experimental *vs*. predicted data

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Surface Roughness Prediction in Machining Magnesium based AZ31 Alloy: A Comparison of Modelling Techniques

Abhijith S.[1], Srinivasa Pai P.[2] and Goutama Hebbar[3]

Abstract Magnesium alloys have been widely used in automobile, electronics and aerospace fields for its excellent properties such as low density, high strength to weight ratio and high stiffness. In this work, the milling of AZ31 Mg alloys has been conducted using uncoated carbide and PCD inserts in a CNC vertical machining centre. Cutting speed, feed rate and depth of cut are the cutting parameters which are taken into consideration. Surface roughness has been measured in terms of R_a(Average Surface Roughness). In this paper, surface roughness modelling techniques namely Response Surface Methodology (RSM)and Artificial Neural Network(ANN) has been used to predict surface roughness of biodegradable magnesium alloys by using uncoated carbide insert and PCD insert. RSM has been used to develop multiple regression models to predict surface roughness. ANOVA has been used to understand the importance of cutting process parameters on surface finish. ANN has also been used to develop prediction models using data obtained from both inserts. The results of surface roughness modelling techniques have been compared for both the inserts.

Keywords: Cutting Speed, Feed Rate, Depth of Cut, Surface Roughness, RSM, ANN

Introduction

AZ31 is a magnesium alloy used as a biomaterial which comprises 96% of magnesium, 3% of aluminum and 1% of zinc. Surfaces produced from machining process or other manufacturing operations, have a huge impact on the product performance and reliability. Liwei Lee et al (2016) performed high speed cutting machining of AZ31 Mg alloy and showed that the cutting parameters have an important effect on surface roughness. Roughness decreases with increase of cutting speed, while it rises with the increase of depth and feed rate [1]. Cosmin Constantin et al (2015) analysed surface roughness by varying the milling parameters of biomedical implants made from magnesium alloys. Face milling experiments under dry conditions were carried out on AZ61, a biodegradable alloy. ANOVA analysis of the data was carried out using the Design Expert software in order to understand the cutting parameters relevant for the roughness change. The obtained results showed that only the milling speed and feed rate have a significant role in obtaining the optimal surface roughness [2]. Ireneusz Zagorski *et al.* (2015) conducted end milling experiments on AZ91 and AZ31 alloys. They studied the variation of surface roughness with respect to cutting speed and feed with carbide tool and PCD cutting tool. The best surface improvement was achieved with PCD cutting edge and the worst for a coated solid carbide tool [3]. In any physical problem containing numerous variables, it is very important to find the relationship between input variables and the output. To achieve this numerous modelling techniques are available. This includes statistical techniques like RSM [4] and ANN [7]. RSM is a useful mathematical and statistical technique for modelling and analysis of problems in which dependent parameters are affected by several independent parameters to minimize the value of dependent parameters. A number of researchers have applied RSM for modelling and analysis of process parameters in manufacturing[4]. Ashvin J. Makadia *et al.* (2013) developed a mathematical model of surface roughness in terms of machining parameters for turning operations. The significance of these parameters on surface roughness was examined by using RSM. They concluded that feed rate is the significant factor which influences R_a[5]. Grynal D'Mello *et al.* (2013) investigated the influence of cutting parameters on two surface roughness parameters i.e R_a and R_t during high speed turning of

E-mail: [1]abhijith581@gmail.com, [2]srinivasapai@nitte.edu.in, [3]gouthamahebbar@nitte.edu.in

[1]M.Tech (Machine Design) Student, NMAM Institute of Technology, Nitte–574110, India

[2]Professor, Department of Mechanical Engineering, NMAM Institute of Technology, Nitte–574110, India

[3]Asst. Professor, Department of Mechanical Engineering, NMAM Institute of Technology, Nitte–574110

Ti-6Al–4V. The surface modelling was done using RSM. The experimental studies showed that surface roughness parameters R_a and R_t increases with increase in feed rate and cutting tool vibrations while increase in cutting speed and tool wear decreased the surface roughness[6]. Neural networks are widely used artificial intelligence techniques which are adopted for modelling different manufacturing operations because of its capability to learn complex non-linear and multivariable relationships between cutting parameters[7]. Hence Magnesium based alloys particularly biodegradable require good surface quality for performing their intended functions in the body. Some of the desirable characteristics include cutting speed, feed rate, depth of cut and surface roughness influences all of them. There have been limited efforts in investigating and comparing modeling techniques for modelling and predicting surface roughness during milling operation in Mg based alloys. In this study, Mg alloys are milled using uncoated carbide and PCD insert by varying the cutting speed, feed rate and depth of cut. There is a need to know effect of these parameters on the surface roughness. RSM and ANN are employed to model and predict R_a. Further the results from both the techniques are compared for both the inserts.

Experimental Details

Milling center: CNC milling center (BFW– BMW45T20) with a max spindle speed of 6000 rpm. Workpiece material, AZ31 in the form of block of length 120 mm and 60 mm width is used in dry face milling process. Uncoated carbide insert and PCD insert is used as cutting tool in cutter of dia-50 mm. The machining (milling) process of Mg alloys is conducted by taking cutting parameters into consideration such as Cutting speed, feed rate and depth of cut. R_a is measured using stylus type instrument (Taylor and Hobson, Talysurf). For 27 different combinations of cutting conditions. Surface roughness parameter considered is R_a(Average surface roughness value). Fig. 1 shows Taylor and Hobsun, Talysurf surface roughness measuring device.

Response Surface Methodology (RSM)

RSM is a combination of mathematical theory and statistical process which is useful for modelling and analysing problems in which a output is influenced by different parameters and the aim is to optimize this output. In this experiment, RSM has been used for modelling and analysing the surface roughness in terms of cutting conditions[5]. The mathematical relationship between input variables and R_a, which is the dependent output variable has been obtained in terms of a first order model of the form as represented in Eq.(1)

$$y=\beta_o+\beta_1 x_1+\beta_2 x_2+\ldots\ldots+\beta_k x_k +\in \quad (1)$$

where, y is the predicted output, x_i is the input variable that influences the output variable, β_o is the intercept,ϵ represents the error observed in the output[6]. The second order model is represented as in Eqn (2)

$$y=\beta_o+\sum^{k}_{i=1}\beta_i x_i+\beta_{ii}x_i^2+\sum_{i<j}\sum\beta_{ij}\, x_i\, x_{j} + \in \quad (2)$$

where, x_i represents the variables that correspond to the studied machining parameters[4]. The contributions and effect of cutting parameters on R_a(μm) have been studied. To further understand the effect of the interactions of the various input parameters, second order polynomial models have been developed. The regression analysis has been performed using Minitab17software [11].

Fig. 1 Talysurf surface roughness measuring device

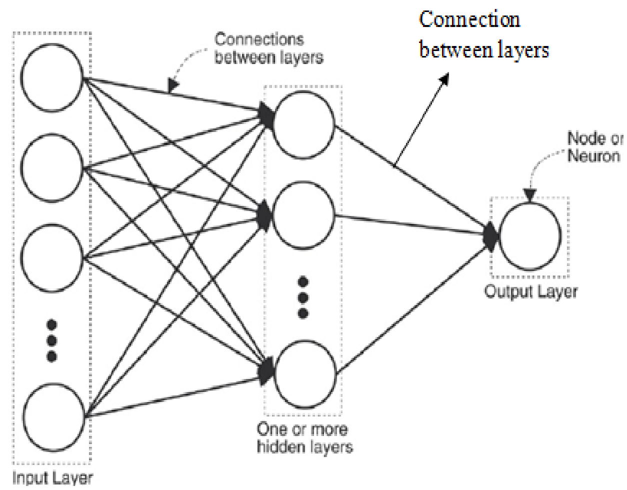

Fig. 2 MLP ANN architecture

Artificial Neural Network

It processes information in the way nervous systems, such as the brain, for optimized decision making. The fundamental processing element of ANN is an artificial neuron (simply a neuron) [8]. An ANN model basically consists of three layers: input layer, hidden layers and output layer. Input layer comprises of neurons through which data is fed and the number depends on the number of input parameters, hidden layers consists of some neurons for manipulation and the output layer gives required output. The neurons of the adjoining layers are interconnected through weighted links[9]. MLP neural network is a supervised neural network type which has been used to develop the model. The model development has been done using toolbox available in MATLAB2013a [12]. MLP is a feed forward multi layered neural network and is shown in Fig. 2. By altering the values of the connections between neurons, it is possible to train the neural network to perform the required function. Hidden layer and the output layer processes the information[10]. The mean squared error (MSE) will be calculated between the predicted output and the desired output and the expression is given by eqn (3)

$$MSE = \frac{\begin{pmatrix} Predicted\ value- \\ Experimental\ value \end{pmatrix}^2}{2} \quad (3)$$

Prediction Model Development

Model 1: RSM Modelling for PCD insert

In order to evaluate the result of milling process, the experimental data were used to develop the mathematical model. The quadratic model was developed using the input and output parameters. The quadratic model developed for R_a for PCD insert is represented as:

R_a=-0.014+0.00019*(V_c)+3.731*(f)-0.213*(d)+1.87*$(f)^2$-0.0099*$(d)^2$-0.000789*(V_c*f)+0.000057*(V_c*d)-0.056*(f*d)

Model 2: RSM Modelling for Uncoated carbide insert

The quadratic model developed for R_a using Uncoated carbide insert is represented as:

R_a=0.545-0.00077*(V_c)+1.372*(f)-1.028*(d)+0.28$(V_c)^2$+1.562*$(d)^2$-0.000578*(V_c*f)+0.000583*(V_c*d)-1.176*(f*d)

Model 3: *Model 4*: ANN Modelling using data from PCD and Uncoated carbide insert

Experimental data obtained from PCD and Uncoated carbide inserts have been used to develop ANN models for predicting R_a The hidden neurons have been varied from 5–25[18]. MSE of 0.001has been taken as the desired goal and the network is trained until the target is reached and the learning rate of 0.01 has been set. The total number of data is 27. Out of these 23 data have been used for training the network and remaining 4 data have been used as test data and the prediction accuracy of the network has been calculated. In the present work, tansig and logsig transfer functions have been used in the hidden neurons and network is trained using various training algorithms.

Results and Discussions

RSM Analysis

In order to determine the results from milling the experimental data were taken to develop the mathematical models. In this work, a commercially available software (MINITAB14) was used for the computation process[11]. The quadratic model was developed using RSM method. The quadratic model produced the highest R^2 value, i.e. Correlation coefficient of 0.9481 for uncoated carbide insert and prediction accuracy obtained is 82.6%. For PCD inserts, the highest R^2 value obtained is 0.9422 and prediction accuracy is 79.16%. ANOVA is used to evaluate the experimental data and identifying the factors which have a significant influence on the output variables i.e. surface roughness[6]. This analysis has been performed for 95% confidence level. The *p* value less than 0.05 indicate that the surface roughness model is significant. The p values or probability values show the significance level of each factor. Lower p values shows that the factor has higher probability of falling within the ranges which impact the output of the experiment. Table1 shows the ANOVA results for PCD insert, Cutting speed and Feed rate are the most significant parameters and depth of cut has no significance. Table 2 shows the ANOVA results for Uncoated carbide insert which also indicates that depth of cut is the least significant factor and Cutting speed and feed rate are most significant parameters. Using RSM modelling, the predicted values of R_a are found. Fig. 2 and Fig. 3 shows the plot of predicted and experimental values obtained using PCD and Uncoated carbide inserts.

Table 1: ANOVA analysis by RSM for PCD insert

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	0.022160	0.002462	23.56	0.000
Linear	3	0.014976	0.004992	47.76	0.000
Cutting Speed	1	0.004717	0.004717	45.12	0.000
Feed rate	1	0.011264	0.011264	107.76	0.000
Depth of cut	1	0.000000	0.000000	0.00	0.951
Square	3	0.000108	0.000036	0.34	0.794
Cutting Speed*Cutting Speed	1	0.000001	0.000001	0.01	0.939
Feed rate*Feed rate	1	0.000103	0.000103	0.98	0.340
Depth of cut*Depth of cut	1	0.000005	0.000005	0.04	0.838
2-Way Interaction	3	0.004236	0.001412	13.51	0.000
Cutting Speed*Feed rate	1	0.004138	0.004138	39.59	0.000
Cutting Speed*Depth of cut	1	0.000097	0.000097	0.93	0.352
Feed rate*Depth of cut	1	0.000001	0.000001	0.01	0.930
Error	13	0.001359	0.000105		
Total	22	0.023519			

Table 2 ANOVA analysis by RSM for Uncoated carbide insert

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	0.033348	0.003705	26.39	0.000
Linear	3	0.030276	0.010092	71.87	0.000
Cutting speed	1	0.003278	0.003278	23.35	0.000
Feed	1	0.019577	0.019577	139.42	0.000
DOC	1	0.000003	0.000003	0.02	0.629
Square	3	0.001172	0.000391	2.78	0.813
Cutting speed*Cutting speed	1	0.000020	0.000020	0.14	0.896
Feed*Feed	1	0.000002	0.000002	0.02	0.696
DOC*DOC	1	0.000005	0.000005	0.05	0.868
2-Way Interaction	3	0.000636	0.000212	1.51	0.000
Cutting speed*Feed	1	0.000051	0.000051	0.36	0.000
Cutting speed*DOC	1	0.000164	0.000164	1.17	0.300
Feed*DOC	1	0.000313	0.000313	2.23	0.490
Error	13	0.001825	0.000140		
Total	22	0.035173			

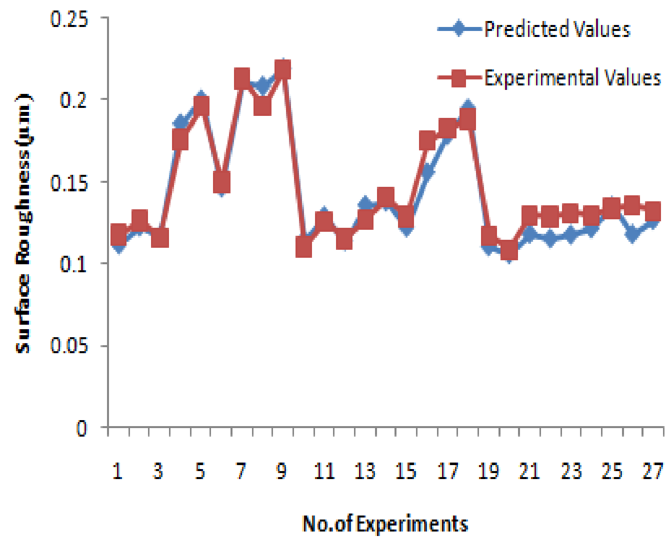

Fig. 3 Predicted and experimental values obtained by PCD inserts

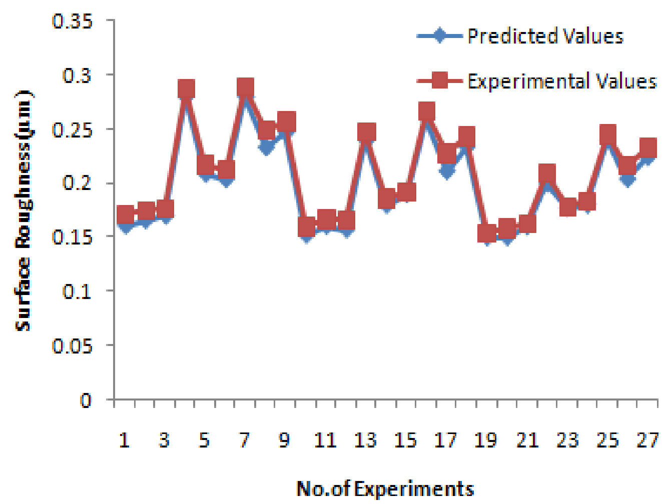

Fig. 4 Predicted and experimental values obtained by uncoated carbide inserts

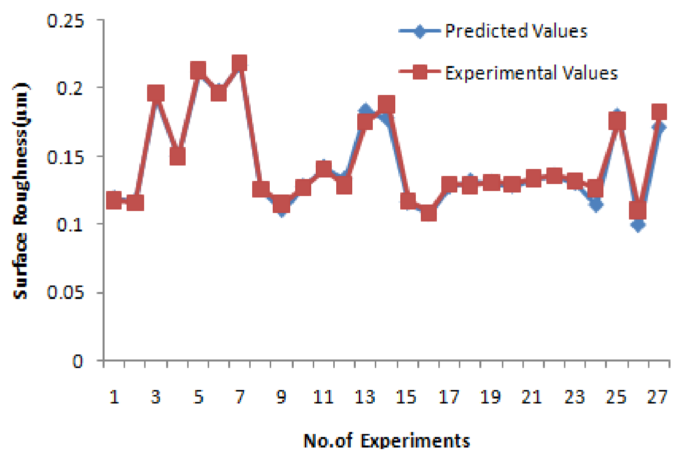

Fig. 5 Predicted and experimental values of Ra obtained using PCD insert

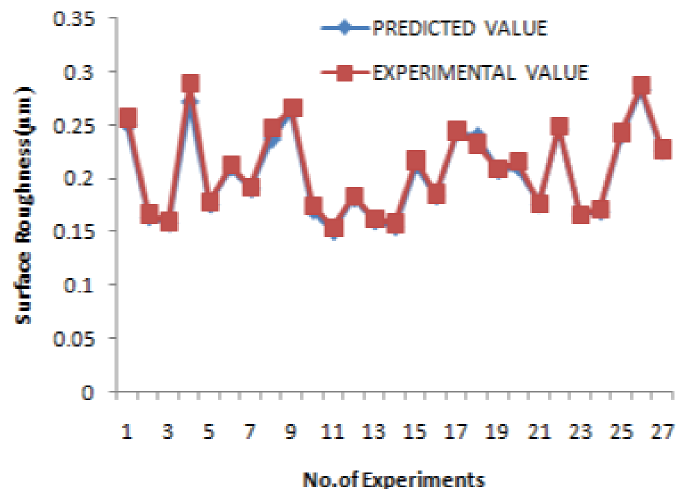

Fig. 5 Predicted and experimental values of Ra obtained using uncoated carbide inserts

Table 3 MLP performance comparison for R_a (uncoated carbide insert)

Transfer Function	Training Algorithm	Epochs Reached	MSE	Hidden Neurons	Training Data	Test Data
					Prediction Accuracy %	**Prediction Accuracy %**
tansig	trainlm	14	0.000634	16	100	75
	trainbfg	21	0.000312	12	95.8	75
	traincgf	30	0.000456	15	95.8	75
	trainscg	30	0.000578	15	95.8	75

Table 4 MLP performance comparison for Ra (PCD insert)

Transfer Function	Training Algorithm	Epochs Reached	MSE	Hidden Neurons	Training Data	Test Data
					Prediction Accuracy%	**Prediction Accuracy%**
tansig	trainlm	11	0.000965	13	100	75
	trainbfg	18	0.000726	18	95.8	75
	traincgf	28	0.000625	17	95.8	75
	trainscg	30	0.000913	16	95.8	75

Table 5 Comparison of modeling techniques

Insert Used	Modelling Techniques	R2	R2	Prediction Accuracy (%)	
		Training Data	**Test Data**	**Training Data**	**Test Data**
PCD	RSM	94.22	90.1	78.2	75
	ANN	96.32	94.9	100	75
Uncoated Carbide	RSM	94.8	91.6	82.6	75
	ANN	97.9	95.7	100	75

Artificial Neural Network based Modelling

Initially the ANN model performance is evaluated considering tansig as a transfer function and with various training algorithms which are given in Table 3. From the table, it is evident that the best prediction accuracy is obtained for 13 hidden neurons, with trainlm as training algorithm with 100%prediction accuracy on training data and 75% for test data. By taking logsig as a transfer function and with various training algorithms it showed that best prediction accuracy is obtained for 14 hidden neurons, with trainlm as training algorithm with 95.8% prediction accuracy on training data and 75% with test data. It can be concluded that tansig as transfer function and trainlm as training algorithm gives best prediction accuracy for PCD insert. The ANN model performance is evaluated taking tansig as a transfer function and training algorithms which is illustrated in Table 4. From Table, it indicates that the best prediction accuracy obtained is taking 16 hidden neurons, tansig as transfer function, trainlm as training algorithm with 100% prediction accuracy for training data and 75% for test data. By considering logsig as a transfer function and with various training algorithms the best prediction accuracy obtained with taking 17 hidden neurons, trainlm as training algorithm with 95.8% prediction accuracy on training data and 75% with test data. It can be concluded that tansig as transfer function and trainlm as training algorithm gives best prediction accuracy for Uncoated carbide insert based data. Fig. 4 and Fig. 5 shows the predicted values and experimental values obtained for PCD and Uncoated carbide insert for 27 experiments respectively.

Comparison of Modelling Techniques

The prediction accuracies of RSM and ANN modelling techniques for both inserts are compared.

PCD Insert

From Table 5, For Model 1 using RSM modelling the R^2 value obtained for training data is 94.22% and for test data the R^2value obtained is 90.1% and the corresponding prediction accuracy for training data and test data obtained is 78.2% and 75% respectively.

For MLP, the R^2 value obtained for training data is 96.32% and for test data it is 94.9% and the corresponding prediction accuracy obtained are 100% and 75% respectively. The comparison suggests that ANN model gives better results, when compared to RSM modelling.

Uncoated Carbide Insert

From Table 5, Using RSM modelling the R^2 value obtained for training data is 94.8% and for test data it is 91.6% and the corresponding prediction accuracies are 82.6% and 75% respectively.

For MLP, the R^2 value obtained for training data is 97.9% and for test data it is 95.7% and the corresponding prediction accuracies are 100% and 75% respectively. The comparison of modelling techniques indicates that the ANN is better in modelling surface roughness than RSM.

Conclusion

Key findings of the experimental, statistical and surface modelling studies are as follows:

1. PCD insert is a better option while machining AZ 31 Mg alloy, as it results in lower surface roughness values when compared to uncoated carbide insert.
2. From experimental results and discussions using uncoated carbide insert and PCD insert, it can be concluded that R_a decreases with rise in cutting speed and it increases with rise in feed rate. This study has demonstrated that cutting speed and feed rate have significant effects on R_a. Depth of cut has no significant role on surface roughness quality.
3. From the RSM analysis and ANOVA results, it shows that feed rate and cutting speed are the main influential factor on the roughness. Depth of cut has no significant effect on R_a.
4. The present study focused on prediction of surface roughness produced using uncoated carbide insert and PCD inserts using MLP models. The following observations can be made from the study:
   i. MLP can be implemented successfully to predict the surface roughness parameter R_a for machined surface produced using uncoated carbide and PCD insert.
   ii. tansig transfer function provides higher prediction accuracy for both inserts when compared to logsig transfer function.
   iii. ANN based modelling was found to be more efficient in developing prediction models for surface roughness compared to RSM modelling.

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TQM–Integrated Process Approach for Continuous Improvement of Projects in Engineering

S. Balamurugan[1]

Abstract This paper examines the important features of Total quality Management and its relative importance and its impact on manufacturing .TQM variables are identified for effective implementation with example. There has been particular interest of quality in manufacturing to avoid delays and save time. By the use of various types of quality tools, production becomes simple and if implemented will satisfy the needs of the industry to achieve its objectives. In this paper TQM is explained and integrated methodology is developed for better project assessment. Due to increased competition, the Indian industry has started to adapt the Total quality management to improve the quality of their products. It is embedded in each unit of the work system (technology and people), thus problem–solving and decision making skills changes and allows people to take corrective action, in order to deliver a product or service to satisfy the needs of the customer. It is the time for industries to concentrate on customer satisfaction with a focus on understanding customer needs and expectations. It also analyses the present situation in industry and presents a suitable model that can be incorporated for industries.

Keywords: TQM, Bench marking, QFD,

Introduction

Technological Innovations, globalization, Stiff competition - both National and International have shift sellers market to Buyers Market. Thus there is a greater awareness among the customers, about Quality. Quality is whatever a customer wants the product to be. It is the degree of goodness of a product or Service as perceived by the customer. So Quality is critical in achieving competitiveness in domestic and global market and quality is prerequisite to have satisfied customers. TQM means that the organizations culture is defined by and supports the constant attainment of customer satisfaction through an integrated System of tools, techniques and training. The Philosophy of Management is customer-oriented. TQM incorporates the concept of product quality, process Control, quality assurance and quality improvement. It is the control of all transformation processes of an organization to better satisfy customer needs in the most economical way. It allows people who do the work to both measure and take corrective action in order to deliver a product or service that meets the needs of their customer.

TQM (Total Quality Management)

It is a philosophy that is designed to make an organization faster, flexible, focused and friendly. It leads to a structured system that focuses each employee on the customer. It creates an environment that allows organization–wide participation in planning and implementing a continuous improvement process to meet customer needs.

TQM emphasizes continuous improvement through the development of new managerial philosophy and practices that should permeate every aspect of a product's life cycle.

TQM means 'Total' every person in the firm is involved; 'Quality' customer requirements are met exactly; 'Management' senior executives are fully committed.

The Eight Elements of TQM

An Organization must concentrate on the eight elements for successful implementation of TQM

1. Ethics
2. Integrity
3. Trust
4. Training
5. Teamwork
6. Leadership
7. Communication
8. Recognition

TQM is built on a foundation of ethics, integrity and trust. The Bricks for the building are Training, Teamwork and Leadership. The binding mortar is communication. The

[1]Academic Counsellor, Indira Gandhi National Open University, New Delhi

roof of the building includes recognition. Now we will see each one in detail.

1. Ethics: Ethics is the discipline concerned with good and bad in any situation. It can be organizational and individual ethics. Organizational ethics establish a business code of ethics that outlines guidelines that all employees are to adhere to in the performance of their work. Individual ethics include personal rights or wrongs.
2. Integrity: It implies honesty, morals, values, fairness and adherence to the facts and sincerity. It depends on customer expectations and deserves to receive.
3. Trust: It builds the co-operative environment essential for TQM. Trust is a by product of integrity and ethical conduct. The frame work of TQM is built on trust. It encourages full participation of all members and commitment.
4. Training: TQM teaches employees of the company how to be effective in the processes. Training is very important for employees to be highly productive. It includes problem solving, decision making, job management, performance analysis, inter-personal skills. Supervisors are solely responsible for implementing TQM within their departments and teaching their employees the philosophies of TQM.
5. Team work: It fosters unity and integrity among the workers. It enables to receive quicker and better solutions to problems. It mainly consist of three types of teams a, Quality improvement teams b, problem solving teams c, Natural work teams.
6. Leadership: Managers are required to provide an inspiring vision, make strategic directions that are understood by all and to install values that guide subordinates. The supervisor is responsible for strategies, philosophies values and goals are transmitted down throughout the organization to provide focus, clarity and direction. It must appear everywhere in organization.
7. Communication: It means a common understanding of ideas between the sender and receiver Supervisors must keep open ways so that employees can send and receive information about the TQM process. The communication must be creditable and the message must be clear and receiver must interpret in the way the sender intended.
8. Recognition: It is the last and final element in the entire system. It brings changes in self–esteem, productivity, quality and the amount of effort on the job.

TQM changes the organizational structure as more flexible and less hierarchical. There is continuous improvement in Systems and processes. It changes the concept and supervisors as coaches and facilitators, managers as leaders. The decisions are taken based on facts and systems.

The Success factors for TQM implementation in the Indian organizations as 1, Organizational commitment 2, human resources management 3, Supplier integration 4, Quality policy 5, Role of Quality department 6, Quality Information Systems 7, technology utilization 8, operating procedures 9, Training.

Quality and productivity have similar roots. Both rely on reduction of disruptions and rework, improvement to work processes and well trained workforce. They reflect how workers feel about their jobs and positively related. Another factor, team work as collaboration between managers and subordinates between functions and between customers and suppliers is another TQM principle. Here, in TQM, how to integrate Quality strategy with corporate strategy to improve Quality along with productivity.

Quality tools: 1. 5s activities 2. Pareto diagram 3. Bench marking 4. TPM (total productive maintenance) 5. Why Why analysis 6. Control charts 7. Kaizen activities 8. Scatter plot 9. SPC 10. PERT / CPM 11.PDCA circle (plan, do, check, act) 12. Six Sigma, 13. Suggestion Scheme 14. Run chart 15. Brain Storming 16. QED (Quality Function deployment) 17. FEMA (Failure mode Effect Analysis) 18. Histogram.

Quality

- Quality is getting people to do better all the worthwhile things they ought to be doing anyway
- Fitness for purpose
- Quality is meeting customer needs
- The totality of features and characteristics of a product and service which bear on its ability to satisfy stated or implied needs.

Total Quality management is an effective system for integrating the quality development, Quality maintenance and Quality improvement efforts of various groups in an organization so as to enable production and service at the most economical level which allows for full customer satisfaction.

Customer relationship management (CRM) attempts to integrate the many communication channels between an organization's units and its customers, record information about customer preferences. It is to use the information to develop and strengthen the relationship and the profitability of the customer.

TQM Variable for Effective Implementation Enablers

1. Leadership
2. Strategic planning
3. Information management

4. Human resource focus
5. Customer and market focus
6. Supplier focus
7. Process management

Results

1. Impact Society
2. Human resource Satisfaction
3. customer satisfaction
4. Supplier Satisfaction
5. Company Specific business results

In the organization, the managers are to provide clear vision and values that build culture. They remove cross–departmental barriers and act as facilitator by encouraging participation, involvement and development of employees. Strategic planning means identify long-term goals and objectives for the organization, that is communicated within the organization. For this purpose, they consider customer and market expectations. They identify timely and accurate information for effective control by taking timely proactive actions. The suppliers are treated as partners in the process of improvement. Supplier training and development, Supplier rating system are part of organization activities.

Implementation of TQM requires commitment and a clear understanding of TQM goals. A growing number of Indian industries are coming to understand positive impact that the implementing TQM can bring a efficient and cost effective quality system. TQM is for business excellence. It provides significant improvement in business results and scopes for project them in the market.

A Study is Conducted in Manufacturing Industries in India with the Following Objectives

1. Conduct diagnostic study on the areas of improvement because of TQM implementation
2. prepare a report about the application of various TQM techniques
3. Audit report of TQM

The methodology is employed from collection of primary data of 150 industries and analyzing using a selective Quality tools.

Diagnostic Study

The areas where TQM techniques and Quality tools are identified. First it is started with customer satisfaction, (what do customers want?) using the index of customer perception of Quality. Secondly, customer complaints, a. dealing with complaints, b. benefits of satisfying customer complaints, thirdly, measuring service quality and customer satisfaction. To measure service Quality, gap model can be employed.(parasuraman et al)

Gap 1: Consumer expectations–management perceptions of consumer expectations.

Gap 2: Management perceptions of consumer expectations–service quality specifications actually set.

Gap 3: Service quality specifications–actual service delivery.

Gap 4: actual service delivery–external communication about the service.

Gap 5: Gap 1-4 together contribute to consumer's expectations and perceptions of actual service.

Application and Implementation

In the second stage, training program was conducted for employees including supervisors.

1. *Seven tools of Quality:* Flow charts, Run charts, Pareto charts, cause and effect diagrams, Histograms, control charts, Fishbone diagram.
2. *Six Sigma: At its core, six sigma revolves around a few key concepts Critical to Quality:* Attributes most important to customer
   Defect: Failing to deliver what the customer wants
   Process capability: What your process can deliver?
   Variation: What the customer sees and feels?
   Stable operation: Ensuring consistent, predictable processes to improve what the customer sees and feels?
   Design for six sigma: Designing processes to meet customer needs and process capability.
3. Bench marking: It is the process of identifying, understanding and adapting outstanding practices from organizations anywhere in the world to help your organization improve its performance.
4. QFD–quality function deployment. It can contribute continuous cross functional. Participation from start to finish and generate consensus decisions about trade off. The QFD process helps managers in each function or department to 1. Understand what the external customer values 2. Understand their contribution of the systems and processes that provide the value. This understanding provides a basis for cross functional team work and participation.
5. Total productive Maintenance (TPM) is a maintenance programme which involves a newly defined concept for maintenance of plants and equipment. The goal of TPM programme is to markedly increase value added production, achieve world class quality standards and minimum cost of production, and ensure optimum delivery schedule and safety & environment protection while at the same time increase employee morale and job satisfaction.

Auditing for Efficiency

Quality audit is done for the above techniques by inspecting the units after that results are obtained as follows

a. Productivity improvement by 10%
b. Total cost saving per month is improved
c. Machine opportunity cost savings per month increased
d. Down time reduced
e. Scrap reduction cost savings per month is doubled
f. It reduces the operator fatigue and boosts employee morale
g. It reduces man power cost considerably
h. It reduces the machine stoppage due to frequent disruptions and hence improves productivity.

Conclusion

TQM may be the only thing that stands between success and total failure for some companies. Employees must be educated about its benefits and the management has to be totally committed to the programme. So TQM is sustainable and successful in engineering Industries, which will not only enhance competitiveness but also increase savings, productivity and time. It is the measure of technical efficiency of the Industries.

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Waste Heat Utilization in Hot Food Storage Vessel by Usage of Phase Changing Materials

A. Aadhitya[1], M. Sivaprakash[2], V. Vignesh[3] K. Gurushankar[4] and J. Sarathkumar Sebastin[5]

Abstract Hot food in the storage vessel loses it's hotness with respect to time. To utilize the heat of the food better, and to improve the way of maintaining the food temperature, we used the heat absorbing phase changing material (i.e. Paraffin Wax). Paraffin wax will absorb heat and changes it's state from solid to liquid and vice versa. A phase changing material (PCM) is a substance with a high heat of fusion in which melting and solidifying at a certain temperature, is capable of storing and releasing large amount of energy. The proposed concept of hot food storage is cheap and effective. This application can be used in hotels, homes and where there is a need to keep food warm.

Keywords: Hot food storage, Paraffin wax, Phase changing materials, Thermal conductivity.

Introduction

In general people prefer to have hot food in hotels or at home. Once it is served, it's hotness is reduced because of the outside temperature. Outside temperature is less than the temperature of food serving vessel temperature. Therefore, the heat loss is quick and maximum. However, we use hot boxes to reduce the heat loss but it is less efficient to reduce the heat loss of the food for a longer time and it should be kept closed to retain the heat.

In order to address this problem and improve the efficiency of hot box, we thought of phase changing material in which heat is absorbed or released when the material changes it form [1].

In our study we utilized a phase changing material (PCM), which is capable of storing and releasing large amount of energy. Since the thermodynamic properties of the phase changing materials are favor for this particular application, it should be efficient and effective also cost effective one for waste heat utilization and hot food storage.

Phase Changing Materials (PCM)

A phase changing material (PCM) is a substance with a high heat of fusion in which melting and solidifying at a certain temperature, is capable of storage, and releasing large amount of energy. Latent Heat is thermal energy released or absorbed by a body or a thermodynamic system during a constant temperature process- usually a first-order phase transition. Thus, PCM is a major source to act as latent heat storage units. Figure 1 describes the nature of PCM. As seen from figure 1, A represents the Heat Absorption, B represents the Heat Storage and C represents the Heat Release. We can easily understand the properties such as absorption, storage and release, respectively. In Addition, It should have special thermodynamic and other following properties:

- High latent heat of fusion per unit volume
- Melting temperature in the desired operating temperature range
- High specific heat, high density and high thermal conductivity
- Chemical stability
- Complete reversible freeze/melt cycle

E-mail: [1]ayyappanaadhitiya6053@gmail.com, [2]sivap0890@gmail.com, [3]vickykalam99@gmail.com, [4]kgurumsc@yahoo.com and [5]sebastinaero@gmail.com

[1]Department of Mechanical Engineering, Kalasalingam University, Kalasalingam Academy of Research and Education, Anand Nagar, Krishnankoil–626126, Tamil Nadu, India

[2]Department of Mechanical Engineering, Kalasalingam University, Kalasalingam Academy of Research and Education, Anand Nagar, Krishnankoil–626126, Tamil Nadu, India

[3]Department of Mechanical Engineering, Kalasalingam University, Kalasalingam Academy of Research and Education, Anand Nagar, Krishnankoil–626126, Tamil Nadu, India

[4]Department of Physics, Kalasalingam University, Kalasalingam Academy of Research and Education, Anand Nagar, Krishnankoil–626126, Tamil Nadu, India

[5]Department of Aeronautical, Kalasalingam University, Kalasalingam Academy of Research and Education, Anand Nagar, Krishnankoil–626126, Tamil Nadu, India

- Non-corrosiveness, non-toxic, non-flammable and non-explosive materials
- Low cost
- Availability
- Retain it's property and do not loss it's efficiency till the entire life cycle of the product.

Paraffin Wax (PCM)

We identified a suitable PCM with above properties as Paraffin wax. Paraffin wax is a white colorless of solid derivable from petroleum, coal or oil shale that consists of a mixture of hydrocarbon molecules containing between 20 and 50 carbon atoms. It's melting point is 46-68.c and density is 900kg/m3. It is insoluble in water, but soluble in ether, benzene and certain esters. It's heat of combustion is 42kJ/g. Wax expands considerably when it melts and this allows it's use in wax element thermostats for industrial, domestic, and particular automobile purposes. Figure 2 represents the chemical structure of paraffin wax.

Methodology

The proposed work consists of the following components. These are Paraffin wax, hot food storage vessel, thermal casing, food sample, thermometer and stop watch.

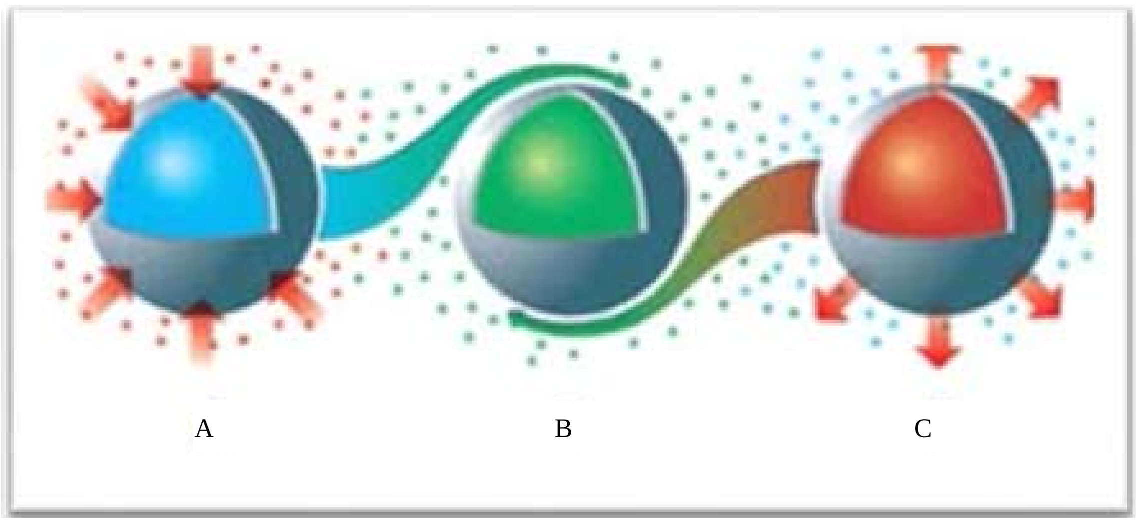


Fig. 1 Property of PCM

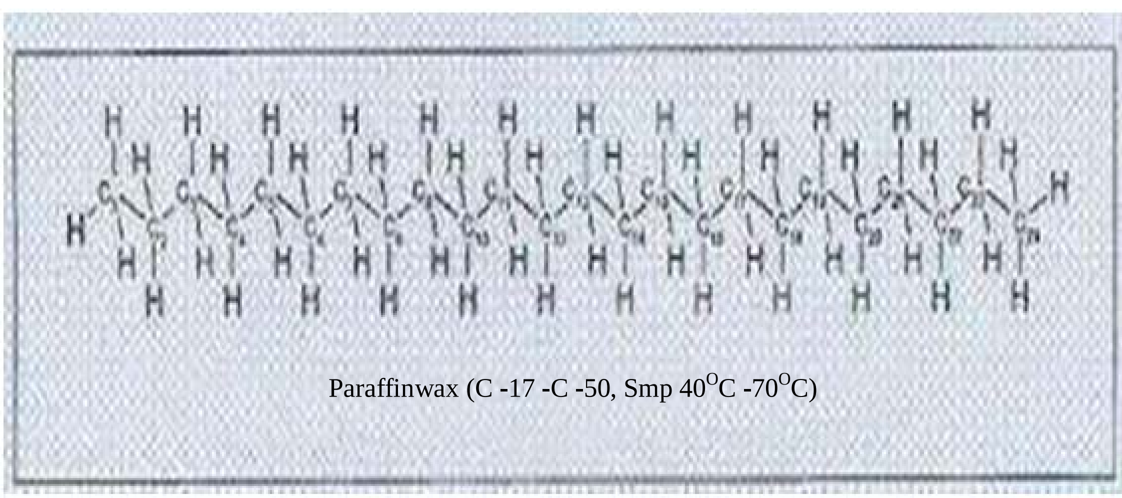


Fig. 2 Chemical structure of paraffin wax

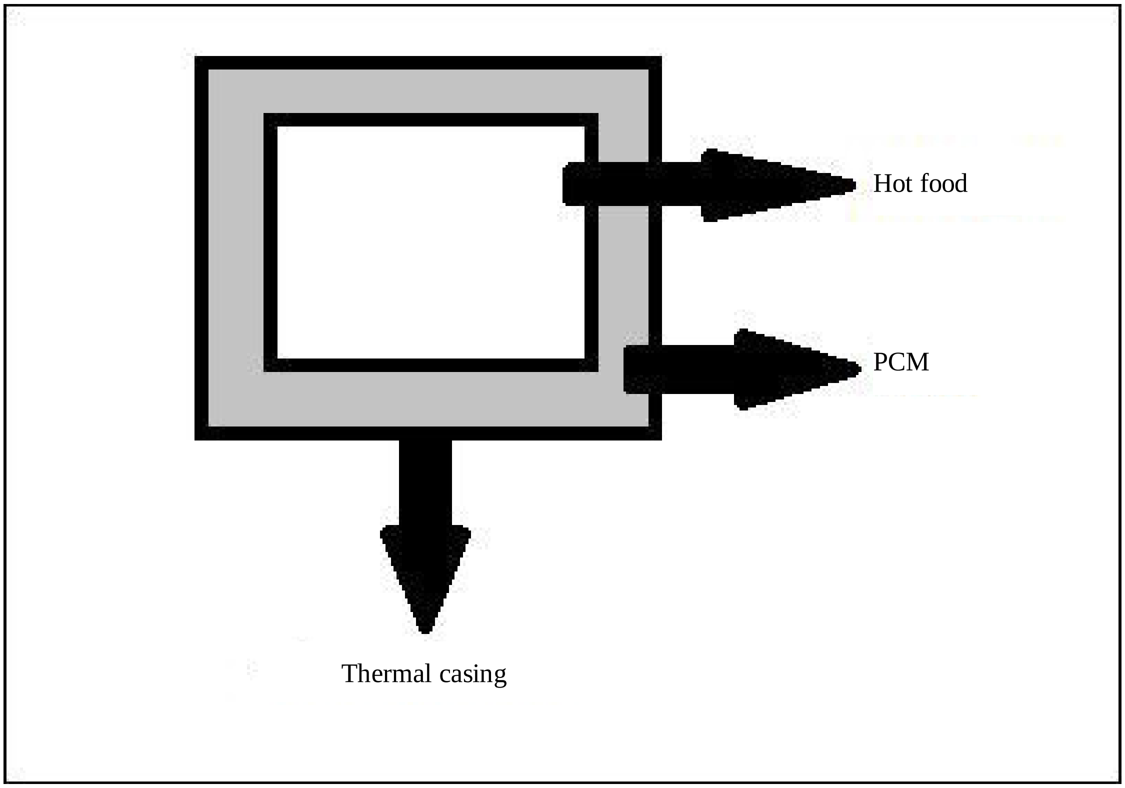


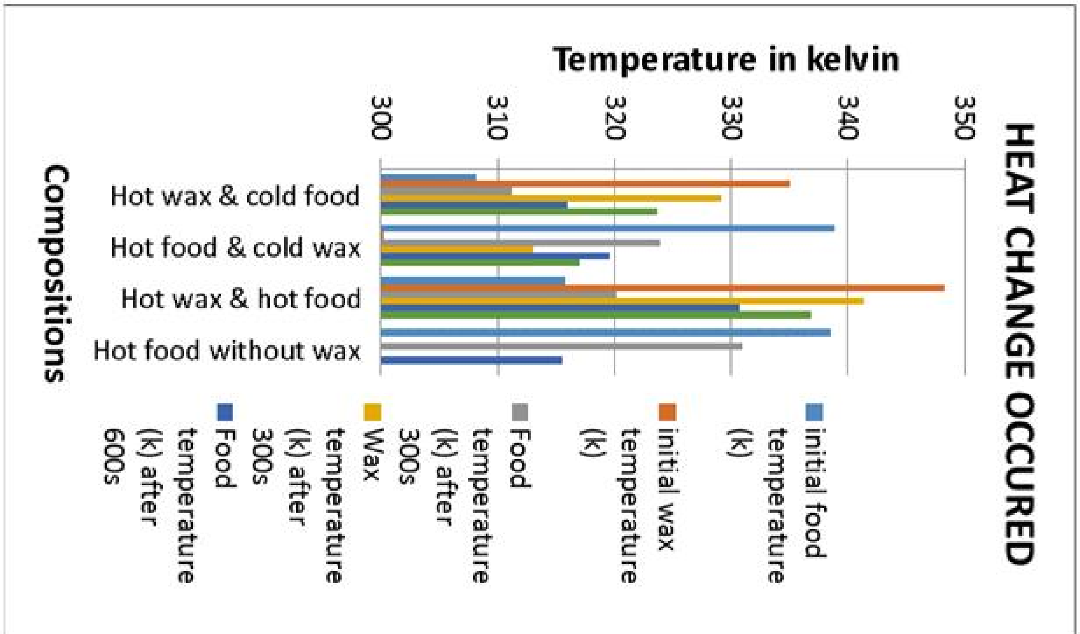
Fig. 3 Schematic diagram of Experiment on paraffin wax and hot food storage vessel

Table 1 An experiment on paraffin wax and hot food storage vessel

Combination	Time	Food Temperature	Wax Temperature
Hot wax & Cold food	0 s	308.2 K	335 K
	300 s	311.3 K	329.1 K
	600 s	316 K	323.7 K
Hot food & Cold wax	0 s	338.9 K	300.3 K
	300 s	323.9 K	313.1 K
	600 s	319.6 K	317 K
Hot wax & Hot food	0 s	315.8 K	348.3 K
	300 s	320.2 K	341.4 K
	600 s	330.7 K	336.8 K
Hot food without wax	0 s	338.5 K	Not Applicable
	300 s	330.9 K	Not Applicable
	600 s	315.5 K	Not Applicable

The above schematic diagram represents the working of hot food storage vessels in the proposed work. In the experiment we used a thermal casing to prevent the heat loss of PCM.

It is essential to prevent the heat loss of PCM so that it provides the heat only back to the food. When hot food is placed in the container which placed inside the PCM, the PCM absorb the heat from the food, by utilizing the absorbed heat and in away of storing the energy PCM changes from solid to liquid form. After some time once the food temperature drops below the PCMs then the PCM supply the absorbed heat back to the food and gets cool down. The cycle gets repeated again and again till the temperature is being equalized to room temperature. But which takes large period of time to equalize the temperature. Experimental readings are given in the table 1. The readings in the table are graphically represented in the graph1.



Graph 1 Represents the variation of temperature in different situations

We absorbed from the experiment that, wax absorbed the food temperature and melted. Similarly, the food absorbed the heat from the melted wax. So we can maintain the food temperature longer by adding wax material.

Conclusion

The effectiveness of adding phase changing material is that, it acts as thermal storage and it will be useful in many of the industrial and social applications. Since we have used paraffin wax, it is cheap, available, and effective method for waste heat utilization in hot food storage vessels. The present technology or method to keep the food warm is hot box. But the difference of our hot food storing vessel is:-

Hot box is of high cost when compared to hot food storing vessel.

Hot box should be kept closed to maintain the temperature and keeping it close results in water precipitation inside the hot box which lead to change in the taste of food proves difficult to maintain the quality of the food but our hot food storing vessel can be kept open and have less chance of water precipitation, will not have any change in taste and quality.

Hot box hold heat keep the food warm for a short period only but hot food storing vessel has a very long period of holding heat because of it's thermal property. PCM will not have any effect in this regard as days goes by.

So we conclude that the experiment is useful, effective and efficient in many aspects so that the society will be benefitted in many ways.

Acknowledgement

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Zero Defect Zero Effect (ZED) Model in Chennai Automotive Industry

E. Bhaskaran

Abstract The Micro, Small and Medium Enterprises (MSMEs) of India, should manufacture goods in the country with "zero defects" and to ensure that the goods have "zero effect" on the environment. The objective is to study on ZED Discipline Enabler for Process Quality, Resource Management and Outsourced Activity (Zero Defect) and to study on ZED Discipline Enabler for Emission, Effluent & Waste Disposal Activities for Automotive Components Manufacturing Industry at Chennai (Zero Effect). The Outcome Parameters for Quality, Process, Environmental and Company Performance are also studied and ZED Maturity Assessment Model for Automotive Components Manufacturing Industry at Chennai is developed. To conclude ZED rating for Automotive Components Manufacturing Industry at Chennai is Diamond one i.e., Achiever (Level 4) and the Industry has to achieve upto Platinum Level i.e., World Class (Level 5) to compete in the International Market.

Keywords: ZED Model, Automotive Industry.

Introduction

"Let's think about making product which has 'zero defect' and 'zero effect' so that the manufacturing does not have an adverse effect on our environment". The Micro, Small and Medium Enterprises (MSMEs) of India, should manufacture goods in the country with "zero defects" and to ensure that the goods have "zero effect" on the environment.

Zero Defect (Focus on Customer)

- Zero non-conformance/non-compliance
- Zero waste

Zero Effect (Focus on Society)

- Zero air pollution/liquid discharge (ZLD)/ solid waste
- Zero wastage of natural resources

Ecosystem

The ecosystem of ZED as shown in fig.1 has dynamic systems & processes working in synergy with specific roles to play in the foreseeable future. The sector specific models are aligned with all 25 sectors under the Make in India initiative, to begin with. The Rating & Certification on the maturity assessment model is valid for a specified time period within which system of surveillance is inbuilt in the model.

Benefit to MSMEs

- Easy access to Loans
- Credible & reliable vendor database
- Reducing negative effect on our environment
- Awards & Rewards
- Aligning with best practices
- Global Competitiveness
- Visibility & brand recognition

Rating In order to prepare the MSMEs to create a value chain for the new regime, it is important that quality and competitiveness of Indian MSME is enhanced over a period of time. It will also provide an opportunity to units to strive to continuously improve its processes thereby aiming to move up the maturity assessment model (Bronze-Silver-Gold-Diamond-Platinum). The Rating is a weightage average of the marks obtained on each parameter. The rating provided will be valid for a period of 4 years. Surveillance audit will be carried out by QCI.

E-mail: [1]e.bhaskaran19@bsnl.in

[1]Deputy Director of Industries and Commerce, Department of Industries and Commerce, Government of Tamil Nadu, Guindy, Chennai, India

Fig. 1 Ecosystem for ZED

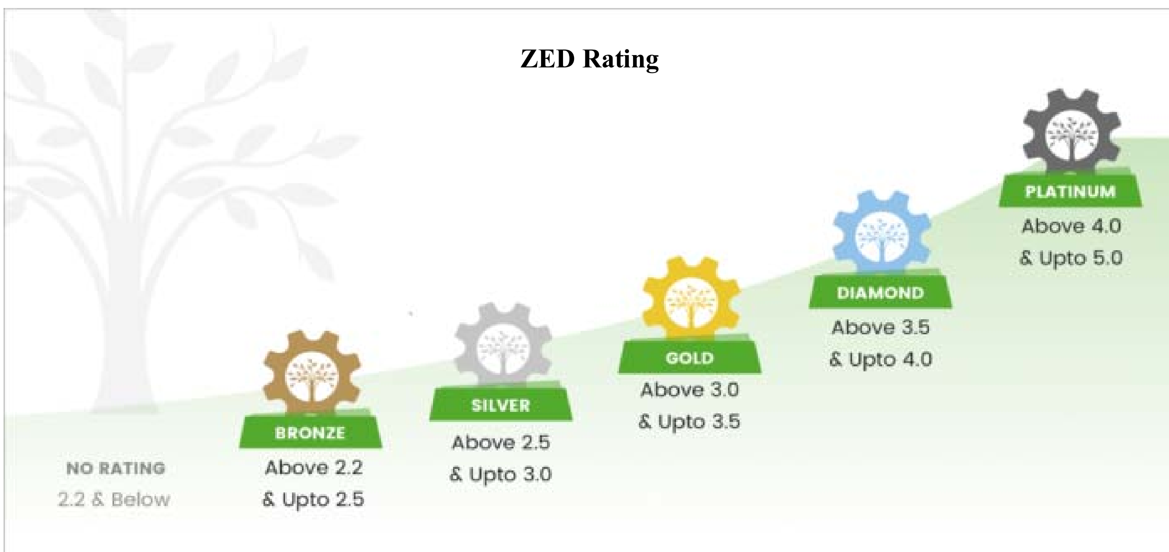

Fig. 2 ZED Rating

ZED Maturity Assessment Model

ZED Maturity Assessment Model is an integrated and holistic Certification System, which accounts for processes related to:

- Production Management
- Quality Management
- Design Management
- Safety Management
- Environmental Management
- Energy Management
- Natural Resource Management
- Human Resource Management
- Intellectual Property Management
- Performance Management

Assessment Criteria

There are 50 parameters on which the MSMEs will be assessed and rated. The MSME applicant is required to comply with identified 20 essential parameters & at least 10 other parameters (as per the MSMEs domain competency, i.e. sector of operation and type of industry). Hence, the MSMEs will be rated on a minimum of 30 parameters. MSMEs may seek ZED rating on more than 30 parameters as per the processes and systems available at the MSME.

Each parameter comprised of 5 Maturity levels and ratings.

- Level1= 0 Marks– Struggler-Bronze
- Level 2 = 2 Marks- Beginner-Silver
- Level 3= 3 Marks- Organized-Gold
- Level 4= 4 Marks- Achiever-Diamond
- Level 5= 5 Marks- World Class-Platinum

The Rating is based on a weighted average level. The company is encouraged, handheld and trained to achieve a higher level for each parameter and thus elevate itself in the maturity model.

Financial Support

The Government of India has decided to implement the "Financial Support to MSMEs in ZED Certification Scheme" with a total budget of Rs. 491.00 crores (including Govt. of India contribution of Rs. 365.00 crores). Financial Support (Subsidy) available to first 22,222 MSMEs (Site Assessments) are available in https://www.zed.org.in/.

Technical Survey

Six Sigma was not the first quality concept introduced to business. It could probably trace the first real attempts to polis processes to Henry Ford at the beginning of the twentieth century. The Ford assembly lines were the product of never-ending attempts to optimize the process. Ford didn't stop with the assembly lines- he also improved the product, sometimes with innovative new substances.[1] Many studies has been made to identify performance for Automotive Components Industries at Chennai under Cluster Development Approach, [2][3] Lean Six Sigma [4][11] and Sustainable Development [5][6][7][12]. The Quantitative, Qualitative and Impact Assessment of Auto Components Industries prove that there is increase in productivity and decrease in cost. [8][9][10]. The Automotive Component Industry at Chennai under study, is based on ZED Maturity Assessment Model of Ministry of MSME, Government of India. [13]. The ZED Certified MSMEs are available inhttps://www.zed.org.in.

Objective

The objective is:

1. To study on ZED Discipline Enabler for Process Quality, Resource Management and Outsourced Activity for Automotive Components Manufacturing Industry at Chennai. (Zero Defect)
2. To study on ZED Discipline Enabler *for Emission, Effluent & Waste Disposal Activities* for Automotive Components Manufacturing Industry at Chennai. *(Zero Effect).*
3. To study on Outcome Parameters for Quality, Process, Environmental and Company Performance.
4. To develop ZED Maturity Assessment Model for Automotive Components Manufacturing Industry at Chennai.
5. To find the ZED rating for Automotive Components Manufacturing Industry at Chennai.

Methodology

The methodology adopted is the researcher interacted with one of the partners of Automotive Component Manufacturing Industry at Ambattur, Chennai and collected the primary data and secondary data. The data collected are analyzed using 50 parameters from Level 1 to Level 5and Scores were calculated as shown in Table 1.

Table 1 A-process design for quality

Parameter	Level	Score
A1-Technology Selection and Continual Upgradation	50-75% critical machines have automated setting Alarms /trips with feedback loop for correction established to monitor machines Technology planned proactively incorporating customer/market needs using process/design failure analysis	4
A2-Process Capability Assessment and Enhancement	Corrections are made to the processes on the basis of process trend. Statistical process implemented on 20-50% critical machines for process capability assessment. Process capability measured (Cp, Cpk) for 20%-50% critical processes and used for any improvement initiatives. All corrective actions are implemented.	3
A3-Low Cost Automation	Low cost automation aimed to address energy conservation along with productivity, quality and capacity utilisation Low cost automation is evident by usage of Pneumatic, hydraulic, electric, hybrid, electronic controlled systems in a wide variety of manufacturing areas Improvement goals met in case of >75% to 95%	4
A4-Waste Management	Top and middle management, plus line supervisors are aware on waste and effect on profitability Targets met for >75%-95% ideas on waste reduction Training provided on 7 wastes,3Ms and lean concepts plus examples of these being implemented on the shop floor Tools like Time motion study implemented to eliminate overburdening (Muri) along with tools to manage Mura and Muda	4
A5-Safe Working Environment	Formal safety policy addresses the concern of suppliers and community at large in addition to employees and contract workers Safety policy communicated through comprehensive means (display in notice board, employees handbook) Classroom and practical sessions on safety done for 100% employees Safety information reviewed, leading to identification and implementation of CAPAs "Near Misses" with respect to safety are recorded, analysed and acted upon. CAPAs are documented and reviewed SOP established for safe working environment throughout the factory	4
B-Pre-production (startup activities)		
B1-Process Validation	Process validation done for critical/key processes e.g. First piece validation/pilot manufacturing/prototype manufacturing in place All corrective actions are implemented to improve processes to ensure design requirements Periodic review process in place. Post validation, process parameters are measured, documented and communicated.	3
B2-Supplier Development	Work as a partner; Investment in R&D for technology development Performance management including supplier rating is used for business allocation to different suppliers Supplier core competency developed for productivity, quality and delivery	5
C-Production and maintenance activities		
C1-Swachh Workplace	Visual management on 5S is seen everywhere. Continuous Improvement Activities are evident and ongoing 4S (Standardization of procedures) have been implemented using various tools, e.g., job cycle charts, visual cues, checklist etc. 5S Audit assessment score for 4S > 80 cross zones	4

Parameter	Level	Score
C-Production and maintenance activities		
C2-Daily Works Management	Dashboard established across product lines for monitoring performance on QCDSM Digital board highlights the performance on QCDSM on a daily basis, MTD/YTD Target (plan & achievement). All workmen participate in daily meetings. Flexibility to adjust staffing when the situation warrants. Cross Training, Job rotation and shared resources (90% to 100% workmen involvement). >75-95% targets have been met for QCD improvements All corrective actions are implemented and risk mitigation done to avoid gaps in QCDSM targets elsewhere, e.g. other lines	4
C3-Planned Maintenance	Preventive Maintenance plan is available for 50%-75% of critical machines Adherence to planned maintenance plan is 80%-95% Step 1-2-3 of autonomous maintenance implemented ; Step 1-Initial cleaning and tagging; Step 2-Counter-measures for contamination/dirt; Step 3-Cleaning inspection and lubrication standards MTTR and MTBF measured at <30% of critical machines	3
C4-Process Control	Details SOPs / Work instructions are available basis control plans to ease the process understanding Process control plans in place with adherence 40%-60% Process control approach available for critical processes CAPAs to control variances identified in >50% critical processes	3
D-Product design for quality		
D1-Design Capability	Design group in place with proactive design capability. All possible reasons for low capability are investigated. Design for Reliability (DFR) in place incorporating risk analysis and DFMEA conducted. Design capability is continuously assessed. Benchmarks are used to compare capability on various design characteristics. There is at least 1 design patent / IPR filed.	4
D2-Design Process and Methodologies	Design planning to ensure that the customer specifications and regulatory requirements are met Design validation done at SME through prototyping Customer complaints with respect to designs are maintained with reasons for failures investigated & suitable actions taken for prevention	4
E-Post production activities		
E1-Transportation and Storage	Statutory / regulatory requirements met for packaging and transport Customer (internal/external) feedback captured, analysed and acted upon to improve transportation and storage Improvement activities/Kaizen in place for improvement of transportation and storage conditions in addition to defined customer needs	3
E2-Timely Delivery	Lean principles / projects are deployed to enhance timely delivery adherence to process delivery contracts is >75%-99% Corrective actions taken on delivery delays and risk mitigation done to prevent recurrence	4
E3-Customer Education for Product Usage Maintenance and Service	Usage of videos and other mediums (white papers, eBooks and newsletters etc.) for product demonstration >60-95?Hence to customer education process Customer satisfaction index established and actions are taken basis the index received. CAPAs in place and Customers testimonials are taken and displayed within organizations	4

Parameter	Level	Score
E-Post production activities		
E4-Customer Service	Customer service camps planned and desired service levels achieved in addition to documentation of queries >75%-95% queries resolved within TAT Gaps in customer service identified, corrective actions taken and risk mitigation done to prevent recurrence	4
F-Process design for environmental management		
F1-Technology Selection and Continual Upgradation	Environmental impact assessment done before any technology selection and has up to 25% weightage while selecting a technology Policy in place to consider environmental aspects while selecting/developing/sourcing technology / process for product and Implementation taken up on selective basis 50% processes, machines, furnaces, chemical plants etc. are monitored and environmental wastes measured for all of them	3
F2-Systems for Abatement of Effluent, Emissions and Wastes	A compliance register has been developed identifying the legal requirements that the organisation has to meet from environmental aspect and the requirements have been implemented Plant equipment's are in place to address complete compliance effluents / emissions and has systems to handle disposal of wastes System in place for semi-annually checking environmental compliance 50%-75% improvement observed in environmental variances	3
F3-Systems for Energy Efficiency	All energy performance parameters are fully defined Meters are installed in areas of energy consumption and regularly monitored Energy saving devices like variable frequency drives and power capacitor banks are installed. Targets are fixed for energy conservation and accordingly plans are made. Progress reviewed at HOD level System in place for semi-yearly checking of energy efficiency 50%-75% improvement observed in variances	3
F4-Systems for Natural Resource Conservation	Quarterly internal audit and yearly external audit of natural resource conservation is carried out >75%-95% improvement observed in variances Goals for natural resource conservation in place and >60% of its targets are achieved Time bound action plan in place for conservation of identified natural resources and increasing use of renewable resources	4
G-Pre-production (startup activities) for environmental management		
G1-Installation of Environmental Protection and Measuring Systems	Satisfactory dry trial runs of all environmental protection and measuring equipment are completed before commissioning of the complex Installation of all production units and environmental management & measuring systems are completed before taking up commissioning activities and Continuous equipment up-gradation in place Pollution control facilities Installation happens before taking up any commissioning activities	4
H-Production and maintenance activities		
H1-Planned Maintenance of Environmental Management Systems	MTTR and MTBF measured at <30% environmental management systems PM plan for 50%-70% critical environmental management systems Adherence to planned maintenance is 50%-75%	3
H2-Planned Maintenance of Energy Control Systems	PM plan available for >70%-99% energy control systems Adherence to planned maintenance is >75%-99% MTTR and MTBF measured at 30-60% energy control systems	4

Parameter	Level	Score
I-Product design for environment		
I1-Design Compliance with Regulatory Requirements	Designs are reviewed and approved by cross function team on periodic basis. ECN/ECR(Engineering change note/record) process is in place Meets national standards for regulatory compliance requirements System in place integrating environmental regulatory requirements while designing and developing products in addition to meeting customer specifications, regulatory and statutory requirements	4
J-Post production activities		
J1-Disposal After Use	Complete information on safe disposal of its products after use printed on packaging. Wide publicity to the same for educating the customers is done. Education in the form of forums, blogs, Videos/ On-line channels like You-tube etc. done Detailed instructions on its use, storage and safe disposal mentioned on the packaging All products are covered; Customer awareness survey Index	4
K-Facility		
K1-Plant Layout	Reduction in material distance, time and manpower is measured and reviewed for continual improvement Comparison of various layout options with the help of cross functional team. Lean principles & process is established in organization Visual management of total flow and plant layout exist	4
K2-Material Management	Advance planning and scheduling (APS) begins to occur, providers are given access to actual planning schedules so that they can have the right equipment available and resource -alert at the right point ; A well-defined demand /supply balancing processes that combines forecasting and planning with sourcing and manufacturing is evident at this level Demand characteristics like volatility, seasonality, latency and short order lead times are routinely factored in for managing the supply chain The decided stock levels are maintained and reviewed to ensure reduction in inventory >90-95% timely availability of material	3
K3-Material Handling Systems	Focus area of Material handling systems is to eliminate wasted time of operators/ other resources and build quality into workplace system; Improvement goals and plans are made with the team after awareness training and participation Few operators are trained through informal techniques on material handling and hazardous material Plan is in place to establish material handling system which is efficient, flexible, easy to deploy, scalable and affordable. Detailed SOP's and processes/ Ready references for usage of right tool for the job. Quality defects/ damages attributed to handling are identified and CAPAs taken	3
L-Human resource		
L1-People Development Plan	Comprehensive employee development plans are created for employees Detailed technical skill mapping done for deploying people for different tasks. Multiskilling of operators in few areas 50-75, hence to people development plans	3

Parameter	**Level**	**Score**
L-Human resource		
L2-Employee Involvement Activity	Available, followed and improvements done Employee recognition scheme available and followed every month Business plans & performance shared with all employees with targets at all levels are drawn in consultative mode. Teams empowered to manage their work areas, with manager playing facilitators' role	4
M-Outsourced activities		
M1-Outsourced Activities: Selection, Control and Improvement	Contract agreements are in place Basic outsourcing strategy in place that aids identifying areas for outsourcing A formal selection and evaluation process for vendors exists and periodic evaluation as per the evaluation process is done	3
N-Innovation and creativity-safeguarding		
N1-Trademark	Limited understanding of brands Knowledge about IPRs is available. Trademark for the industry registered Knowledge about IPRs but no steps taken to work for defining Trademarks for the Organisation	2
N2-Industrial Design	Organisation is proactive and protection is provided for a shape configuration, surface pattern, colour, or line (or a combination of these) which when applied produces or increases aesthetics and improves the visual appearance of design. Process in place for renewal of existing design >15%–30% products registered for industrial design in the name of company	3
N3-Copyright	Legal system in place to protect against infringement of copyrights of organisation >50%–75% of the products are registered for copyrights in the name of company	4
N4-Patent	Owns domestic patents for indigenous product/ process/ technology and Organisation is monitoring inventions as a result of considerable efforts and long term investments in R&D, many simple and inexpensive technical improvements, of great market value, have yielded significant income and profits to their inventors or companies Capability to generate maximum benefits from innovative ideas and technological capabilities	4
O-Outcomes for quality performance		
O1-Outgoing Quality Performance Level	Outgoing quality is >75–95% of industry benchmark Customer Satisfaction Index is measured beyond Number of complaints received. A customer satisfaction form is in place & the satisfaction score is between 4.0 to 4.5 (on a scale of 1.0 to 5.0, 5 is the best)	4
O2-In Process Quality Performance Level	In-process manufacturing quality is >75–95% of industry benchmark Process adherence audit system established & audit score is between 95% and 98%	4
O3-Field Performance Level (Based on Customer Defined Targets for Field Performance)	Level of warranty/ guarantee/ recall is >75–95% of industry benchmark 100–1000 PPM or 75–95% of industry benchmark of field performance level	4

Parameter	Level	Score
P-Outcomes for process performance		
P1-Total Employee Involvement	>80% employees have been involved and >50% employees have given one Idea for improvement Company results are bench-marked as best in class in industry and shows >50% improvement on YoY basis	5
P2-Scrap (% of Gross Sales)	0.2%–0.5% scrap as a % of gross sales or >75–95% of industry benchmark	4
P3-Process Capability (Cp/Cpk)	>50%–75% CQAs have Cpk value of >1.0	3
P4-Overall Equipment Effectiveness	OEE is between 50% and 60%	3
Q-Outcomes for environmental performance		
Q1-Optimal Use of Natural Resources	Organisation works towards continual improvement plan to improve all applicable, one or more of the following; 50% conversion from fossil fuels to clean fuel; Apart from evaporation, 75% water recycled; Rain water harvesting and recharging of ground water is practiced; 100% own plantation and no virgin forest is cut (where wood is a consumable)	4
Q2-Energy Performance	All energy performance indicators defined and monitored, e.g. Indicators for (1) Reduction in lighting required (2) Installing more energy-efficient lighting system (3) Usage of day lighting (4) Air distribution system loss (5) Water/Stream distribution system loss (6) Improve boiler and furnace efficiency (7) Selection of efficient/ star rated cooling and heating systems (8) Installation of energy efficient motors Achieves between 2% to 5% reduction over previous year in specific energy consumption for the products	3
Q3-Environmental Performance, Air/Effluent, Solid Wastes	All environmental parameters are monitored and show compliance at least 75% time. CAPAs are in place and regular reviews happen to discuss performance	3
R-Outcomes for overall company performance		
R1-Turnover Growth	Turnover growth of 15% over last 3 financial years >20%–40% growth due to new product lines	4
R2-Operating Profit/ % Improvement (Measured as Gross Profit)	Growth of 10% in the operating profit over last 3 financial years. Risk management analysis done	3
R3-Safety Score	No fatal accidents or temporary disabilities in the last 1 year	3
R4-Inventory Turnover	Measured and Actions taken to ensure delivery for FG/RM/WIP Inventory turnover is >15–25	4

Source: Primary Data

Discussion

Table 2 Rating

Parameters	Level	Marks
1	2	2
20	3	60
27	4	108
2	5	10
50		180
		3.6

Source: Computed Data

Auto Component Manufacturing Industry at Chennai, Rating is given in table 2.Total points / Applicable levels: 180/50 = 3.6, hence the Manufacturing Industry at Chennai is a ZED Diamond Company.

Conclusion

The objective is to study on ZED Discipline Enabler for Process Quality, Resource Management and Outsourced Activity for Automotive Components Manufacturing Industry at Chennai. (Zero Defect) and to study on ZED Discipline Enabler for Emission, Effluent & Waste Disposal

Activities for Automotive Components Manufacturing Industry at Chennai.(Zero Effect). The Outcome Parameters for Quality, Process, Environmental and Company Performance are also studied and ZED Maturity Assessment

Model for Automotive Components Manufacturing Industry at Chennai are developed. To conclude ZED rating for Automotive Components Manufacturing Industry at Chennai is Diamond one i.e., Achiever (Level 4) and the Industry has to achieve upto Platinum Level i.e., World Class (Level 5) to compete in the International Market.

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Group D

- **Metallurgical & Materials Engineering**
- **Mining Engineering**

Application of Metals and Allos Micro Structures in Textile Design

Nilmoni Mitra[1]

Abstract Art work have always been a matter of fascination of human mind. This natural inclination inspires an artist to draw spectacular designs, patterns, picturesque landscapes and so liked by people. This aspect is taken to advantage in textile production to replicate on clothings and drapery. Thus they play very important role in sales and marketing of textiles. In Indian context designs on saries or suitings and shirtings remain as one of the most important factors in attracting customers to go for the purchase of the clothes with innovative designs on. Every year before festive or on special occasions some kind of iconic designs are floated in the name of some event, movie or actors and like which act as the catalyst in making choice by people and stay as the talking point on fashion on the occasion. Beside there happen to be some reputed kind of designs which have turned in to the synonyms of the place of their origin viz. Pachampalli, like Kataki or Kanjibharam. Designs in general are the art work of brilliant artists who come out with new and attractive graphics or patterns for printing or weaving of the fabric. These designs happen to be human perceptions, however, nature also plays an important role which inspires human mind to reproduce them as artwork and ultimately for their use for, say, textile designs, like flowers with myriad of colours, colour combinations, shapes and sizes. Beside such manifestations of natural creations there also lie hidden sources which are needed to be revealed through metallographic processes and seen at various magnifications, known as microstructures serving as supplement to micro examination which may also inspire a designer to derive the fashion designs on the basis of them and to be reproduced on textiles. Metals and alloys as Cast, rolled, forged, heat treated may display umpteen number of designs by means of revealing of dendritic structure, grain boundary formations, eutectic structures, distribution of intermetallic compounds, inclutions etc. over the matrix or so. Such basic designs inherited from the metallic microstructures may be suitably provided with matching colours or colour combinations to come up with the innovative and attractive patterns. Designs from micro structures of both ferrous and non ferrous materials can be used with advantage in the context.
It is not known as to whether such microstructures have ever been used as the source for textile designs and therefore shall appear as a new and innovative method forging the two engineering viz. metallurgical and textile engineering disciplines together and as such shall evolve as an inter disciplinary subject with immense commercial prospects. This development can lead to going for various kind of alloy designs apart from usual ones to generate innovative pattern to gratify visual taste. Hopefully such designs shall be able to win the market aspirations and the hearts of the prospective buyers of fabric.

Keywords: Textile Designs, Fabric, Microstructure, Ferrous & Non-ferrous–Metals and Alloys, Dendritic, Eutectic Structures, Inter Metallic Compounds, Grain boundary. As Cast, Rolled, Forged and Heat Treted Structures.

Introduction

Human Mind has been inspired from the beginning of civilization towards natures creation of the colourful flora and fauna. There are artworks on the walls of old caves and other human habitats as proof. As the civilization advanced and there was advent of textile the type, nature and variety of art work on the fabric also kept on advancing resulting in attractive patterns and designs with high aesthetic value as liked by people as the clothing to be put on and be admired. Eventually the textile designs emerged as an important factor in the world of fashion. The traditional artwork are drawn on the basis of natures creation of beauty out of scenic designs like mountains, valleys rivers, fountains, greeneries, animals, leaves flowers etc. with umpteen number of colours and their combinations shapes, & sizes and varieties. They all are the natural revealation which are observed through naked eyes and drawn to be printed over the fabrics. They are the macro level revelation which the brilliant artists put into attractive graphics and patterns for adoption in textile printing. Beside the said natural

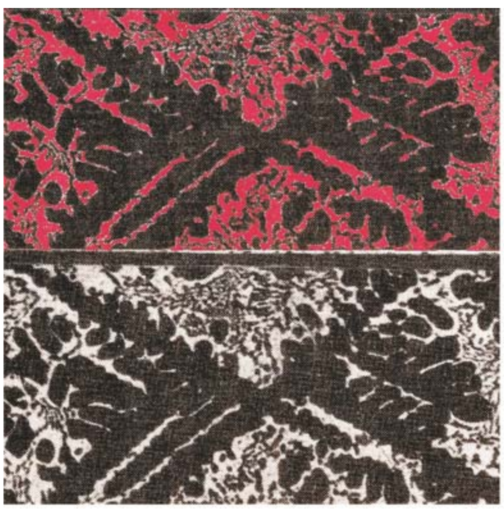
E-mail: [1]n_mitra2000@yahoo.com

[1]Former Director & Head, Metallurgical Engineering Department, Bureau of Indian of Indian Standards, New Delhi

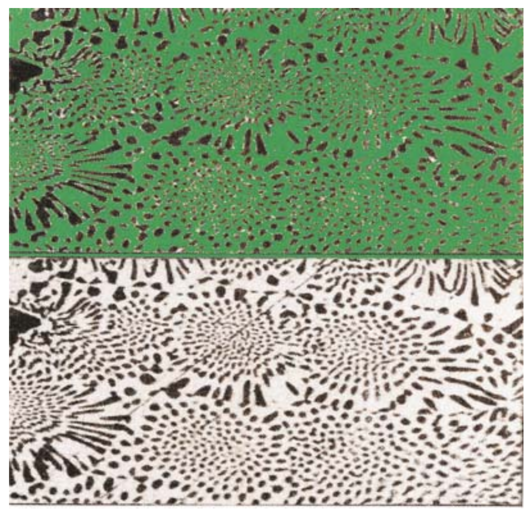
revealation the nature has in store the vast world of designs in micro level, fascinating and attractive, in the realm of metals and alloys produced through casting and solidification of metals, mechanical working and heat treatment on them. The impact of mechanical working and heat treatment are so profound that the properties of an alloy at its various stages of production can be linked to the typical designs so formed. There are very large number of ferrous and non ferrous, metals and alloys of industrial importance which can generate huge varieties of designs which can be observed under large magnifications, photo graphed and given to the artist to suitably modify through colouring andf such artistic patterns taken for weavig, printingon textiles to be admired by the consumers it is likely that the revelation of microlevel patterns or designs of micro structures of metals and alloys shall have immense possibilities to stand as parallel to the creation through traditional process being followed so far in the realm of textile design which will be in consonance with the theme of 32nd Indian Engineering Congress viz Innovation in Engineering competitive Strategy Perspective.

Prospect of Micro Structures Modified with Suitable Art Work for use in Textile Printing

The essence of developing desired micro-structures metallurgic ally is to bring the desired mechanical or other properties as the quality factor of the material. The alternate application of micro structures i.e. for use in textile printing does not hold any such conditions to be fulfilled rather it would seek only aesthetic aspect of the developed microstructural designs. Thus, though a widmannstatten structure in a overheated steel is not a desired quality aspect it may appeal to an artist to be suitable for a textile design on modification. Thus the cast or semi finished metals and alloys may also reveal spectacular designs however in case of heat treatment the aim remains to have a desired microstructures for achieving the mechanical properties in finished material largely together it may also have artistic appeal. Two examples of such micro structures with colour combinations are being provided as illustrations as under.



Pic. A Cooper dendrites in copper silver eutectic x 80

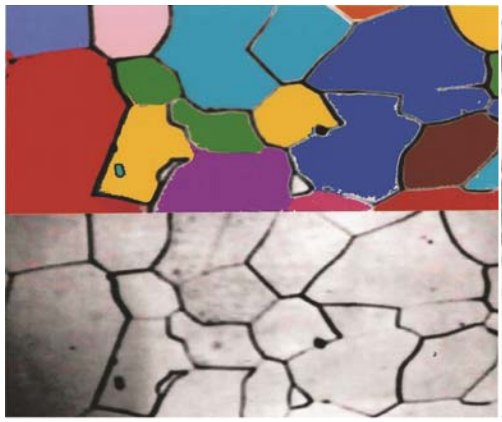


Pic. B Copper silver entectic x 80

Without going for details of solidification mechanism and equilibrium diagrams etc. it will be suffice to say the micro structures may consist of a network of grain structure say in case of a metal. In case of alloys, however it may consist of cored solid solution or eutectic or peritectic phases with inter metallic compounds distributed or segrejated over the matrix and as such there lies the possibility of a structure having a single phase or combination of different phase forming desirable patterns for the choice of the consumers. In short a permutation and combination of the large number of important industrial alloys their state of production viz cast, rolled, forged or heat treated together with their appearance varying with the nagnifitation with which the sample are being viewed provide opportunity to develop huge number of designs.

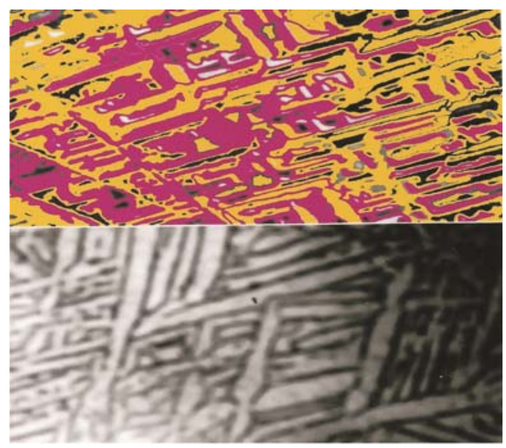
Metallographic Process

Metallography is the technique to bring the microstructures under visual perspective and use as the basis for textile design. The metallographic processes consist of cutting and polishing the samples to a finish, free of scratch. This can be done mechanically or by electrolytic polishing followed by mounting in plasticine or thermoplastic resins. Such samples may be observed under microscope unetehed or after suitable etching either by very dilute acid solution in alchol say 2% Nital for iron & steel and 25% aquous solution of ammonium hydroxide with few drops of hydrogen per oxide for copper & alloys, for example. There are large number of micro etching reagents for various kinds of metals and alloys. for within suitable literatures, can be consulted. Structures can also be viewed through very large magnifications as in Scanning Electron microscope. A few illustrations of representative micro structures are given below with legends. The original micro structure in black and white is given side by side of the modified views after using suitable colouring to make the design suitable for textile printing, in order to highlight the spectacular views originating for textile print.



Pic. C Armco iron x 100

Pic. D Hypoeutechtic case iron x200



Pic. E Martensite needles in austenite x 1200

Conclusion

Metallic Micro structures play vital role in the field of metallurgical engineering in their process and quality control and quality assurance of metals and alloys. They also serve as the tool in the investigation of their failures in service or otherwise. The desired micro structural patterns assist in confirming the suitability of requisite process and quality control having been taken as also the cause of and the direction to further operational course in case the desired structures are not achieved. Whatever be the case the magnified micro structural views also appear as visual spectacle specific to the material under observation. Such visuals appear in the form of network of grain structures as also with artistic patterns of other phases providing the opportunity to use these visuals at suitable magnification as the basis of the artwork use in textile printing. There are large number of metals and alloys of industrial use. These materials may be ferrous, non ferrous as also precious metals and alloys for the purpose. They can be in various stages of processing like cast, mechanically worked and heat treated ending into the form of various designs. Further such designs can be modified through metallurgical controls like say extent of heating, heat treatment or rate of cooling during casting or so. In brief there is a scope in the process to enhance their grandeur and excellence to serve as prints over the fabric with better attraction. As discussed, there is possibility of developing myriad of attractive microstructureal designs through existing industrial metals and alloys or by new alloys developed which can be under taken by metallurgical research laboratories and such innovative alloy designs can accelarate market demand in the areas of textile printing, or in ceramic industry. Hopefully such designs being different based on micro level observations shall be able to win the market aspirations over the traditional art work. Beside the scope of newer alloys, for innovative designs may accelarate the activities of metallurgical research laboratories raising the possibility of adequate commercial returns.

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Development on the Properties of Bismuth Titanate in Terms of Structure, Synthesis and Applications

Soumya Mukherjee[1] and Soumya Kanti Raj[2]

Abstract Bi-Ti-O system is large family of oxides consisting of several phases along with several technological applications. Sillenite phase of Bi-Ti-O is observed to be promising candidate for photocatalyst in compare to TiO_2. Moreover sillimanite phase is also noted to have high electrooptical coefficient, piezoelectricity, low optical activity and high photosensivity in visible region. $Bi_2Ti_2O_7$ another Bi-Ti-O system have cubic pyrochlore structure possess general formula of $A_2B_2O_7$. Pyrochlore structure is observed to have photocatalytic activity while doped one also possesses magnetic and electrical properties. Bismuth titanate ($Bi_4Ti_3O_{12}$) aurivillius structure is constructed by the regular intergrowth of $[Bi_2O_2]^{2+}$ fluorite layer and perovskite $[Bi_2Ti_3O_{10}]^{2-}$ layer where Bi ions occupy twelve-coordinated sites. Generally, it is represented by $[M_2O_2]^{2+}$ and $[A_{n-1}B_nO_{3n+1}]^{2-}$ for fluorite and perovskite layer where n is the number of BO_6 octahedra. A represents 12-fold cation sites which are occupied by Ba^{+2}, Ca^{+2}, Sr^{+2}, Bi^{3+} and rare earth cations while 6 fold coordination of B cations in BO_6 are exhibited by Ta^{5+}, Nb^{5+}, $Ti^{4+}$and others. It is a ferroelectric material having high Curie temperature of about 675°C. The material has excellent fatigue endurance, electro-optic switching properties making it fit for high temperature piezoelectric devices, electro-optic devices, non-volatile ferroelectric random access memory and others. In addition to presence of prominent ferroelectricity, electro-optic nature it also possesses high break down strength, low dielectric strength, low coercive field and high temperature coefficient of resonant frequency. Moreover, Bismuth titanate is observed to have application for capacitors, transducers, sensors, electro-optic application for data storage, oscillators and filters, light deflectors, modulators and displays etc. It is observed from Bi-Ti-O system following the phase equilibrium diagram of Bi_2O_3-TiO_2, prominent phases that are generally obtained are $Bi_2Ti_2O_7$, $Bi_2Ti_4O_{11}$, $Bi_{12}TiO_{20}$, Bi_8TiO_{14} and $Bi_4Ti_3O_{12}$. Bismuth titanate is found to be prepared by several routes like solid state reaction, high energy milling, molten salt method, sol-gel, hydrothermal, oxidant peroxide method, self combustion and others.

Keywords: Bismuth Titanate, Ferroelectric, Dielectric

Introduction

Bismuth titanate (Bi-Ti-O) is a large material system including several phases and various technological applications in various domain. $Bi_4Ti_3O_{12}$ which is an important Bi-Ti-O material system is found to be applicable for memory storage, optical display, piezoelectric converters and photocatalysts [1]. It has been observed that sillenite ($Bi_{12}TiO_{20}$), perovskite ($Bi_4Ti_3O_{12}$) of Bi-Ti-O are more pronounced for photocatalytic actions to degrade organic dyes. Such activity is possible due to special electronic structures, well dispersed electrons of Bi_{65}, which causes wide valence band and hence increase the mobility of electrical charges. [1] Stable solid solution is formed between metal oxides, bismuth oxides due to smaller cation ion radii differences with bismuth ion and also for its presence of higher concentrations. Good oxygen ion conductivity occurs for aliovalent ion doping within the limit since beyond it ordering of vacancies or new phase is formed [2]. The aurivillius bismuth titanate is constructed by regular $[Bi_2O_2]^{2+}$/$[M_2O_2]^{2+}$ fluorite type structure, intergrowth with perovskite layer $[Bi_2Ti_3O_{10}]^{2-}$ represented by formula $[A_{n-1}B_nO_{3n+1}]^{2-}$ where Bi ions occupy twelve-coordinated sites. The material system have low dielectric property, low coercive field, high breakdown strength, high Curie temperature make it fit for promising ferroelectric, piezoelectric and electro-optic material [3]. The material has excellent fatigue endurance, electro-optic switching which makes it suitable for electro-optic devices, high temperature piezoelectric, non-volatile ferroelectric random access memory and others. [4].

E-mail: [1]smmukherjee3@gmail.com, [2]soumyakanti.raj007@gmail.com

[1]Assistant Professor, Amity University, Kolkata, India

[2]Assistant Professor, Heritage Institute of Technology, Kolkata, India

Research indicates bismuth titanates of various combinations $Bi_{12}TiO_{20}$, $Bi_4Ti_3O_{12}$, $Bi_2Ti_2O_7$ and $Bi_{20}TiO_{32}$ as photocatalyst under visible light. But amongst these combinations $Bi_4Ti_3O_{12}$ is noted to be very efficient for organic pollutant degradation with high photocataytic efficiency. [5] $Bi_2Ti_2O_7$ belongs to pyrochlore $A_2B_2O_7$ structure can be tailored or tuned up for photocatalytic activities. However, its role for hydrogen generation as photocatalyst is still a topic of interest and needs to be exploited with more intense throttle [6].

In the present article authors have given brief focus on synthesis, properties and applications of the Bi-Ti-O system.

Methodology

The present Bi-Ti-O material system is noted to be synthesized by various routes like solid state reaction, sol-gel, chemical-precipitation, hydrothermal and others. In the present article, some discussion on the solid state and chemical route synthesis is envisaged.

Solid State Method: M.L. Yuen *et al*. [2] studied synthesis and characterization of bismuth titanate by solid state sintering. Such process is carried out with bismuth oxide and titania as precursors followed by sintering at 700°C, electrical analysis in pelletized form. Jinkai Zhou *et al*. also studied photocatalytic activity of bismuth titanate prepared by solid state process. Photocatalytic activity of methanol decomposition at room temperature in presence of visible light was studied [7]. Solid state synthesis with oxide precursors was also studied by M. Aparna *et al*. They synthesized La doped sodium bismuth titanate by solid state processing involving calcinations at about 800°C for 2 hours, sintering of about 1100°C in air atmosphere in pelletized form [8].

Chemical Method: Xue Lin *et al*. observed photocatalytic activites of bismuth titanate microspheres in presence of visible light. Microspheres of bismuth titanates were prepared by facile hydrothermal route. Precursors like bismuth nitrate, tetrabutyl titanium, KOH solution were put in autoclave for synthesis followed by phase analysis, morphological studies and catalytic action over methyl orange medium [5]. Sankaran Murugesan *et al*. synthesized bismuth titanate pyrochlore nanorods by reverse micelle method. Synthesis procedure is equivalent to templates free reverse micelle method using AOT as surfactant in isooctane solution method which is equivalent to oil-in-water micro-emulsion. Such methods aids in production of high purity, tunable shape and size properties, along with thermal stable samples [6]. Jungang Hou *et al*. studied visible photocatalytic activities of hierarchical assemblies consisting bismuth titanate complexes using facile solution phase hydrothermal method. Precursors used are $Bi(NO_3)_35H_2O$ and $Ti(OC_3H_7)_4$, KOH used to maintain ph of about 14, PVA as capping agent, followed by mixing by ultrasound bath sonicators and transferring the mixed one to stainless steel autoclave maintain temperature of about 150–180°C for 0–48 hours to synthesize the compound [9]. Qunbao Yang *et al*. studied hydrothermal synthesis of aurivillius bismuth titanate using required precursors of bismuth nitrate, Ti sources consisting of Ti-butoxide, Ti-chloride, titania powders along with NaOH as mineralizer. Reaction was carried with Teflon coated stainless steel autoclave reactor at about 150–230°C for 1–12 hours [10]. Thus chemical route was observed to have better size control, microstructure lower temperature in compare to solid state process, though commercial viability is needed to explore keeping in view of the costly precursors involved for large scale synthesis.

Results and Discussion

During hydrothermal reaction for aurivillius bismuth titanate formation, precursors are found to have vital role as noted by Qunbao Yang *et al*. Ti-butoxide was not preferred in compare to $TiCl_4$ for its role as deoxidant under high temperature and pressure converting Bi^{3+} to Bi. Peaks become more prominent with rise in temperature, with well defined crystallinity. Hydrothermal environment accelerates the kinetics of phase formation. At too low temperature and pressure amorphous formations were noted indicating lack of crystallization for phase formations. Thermal analysis does not execute orthogonal to tetragonal transitions at 675°C, which is the Curie temperature, since the concerned synthesis route formed the tetragonal structured material in contrast to solid state reactions [10]. Pallavi Gupta *et al*. observed ferroelectric properties of aurivillius bismuth titanate prepared by sol-gel process. Morphology exhibits agglomeration while crystallite size was about 18.8 nm. Ferroelectric nature was evident from remnant polarization (Pr) and coercive field (Ec) measurement. Both values increases with more applied field due to better dipole formation as Ti, Oxygen ions get aligned in better way in compare to lower field application. In other words, pre-poling is carried by the applied electric field [11].

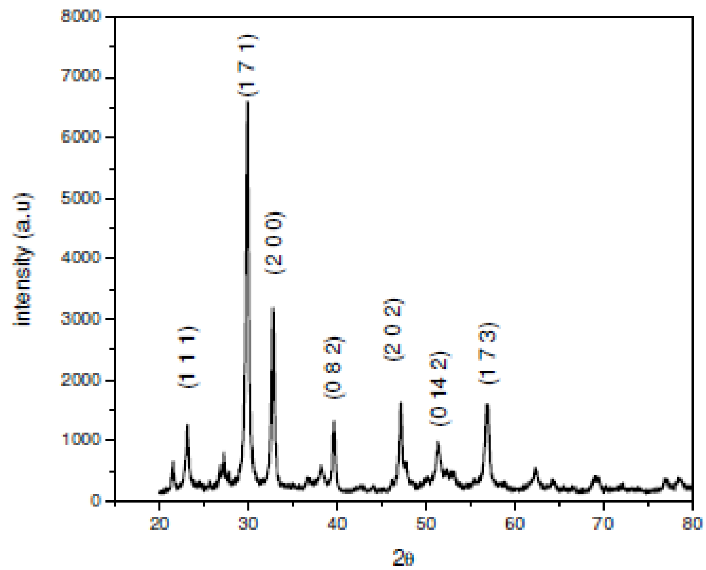

Fig. 1 XRD of aurivillus Bismuth titanate by Sol-Gel Method [11]

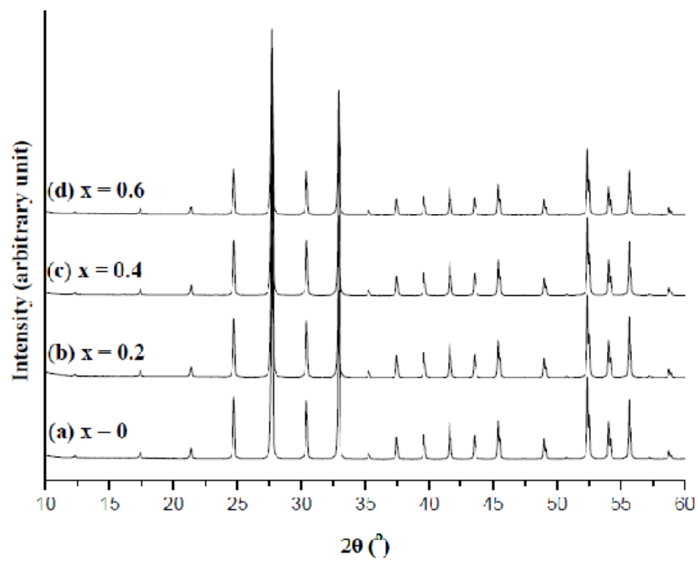

Fig. 2 XRD of Bismuth titanate solid solution by solid state route [2]

Bismuth titanate was also synthesized by Huiwen Hu *et al*. by means of hydrothermal process. Synthesis was carried using precursors like bi-nitrate, glacial acetic acid, titanium-n-butoxide, NaOH as mineralizer maintaining ph of about 3 and Bi:Ti ratio to 1.3:1 inside a Teflon coated autoclave within the thermal range of 160–200°C. Phase analysis was examined by XRD while crystallinity of the powder was quantified by using internal standard technique. Crystalline peaks were noted to be developing from broad amorphous phase peaks due to short diffusion distance between Bi and Ti ions which are mixed on the molecular level within the gel. Crystallization kinetics consists of two regimes one with incubation period having no crystallization, while quantification of the time period for initiation of crystallization though such ordering of kinetics may face hurdle with degree of crystallinity ranging from 0–5%, 95–100% respectively. Secondly, incubation is followed by steady state growth or regime as guided by Johnson-Mehl-Avrami equation. Quantitative chemical analysis by WDS executes that standard deviation of analysis decreases with increase in crystallization which indicates greater compositional homogeneity within the crystalline structure. [12] Linguin Xie *et al*. synthesized tetrahedron bismuth titanate crystallites using hydrothermal route. XRD patterns are observed with different KOH concentration of about 3–4.5

Molar concentrations at about 180–210°C. Low concentration of KOH leads to trace amount of Bi_2O_3 having both monoclinic and cubic phase. Single phase sillenite phase occurs for about 3.0 to 4.5 M. It was noted that with time both crystallinity, particulates with regular tetrahedron shape increases though particle size does not increase to that extent. Above hydrothermal growth was possible due to possible dissolution and recrystallization process [13]. Sol gel synthesis of $Bi_4Ti_3O_{12}$ thin film was carried to observe dielectric, ferroelectric properties. Precursors used for the synthesis are alkoxide solutions Alkoxide and other oxygen sensitive materials are actually stored in argon glove box. Bismuth acetate, titanium methoxyethoxide, 2-methoxyethanol, glacial acetic acid was selected as precursors. Reflux temperature was about 124°C while distillation was used to remove solvent and by products of the reaction. Thin films were fabricated using spin casting of stable sols along with standard photolithography spinner. Effect of hydrolysis conditions, heat treatment conditions, solution additives are some of the parameters required for thin film ceramic processings Spin casting was carried at about 3000 rpm for 30 seconds followed by annealing over hot plate at about 300°C for solvent removal to mature the thin film [14].

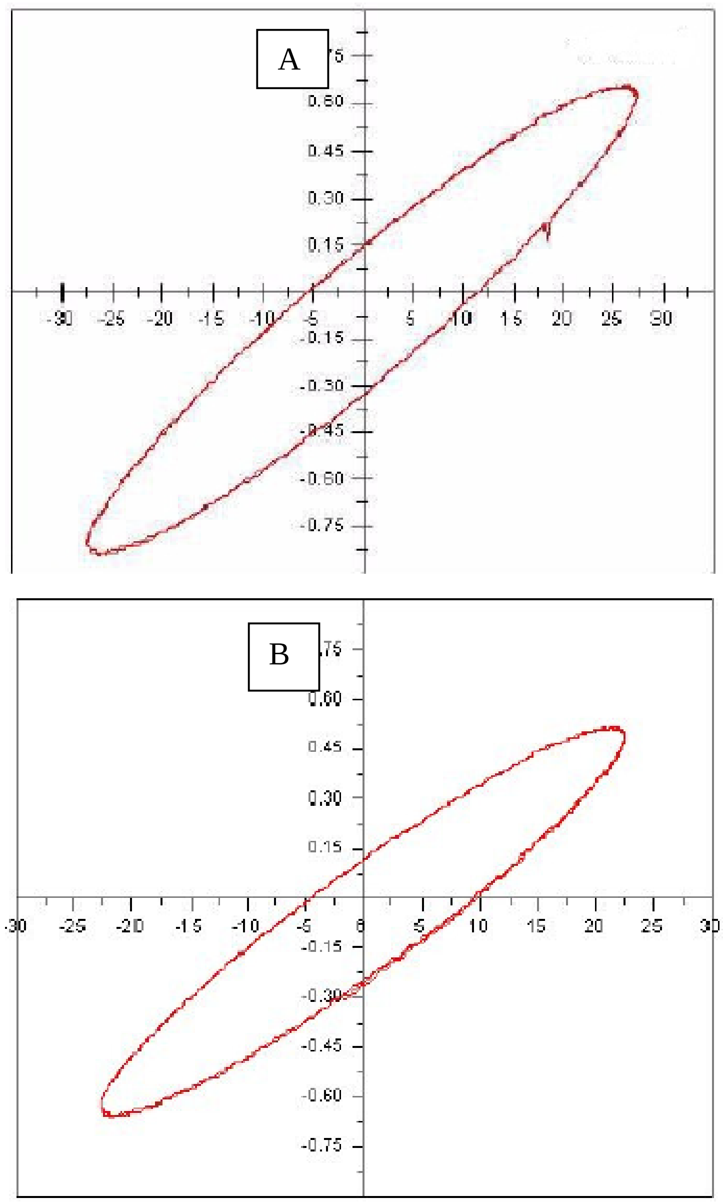

Fig. 3 Ferroelectric loop of bismuth titanate annealed at 500°C under field of a) 12 KV/cm and b) 10 KV/cm prepared by Sol-Gel method [11]

The value for dielectric constant and dielectric loss were obtained after heat treatment at about 700°C with c-axis orientation being carried over Si substrate. Values correspondingly obtained were 120, 0.5% at 1 KHz, 25°C corresponds to electrical property findings for bismuth titanate single crystal synthesis by the flux method. Electric polarization-field analysis of the compound reveals remnant polarization of about 4 $\mu C/cm^2$, coercive field to be about 1.8 KV/cm respectively. The results were in correspondence with the experimental findings of single crystal bismuth titanate prepared by the flux method. I-V characteristics of the thin film executes non-linear coefficient to be around 0.96, thus indicating the films to have ohmic contact with the electrode. Break down voltage was noted to be quite sufficiently high having values about 1080 V [14].

Conclusion

In the present article, a brief glimpse on bismuth titanates were given in terms of synthesis routes. Some discussions in terms of phase analysis were shown with some insight on properties. Bismuth titanates were found to be quite fit for ferroelectric and photocatalytic activities.

Acknowledgment

I would like to acknowledge my research team in Department of Metallurgy and Materials Engg, Jadavpur University for providing the support of the technical articles.

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Effect of Zinc Oxide and Stannic Oxide for Formation of Zn-Sn-O based Compound by Solid State Process with Mild Mill Activation

Soumya Mukherjee[1], Mohammed Shahnawaz[2], Soumya Kanti Raj[3] and Sathi Banerjee[4]

Abstract Zinc stannate (Zn-Sn-O) based compound have both orthogonal Perovskite and Cubic Spinel structure. Perovskite is found to be applicable for ferroelectric, piezoelectric, nonlinear optics, humidity sensors while Spinel has applications as anode material for Li-ion battery, gas sensing, photocatalyst, n-type semiconductors and others. Solid State process with mild milling in agate mortar for activation is used to synthesize the compounds. Precursors Zinc Oxide, Stannic Oxide was used in 1:1 molar ratio for agate mortar activation. Milling activation in agate mortar was carried for about 4hours, 8 hours and 12 hours respectively. After activation of powders, annealing was carried in air atmosphere at about 950°C for about 4hours, 6 hours respectively to prepare four samples. Samples were prepared by milling for 4 hours followed by 4hours, 8 hours annealing period while other two samples prepared have fixed annealing period of 6 hours with 8 hours and 12 hours milling. XRD was carried for all samples to verify the phases formed. For all cases minor phase of ZnO is observed while SnO2 as casseriete is present as major peak with minor amount phase amount. Four hours milling with annealing at 950°C for 4 hours, 8 hours yield mainly spinel phase Zn2SnO4 as major phase fraction. For 8 hours sample annealed sample some perovskite was also noted. For 8hrs, 12 hrs milled sample followed by annealing at 950°C, mainly perovskite ZnSnO3 as main phase fraction was observed. Bond formation and M-O coordination of the phases were identified from FTIR analysis with samples prepared as pellet with KBr powder. EDX spectra analysis was carried for specified sample for better analysis of phase and bonding. Morphology of the sample was studied to obtain the microstructural features of the synthesized Zn-Sn-O based compound.

E-mail: [1]smmukherjee3@gmail.com, [2]guddu.shahnawaz@gmail.com, [3]soumyakanti.raj007@gmail.com, [4]sathibanerjeeju@gmail.com

[1]Assistant Professor, Amity University, Kolkata, India

[2,3]Assistant Professor, Heritage Institute of Technology, Kolkata, India

[4]Assistant Professor, Jadavpur University, Kolkata, India

Keywords: Zinc Stannate, Perovskite, Spinel, Sintering

Introduction

Zn-Sn-O based compounds are noted to have two prominent structures of cubic spinel and orthorhombic perovskite. The combined oxides based on ternary compositions have been focused for semiconductors in the field of electronics. These compounds are also noted to have applications as photocatalyst, optics and optical materials, chemical sensing, promising candidate for potential applications for transparent conductive thin films, synergestic flame retardants, luminescent material, gas sensors, organic pollutant degrading and others. [1] Spinel Zinc stannate is an n-type semiconductor, having wide band gap of 3.6eV. In bulk condition, spinel stannate posses inverse spinel structure, with FCC unit cell. In the inverse spinel structure, Zn ions occupy both tetrahedral, octahedral positions, while Sn^{4+} ions also have octahedral positions. It consists of 32 anions, 24 cations leading to total of 56 atoms and the spinel structure can accommodate huge deviations from the stoichometric balance. [2] Mechanochemical activation studies on $ZnO\text{-}SnO_2$ system by N.Nikolic *et al.* have been concentrated on some possible mechanism for formation of Zn-Sn-O compounds. It is a sort of modifications of dispersed powders used for powder processing. Mechanical activation by grinding is actually a combined action of four stages material communition, new surface generation over the precursor materials, fine grinding and transformation into new product [3]. The material based on $ZnO\text{-}SnO_2$ have been observed to be synthesized by various methods like solid state calcinations, spray pyrolysis, hydrothermal precipitations, mechanochemical activation cum grinding, chemical co-precipation and others [3–8]. In the present article modified solid state processing is proposed for material synthesis which is a very simple method not involving high precursors and processing techniques.

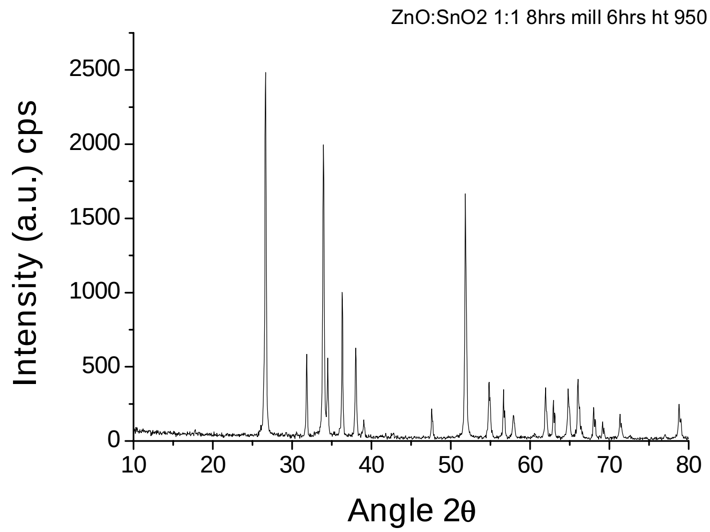

Fig. 1 XRD pattern of Zn-Sn-O compound after 8hrs mill, 6hrs annealing at 950°C

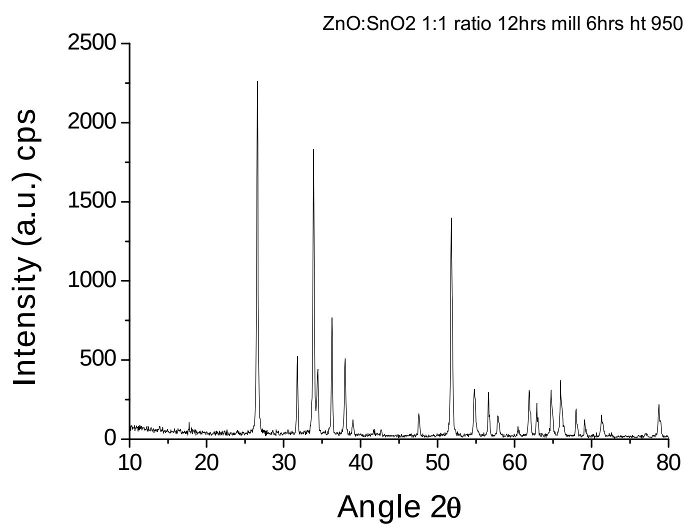

Fig. 2 XRD pattern of Zn-Sn-O compound after 12hrs mill, 6hrs annealing at 950°C

Methodology

In the present article, Zn-Sn-O based compound was prepared using oxide precursors. Modified Solid state milling with agate mortar maintaining required molar ratio was carried for the synthesis procedure. ZnO, SnO_2 are taken as the oxide precursors (AR Grade, Merck India) while both made to undergone solid state mixing by agate mortar activation maintaining 1:1 molar ratio of individual oxides. Milling activation was carried for about 4hrs, 8 hrs and 12 hours respectively in dry state. After milling activation annealing was carried at about 950°C for about 4 hours, 6 hours respectively for all milled samples. XRD analysis confirmed the presence of required phase along with planes of observation. Phase analysis was carried by XRD (Rigaku, Ultima III, 50KV 30 mA) having source wavelength of Cu Kα 1.54Å, with Ni filter. Bond formation and M-O coordination of the phases were identified by FTIR analysis (Shimadzu, IR Prestige-21). EDX was carried to determine the elemental composition of the compound. Morphology analysis was carried by FESEM (Hitachi, S-4800) to evaluate the topographic feature of the synthesized samples along with grain size estimations.

Results & Discussion

Annealing is carried in presence of air at about 950°C to initiate the reaction towards the formation of the compound. Activation by agate mortar leads to distorted zone within the grains, defects which needs to annihilate by annealing. Such mechanical activation actually aids in slight reaction among the precursors for powder sintering or coalescence by diffusion path ways. Such process is expedited to some extent by mechanical activation by means of defects, distortions. Annealing reduces the defect while at the same time causes mass transport of materials to the neck of grain boundary for powder to powder coalescence. Such necking at specific sites leads to solid state reaction among the oxide precursors, shrinkage of radius to radius distance, leading to compound and phase formations. In the present article XRD analysis of 1:1 molar ratio of oxides, after 8 hrs, 12 hrs mill activations, followed by 6hrs annealing of the powders leads to desirable phases of Zn-Sn-O. Fig. 1 and Fig. 2 respectively indicated XRD pattern of the compound with desirable phases. For all the case sharp crystalline peaks are noted without any amorphous hump indicating nullification of the defects and excess distortion which may have been induced during mechanical activation. Some peaks of ZnO and SnO_2 as casseriete is noted though in minor amount. The above analysis are verified from JCPDS card No PDF#01–074–2184, PDF# 01–089–0095, PDF#01–089–0510, PDF#01–071–0652 respectively for Zn_2SnO_4, $ZnSnO_3$, ZnO, SnO_2 phases.

Peak positions remain almost similar for both cases with almost similar peak intensities. FTIR analyses of the synthesized samples are carried to identify the molecular bonding of the compound. M-O co-ordinations of the bond formed after solid state reactions are required to be verified. Such co-ordinations are in close correspondence with the compound formed along with phases. Presence of undesired phases, will lead to undesired M-O coordination with shift. Fig. 3 in the article exhibits FTIR full spectrum of the phases formed. KBr is used to form pellets of 10mm diameter under pressure of $30t/cm^2$ for analysis. The FTIR analysis is carried in normal atmosphere without the influence of any inert gases or controlled atmosphere. The spectra are carried over the scan range of $450–4500cm^{-1}$ in absorbance mode. Absorbance is observed in about $450–650cm^{-1}$ where vibration bands of Sn-O corresponds to $655cm^{-1}$ while that of Zn-O corresponds to $420cm^{-1}$ as observed by Susana Mihaiu et. al [8] FTIR analyses are found to be in correlation with XRD analysis.

FESEM studies are carried to note the topographic features of the synthesized samples. Particulates are observed to have quite uniform distribution with few interconnected pores. Individual particles are found to have spherical shapes with some agglomeration having irregular shapes. Agglomerates are around 0.6µ while individual particulates are about 0.27µ. Presence of interconnected pores indicate the samples to be less dense which may result in less mechanical strength while agglomeration indicate lower surface area with decline catalytic activity. EDX analysis confirms the presence of required elements Zn, Sn, O for desired phase/compounds correlating chemical compositions of the synthesized samples.

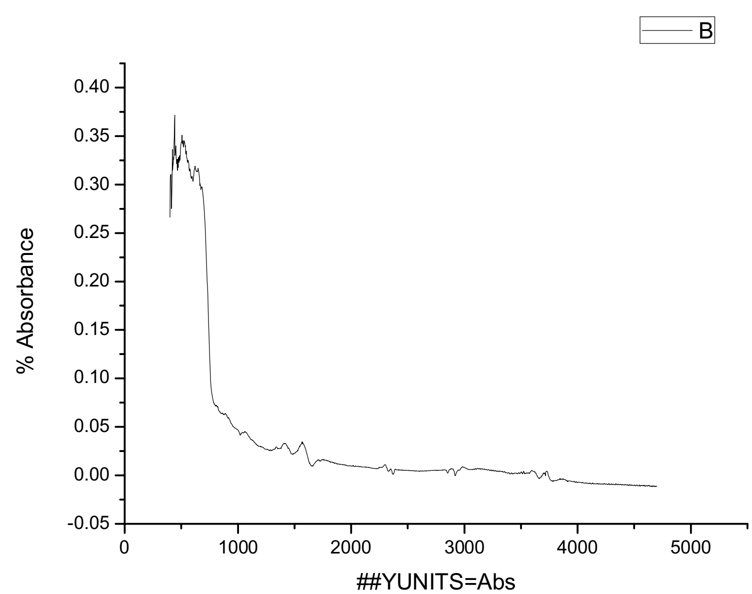

Fig. 3 FTIR spectra of the synthesized samples using KBr for standardization

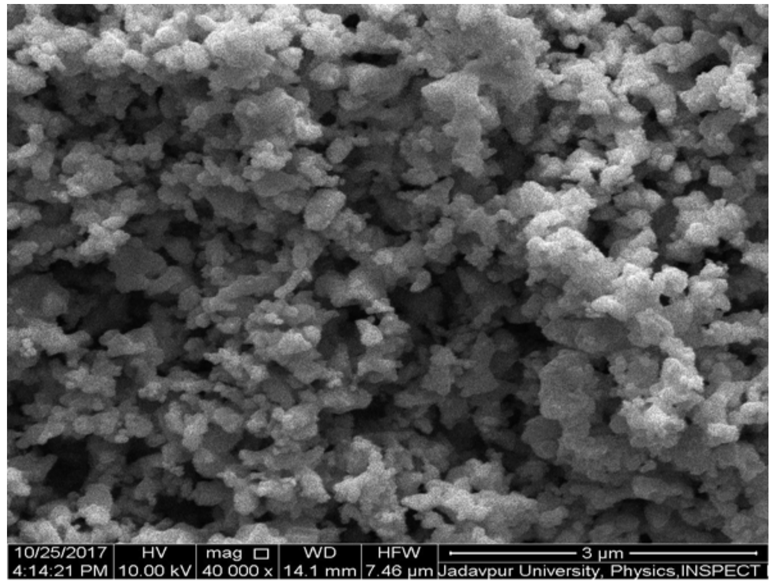

Fig. 4 FESEM of the synthesized samples at 950°C after 12 hrs mill for 6 hrs soaking

Conclusion

Modified solid state processing is used to synthesize Zn-Sn-O based compounds. Milling was carried for two different times followed by annealing for phases development. Effects of time for annealing to form the phases are noted from XRD. Analyses on bond formation, co-ordinations of M-O are studied from FTIR while topographical features are observed by FESEM.

Acknowledgment

The author would like to acknowledge Dr. Kalyan Kumar Chattyapodhyay, School of Material Science and Nanotechnology for providing instrumental facilities for FTIR, FESEM studies.

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Evaluation of Heat Treatment Characteristics for Case Hardening Steels in Automobiles

S. Balamurugan

Abstract The study of Surface engineering is concerned with preparing a surface with suitable modifications so as to meet the functional requirements of the engineering components. The Heat treatment of metal components is to improve the life and performance of parts in Automobile industry. The surface engineering field has undergone a tremendous increase in recent years for quality and reliability. The heat treatment process of steels has modified in to various stages with more advancements in recent years. The case hardening operations are quit important to introduce hardness, strength for long life. This surface engineering is a complex process is itself, as a number of variables affect the success of the process and its quality of the components in the manufacturing of automobile parts. Recent industrial survey indicates that there is a rejection of 9–11% of case hardened components due to various defects in the process. It is very much essential to improve the controlling of process parameters. This article highlights a novel processing techniques of heat treatment in surface engineering and also to evaluate the heat treatment process parameters for the case hardening steels.

Keywords: Surface Engineering, Heat Treatment, Case Hardening

Introduction

Automobiles components like Camshaft gears, bearing Surface, and wear resistant, faces on members, which must be tough, shock resistant and capable of carrying high stresses. Industries usually use the low-carbon steel, and it does not respond appreciably to heat treatment. So a special process is required to meet the requirement of automobile industries. The gears require a hard wear resistant surface called the case and a relatively soft, tough, shock resistant inside called the Core. Generally a low carbon steel, contains about 0.1% carbon, will be tough whilst a high carbon steel of 0.9% or more carbon will have adequate hardness when suitably heat treated.

Case hardening process consists of increasing the carbon content of the case in order to provide a hardened case or layer of a definite depth. The carbon is introduced by the process of diffusion from carbon monoxide gas which is brought into contact with the surface at an appropriate temperature (870º–950º C) by some controlled means. The Special processes that are carried at automobile industries, are gas carburising, nitriding and plating processes (Copper plating and phosphating) which are discussed in the following Sections.

GA Carburizing

Gas carburising is carried out in atmospheric furnaces. There are two types of atmospheric furnaces namely batch type and continuous type. In Industry batch type and continuous type furnaces are used. The schematic sketch of one of the batch type furnaces (sealed quench furnace) is shown below.

It is preferable to carry out gas carburizing in the temperature range 850º C–950º C. This treatment ensures the enrichment of the surface layer of steel parts with carbon. Carbon alone is capable of impairing a high hardness of the parts after hardening. The level of the surface carbon content primarily determines the hardness attained.

Whether or not the maximum hardness will be obtained is determined by the transformation behaviour and the cooling rate. Too high a carbon content may lead to a lower hardness value because of a rather incomplete transformation of the structure at room temperature. The remaining soft retained austenite reduces the overall hardness of the surface layer.

The surface carbon content must therefore be optimized. The carburizing effect of the pure Endogas is very weak. In order to increase it the furnace atmosphere is enriched with the natural gas or propane.

Academic Counsellor,
Indira Gandhi National Open University

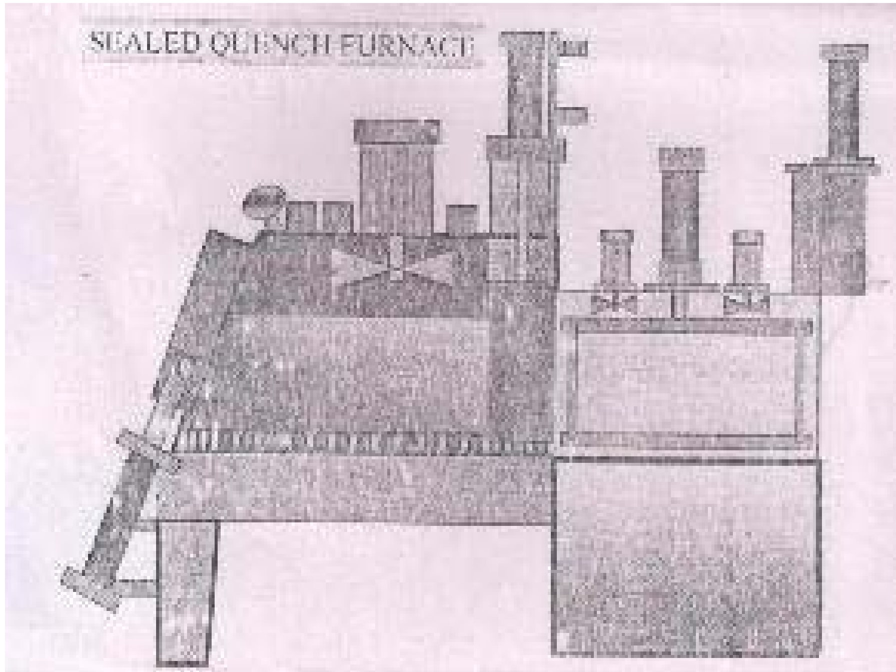

Fig. 1

Total Case Depth and Effective Case Depth

Case depth is defined as "perpendicular distance from the surface of the carburized part to the point at which change in hardness, chemical composition or microstructure of the case and the core cannot be distinguished. This is total case depth of steel. It is not identical with the effective case depth. The effective case depth is dependent not only on the carbon content but also on the quenching conditions and on the transformation behaviour of the steel. Consequently the carbon content at a certain distance from the surface of the part (marked by the upper and lower limit of the effective case depth) has to be increased. Under the given quenching conditions for a work piece the set limiting hardness must be reached between these two points. The carbon content necessary for this is always higher than would be expected.

It cannot be assumed that 99.9% marten site is actually formed in these areas and the curve is only valid in such cases. Carburizing has to be deeper than the respective effective case depth.

The rule of thumb can be taken as:

Effective case depth = 0.7* total case depth

The following equation generally satisfies the relationship between the case depth and carburizing time:

$D = 0\ (t)^{1/2}$

Where D is the total case depth, t is the carburizing time in hours and 0 is the proportionality factor of the material that varies with the carburizing temperature. For low carbon and alloy steels, the values of the proportionality factor is found to be approximately 0.025, for gas carburizing temperature 930º C approximately. Hence the above information can be re written as

$d = 0.025\ (t)^{1/2}$

Another relationship used to determine d is

$d = (31.6*(t)^{1/2})/\{10[6700/(T+460)]\}$

Where T is the carburization temperature.

Surface Carbon Content

During carburization two processes occur simultaneously. Carbon penetrates in to the steel and increases the carbon content of the surface. There is however a simultaneous movement of carbon inwards. As a result of this constant movement of carbon towards the core the surface carbon content reduced, when carburizing for short periods, always built up to the carbon potential expected on the basis of control values. The values will be lower and the shorter for the carburizing time, the lower they will be.

This phenomenon is more obvious with higher temperatures than with lower temperatures. It is therefore advisable to carburize at lower temperatures when shallow case depths are required. Only in this way we can obtain the uniform and adequate supply of carbon to the work piece.

Endothermic Atmosphere

Endothermic atmospheres are generated from natural gas (methane) or from propane or propane/ butane mixtures. They are composed of carburizing, decarburizing and inert components; i.e., of components which will not alter the carbon content of the steel at any temperature. Endogas has various functions:

- It prevents oxidation of the steel parts
- It prevents both carburization or partial decarburization when annealing or hardening, if its carbon potential is adjusted to the surface carbon content
- It acts as a carrier gas when case hardening
- It acts as a diluting agent and is a source of carbon when nitriding

Composition of Endogas

The essential components of the endogases and the effect of the carbon content can be seen in the following table.

With the exception of nitrogen all components react with one another. The atmosphere is regulated, according to the furnace temperature, so that the carbon content of the steel to be hardened remains neutral.

Advantages Gas Carbarizing

When compared to pack carburizing, Gas carburizing is more favourable in heat treatment economics. It eliminates loading and unpacking of boxes. It can be accurately controlled with regard to case depth. This process is rapid and less time is required. The carbon potential can be closely controlled. But skilled personnel are required to maintain necessary control and results are reliable.

Nitriding

In this process, nitrogen is diffused into the surface of the steel being treated. The reaction of nitrogen with the steel causes the formation of very hard iron and alloy nitrogen compounds. The resulting nitride case is harder than tool steels or carbuirzed steels. The advantage of this process is that hardness is achieved without the oil, water or air quench is an added advantage. Hardening is accomplished in a nitrogen atmosphere that prevents scaling and distortion. Nitriding temperature is below the lower critical temperature of the steel and it is set between 925º F and 1050º F. The nitrogen source is usually Ammonia (NH_3). At the nitriding temperature the ammonia dissociates into Nitrogen and Hydrogen.

$2NH3 \rightarrow 2N+3H_2$

The nitrogen diffuses into the steel and hydrogen is exhausted. A typical nitriding set-up is illustrated in Fig. 2.

Table 1

Component	Percentage Volume on Generating from		Effect on the Carbon Content
	Natural gas	Propane	
Hydrogen H_2	39	33	Slightly decarburizing
Carbon monoxide CO	19–21	23–24	carburizing
Methane CH_4	0.1–0.5	0.1–0.5	carburizing
Carbon dioxide CO_2	0.2–0.25	0.3–0.35	decarburizing
Water vapour H_2O	.6–.8	.6–.8	Strongly decarburizing
Nitrogen N_2	Rest	Rest	Inert

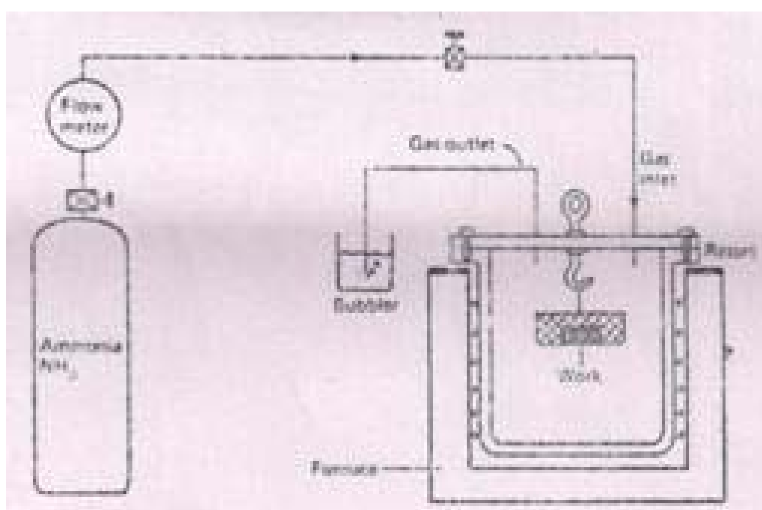

Fig. 2

The white layer shown in Fig. 2 has a detrimental effect on the fatigue life of nitrided parts, and it is normally removed from parts subjected to severe service. Two stage gas-nitriding processes can be used to prevent the formation of white layers. White layer thickness may vary between 0.0003 and 0.002 in., which depends on nitriding time. The most commonly nitrided steels are chromium-molybdenum alloy steels and Nitralloys.

Surface hardnesses of 55 HRC to 70 HRC can be achieved with case depths varying from 0.005 in to 0.020 in. Nitrided steels are very hard and grinding operations should not be performed after nitriding.

Advantages of Nitriding

In Steel, very high surface hardness may be obtained and it has good wear resistance and nitrided parts retain hardness up to 500ºC. The nitrided parts are not quenched the minimum distortion or cracking is got.

But the cost is high and technical Control is required. If a nitride component is accidentally over heated, the surface hardness will be lost and it requires again nitriding. Long cycle time upto 100 hours for 0.038 mm depth. The special alloy steels, which contains Aluminium, Chromium and vanadium can be satisfactorily treated.

Conclusion

In this paper, Gas Carburizing and Nitriding process plays an important role in the manufacture of components like Gears, gauges, Bushings, Value seats Which are used widely in automobiles and other transportation sectors, higher wear resistive is build and its commercially viable. The machining properties are also good and can be used for increasing material life. The effects of these two process are examined and the influential properties are found to be higher hardness and durability. This improves the performance of automobiles and economic benefits are high because of its enhanced properties. Thus by adopting this technique, the manufactured parts have been made not only energy efficient but are operated with reduced maintenance leading to cost Savings.

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Investigation into the Propensity of Coal for Spontaneous Combustion using Adiabatic Oxidation Method

Ravi Varma Rambha[1]

Abstract Adiabatic oxidation tests were carried out on pulverized coal samples. Spontaneous heating potential was measured according to total temperature rise (TTR) while considering temperature rise versus time curves. The effect of moisture content of coal, relative humidity of airflow, airflow rates, coal size fractions, nitrogen suppression and prior oxidation were studied. Results demonstrated that humidity of air is an important factor in deciding whether heating will progress or not. Particle size affected the TTR values whereby oxidation rate of coal increased with decrease in particle size up to a critical diameter below which dependence ceases. A relationship was derived between rate of oxidation and oxygen concentration. Aged or pre-oxidized coals had shown lower TTR values and is shown to be function of initial temperature and time.

Keywords: Coal, Spontaneous Combustion, Adiabatic Oxidation.

Introduction

Spontaneous combustion of coal is initiated by low temperature oxidation of coal that takes place whenever it is in contact with atmosphere [1].

$$C + O_2 \rightarrow CO_2 + 394 \text{ kJ/mol} \quad (1)$$

$$2C + O_2 \rightarrow 2CO + 170 \text{ kJ/mol} \quad (2)$$

This process is an exothermic reaction in which heat generated is dissipated by conduction and convection. If heat generated from the process is greater than heat lost, spontaneous combustion is likely to occur.

Coal oxidation obeys an Arrhenius type rate law, whereby the reaction rate increases exponentially with increased temperature [2].

$$R_i=A_r{}^{-E_r/RT} \quad (3)$$

Where, R_i–reaction rate (W/m^3); A_r–Arrhenius frequency factor (s^{-1}); E_r–Activation energy (kJ/mol); R–universal gas constant; T–Temperature (°C). This type of reaction accounts for the runaway phenomenon. Oxidation of coal that is barely warm can accelerate to the point where spontaneous combustion occurs, and visible fire breaks out.

Self-heating of coal is also observed to decrease with time. This is attributed to the number of active coal particles available. With time a drop in temperature is experienced. The Elovich equation is often used to model this phenomenon [1].

$$dq/dt = a\, exp(-\alpha\, q) \quad (4)$$

Where, q-amount of oxygen taken up per unit mass of coal; α-empirical constant in Elovich equation; a-empirical constant in Elovich equation.

Coal oxygen reaction is governed by extrinsic and intrinsic factors [3-6]. Moisture content in coal can either inhibit or accelerate coal oxidation process [7]. With adsorption and desorption of water, heat is produced due to condensation and vaporization [8]. Heat evolves as moisture physically bonds with dry coal particles and the process is termed as heat of wetting [9]. Effect of increasing particle size, on reactivity, is decreased accessibility of oxygen to internal surfaces of coal [10].

Methodology

Samples of coal, pulverized to grind size of -75µm to +300µm, and weighing 200g, was placed in the reaction vessel encased in a calorimeter (Figure 1) for drying at a preset temperature. The reaction vessel consisted of thermostat cabinet with thermocouples connected to a temperature control unit.

Calorimeter and reaction vessel were set to the adiabatic oven mode at an initial temperature of 40°C using the temperature control unit. Coal samples were dried inside the reaction vessel under nitrogen flow at 40°C for approximately 18 hrs to ensure sample was moisture free. After sample temperature had stabilized, oven was switched to remote monitoring mode and gas selection switch turned to oxygen with a constant flow rate of 200 cc/min. Temperature change with time during oxidation process was recorded by a data logging system.

E-mail: [1]ravivarma.rambha@gitam.edu

[1]GITAM University, Hyderabad, India

Adiabatic oxidation tests were carried out on coal samples at an initial temperature of 40°C to mimic typical conditions in a coal milling plant. Self-heating rate was monitored for approximately 8 hours. Initially self-heating increased at constant rate. Approximately after 4 hrs of testing there was no increase in temperature rise. Total temperature rise (TTR) was considered as the difference between the initial temperature and the maximum temperature observed expressed in °C. Results obtained in this study have been presented as self-heating curves to enable comparison under varying conditions.

Tests were carried out to determine the most suitable airflow rate by changing the airflow rates entering the reaction vessel. Airflow rates of 150, 200 and 250 cc/min were used under the conditions of dried coal and saturated air. Tests with 200 cc/min showed the maximum oxidation potential of the coal sample and this was chosen as the standard flow rate for tests throughout this study.

To check accuracy and sensitivity of the apparatus and verify the self-heating curve is representative of coal sample, repeatability tests were carried out. Tests were conducted with a high volatile bituminous coal sample throughout this study. Proximate analysis of the coal sample was fixed carbon content of 40.7%, volatile matter of 29.4%, ash content of 12% and calorific value of 17,282 kcal/kg. Up to four tests were conducted for a given sample. Variation in total temperature rise between each test was within ±0.5°C.

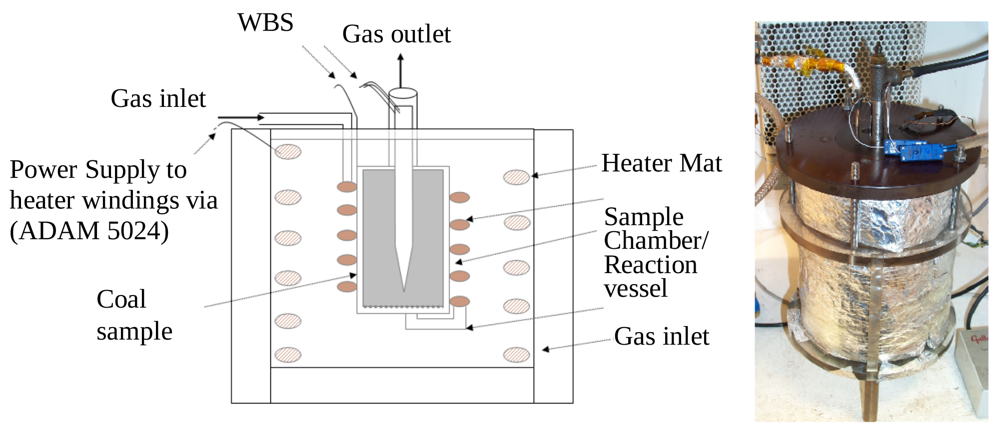

Fig. 1 Schematic diagram of reaction vessel within the calorimeter. picture of the calorimeter installed with air and nitrogen flow inlet and outlet, thermocouples connected to data acquisition and temperature control unit

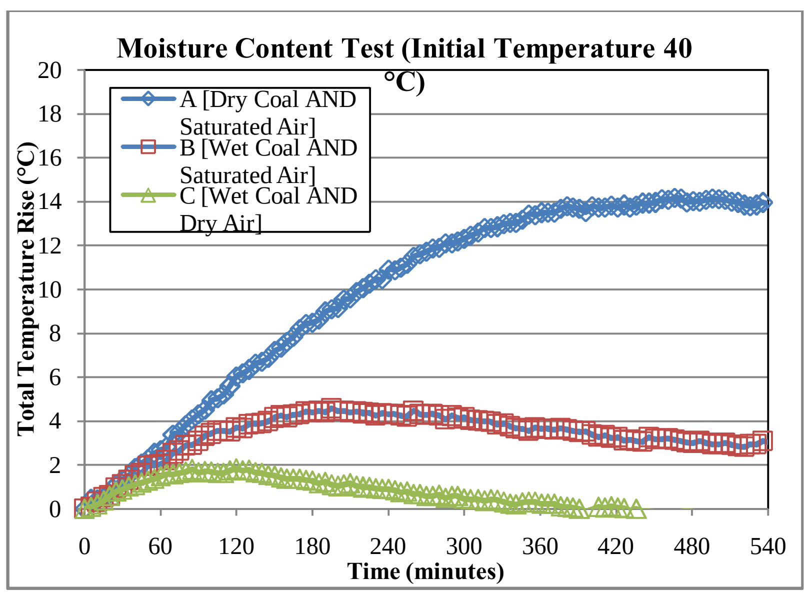

Fig. 2 Self-heating curves for coal sample tested under dry coal & saturated air [curve A]; wet coal & saturated air [curve B]; wet coal & dry air [curve C]

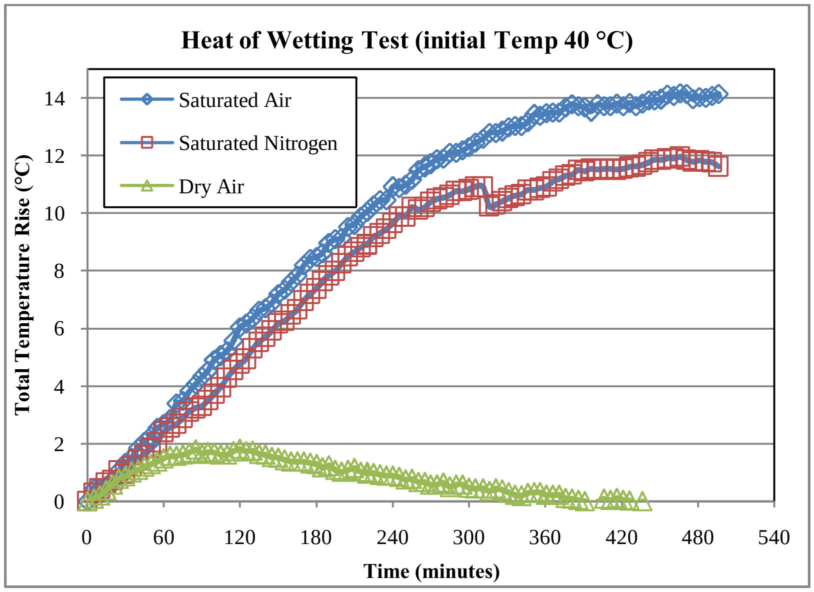

Fig. 3 Self-heating curves for the combined effect of moisture and O_2; saturated N_2(heat of wetting); and dry O_2

Results

Moisture Content Test

Following tests were carried out:

- *A:* Dry coals at initial temperatures of 40°C (equilibrated with dry nitrogen gas flow), with a saturated airflow at 200 cc/min at 100% relative humidity (r.h.).
- *B:* Wet coals (equilibrated at 40°C with wet nitrogen) at moisture content of 100% r.h., with dry airflow at 200 cc/min of 0% r.h.
- *C:* Wet coals (equilibrated at 40°C with wet nitrogen) at moisture content of 100% r.h., with wet airflow at 200 cc/min of 100% r.h.

Results indicated that when moisture content of the coal is in excess of that of the airflow, the temperature of the coal falls below 40°C after an initial temperature rise (figure 2-curve C). The wet coal sample (relative humidity of air in contact with coal was measured 100%) reacted at 40°C with dry air (at 0% r.h.).

Curve B of Fig. 2 shows the heat generated by the adsorption of moisture onto the coal surface. In this case a wet sample (100% r.h. with wet nitrogen) reacted at 40°C with air of 100% r.h. When air containing moisture was used under same conditions a temperature rise up to 4.2°C was recorded. This effect is further illustrated by curve A of Fig. 1. In this case a dry coal sample (5% r.h. of air in contact) reacted with airflow of 100% r.h. The heat generated has increased up to 14°C for given coal sample. These results demonstrated that humidity of air is an important factor in deciding whether self-heating will progress or not.

Heat of Wetting Effect on Self-Heating of Coal

To examine role of moisture as an oxidation catalyst coal sample was tested under both oxidizing (O_2) and non-oxidizing (N_2) conditions at a moisture content of 100% r.h. and flow rate of 200 cc/min. Figure 3 shows results of the heat of wetting test. Temperature rise with saturated N_2 (heat of wetting) and temperature rise with saturated air as the test gas at initial temperature of 40°C is shown. The sample reached a maximum temperature rise of 14°C with saturated air, whereas with saturated N_2 maximum temperature rise was up to 11.8°C.

Despite the absence of oxygen, self-heating due to saturated N_2 accounted for approximately 80% of total temperature rise. The shape of the curve indicates that the oxidation process for this coal is initially very rapid due to the adsorption of moisture. The coal becomes less reactive at later stages, as oxidation process cannot be sustained for longer periods.

In the test with dry air, coal sample reached a maximum temperature rise of just 1.8°C. The shape of the curve indicates that oxidation can sustain self-heating in the absence of moisture during the initial stages. But, at later stages, the temperature of coal falls due to latent heat of the moisture as it evaporates.

In comparing temperature histories in these tests with saturated N_2, and saturated air, it was demonstrated that the heat of wetting is a significant factor in self-heating of coal at low temperatures.

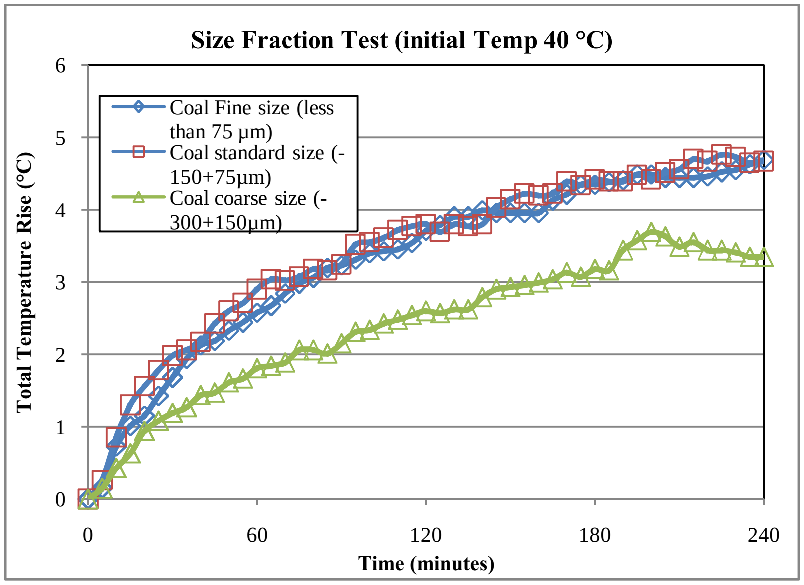

Fig. 4 Self-heating curves for size fraction test on coal samples for Fines [-75mm]; standard size [-75+150mm] and coarse size[-150 +300mm]

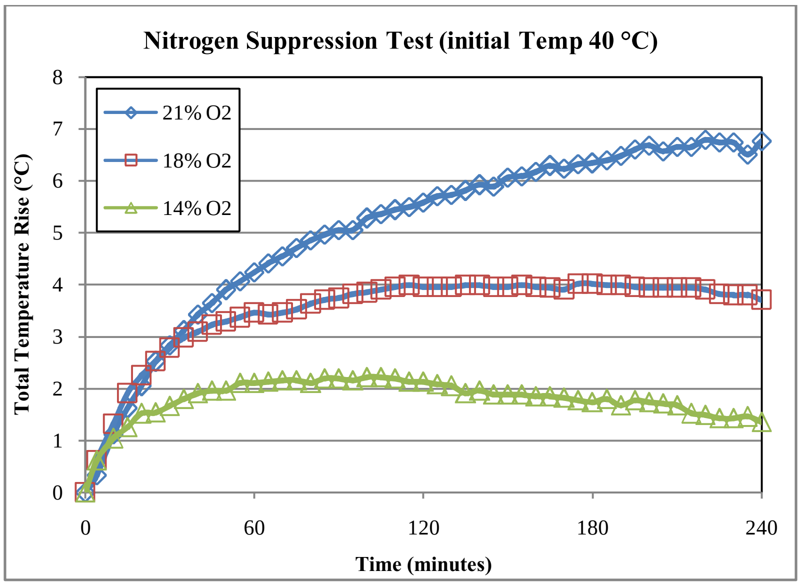

Fig. 5 Self-heating curves for coal at 21%; 18% and 14% O_2 by volume

Size Fraction Test

Effect of increasing the particle size on the self-heating of coal was examined in this study. Three samples of coal of increasing particle diameter were used. Proximate analysis of the coal sample was fixed carbon content of 45.3%, volatile matter of 30.7%, ash content of 8.9% and calorific value of 21,118 kcal/kg. The tests were conducted under standard conditions and results are shown in Fig. 4.

These results indicate a dependence of temperature rise on particle size, down to a particle diameter of 75 to 150µm.

The oxidation rate of coal increases with a decrease in particle size, up to a critical diameter of 75µm. Beyond this particle size dependence ceases. Increased reactivity is due to increased accessibility of oxygen to internal surfaces of coal sample with decreasing particle sizes.

However, based on the above conclusion, one may have expected a greater temperature rise with the fines coal sample (less than 75 µm) when compared with standard size fractions

(-150+75µm). Results have demonstrated that self-heating rate is identical and this may be due to agglomeration of ultra fine particles, causing particles to behave as larger particles.

Nitrogen Suppression Test

To investigate effect of O_2 availability on the self-heating of coal, a coal sample was exposed to flows containing 21%, 18% and 14% O_2 by volume. The coal sample had fixed carbon content of 53.1%, volatile matter of 24.7%, ash content of 13.5% and calorific value of 19,735 kcal/kg. Tests were conducted under standard conditions to determine total temperature rise. Results are shown in figure 5.

The tests with 21% O_2 showed total temperature rise of 6.7°C. Reducing the O_2 concentration to 18% decreased total temperature rise to 4°C. At an O_2 concentration of 14%, the temperature rise was just 2.2°C, a decrease of 67% compared to the test with 21% O_2.

Results showed a decrease in reactivity due to O_2 deficiency. It was found that effect on rate of oxidation differs little regardless of type of coal. Following relationship was derived between the rate of oxidation and the corresponding O_2 concentration:

$$R_1 / R_2 = \{(O_2)_1 / (O_2)_2\}^{0.38} \quad (5)$$

Where, R_1 *and* R_2–rate of oxidation, $(O_2)_1$ *and* $(O_2)_2$– oxygen concentration. These results are in qualitative agreement with the above equation. The measured rate of temperature rise was proportional to the O_2 concentrations in contact with coal raised to the power *0.38*.

Ageing Test

Partial oxidation occurs due to exposure of coal surface to air during sample handling and storage.

Total temperature rise recorded over a period of 60 days is shown in figure 6. These results show that for a stored sample of particle size of–212µm, total temperature rise dropped by 5.2°C. It is clear that an oxidation effect due to ageing has taken place even though samples were stored under controlled conditions. Internal pores of coal are blocked by prior oxidation during preparation and drying of samples. Since oxidation is dependent on diffusion of O_2 into the pores, this has caused rate of oxidation to drop.

Rapid drop in total temperature rise from 12.2ºC to 10.5ºC from day 56 to day 60 was recorded. The decay plot for total temperature rise can be expressed by (6):

$$T_R = T_i\, t^b \quad (6)$$

Where, T_R is maximum temperature rise, T_i is the initial total temperature rise value at $t = 1$, t is time in days, b is a constant that is dependent on sample particle size and storage method. The value for b of *–0.006* was obtained from the line of best fit for these results.

Discussion

Self-heating of coal is most dominant when dry coal was exposed to humidified airflow. Results demonstrated the moisture effect on early stages of self-heating. Humidity of air in contact with the coal is an important factor in deciding whether heating will progress rapidly or not. In a coal mill it is likely that pulverised coal dust will accumulate at some ‘dead’ corners and gradually dry out. When saturated air is introduced, this ‘settled’ coal dust could absorb moisture and release heat, which may provide initial energy for heating. On the other hand, when moisture content of coal is in excess of surrounding atmosphere, temperature of coal falls due to latent heat.

Heat of wetting was shown to be a significant factor in the initial stages of self-heating of a coal mass although it is unlikely heat generated by wetting alone will be sustained at later stages because of limited pore surface area available for moisture desorption.

Oxidation of coal increases with decrease in particle size, down to a critical size up to 150 µm below which dependence ceases. Total surface area available is independent of particle size diameter below this critical size. Also, ultra-fine size fractions may behave as larger particles due to agglomeration, suppressing the reactivity of coal. Nitrogen suppression test indicated the measured rate of temperature rise was proportional to the oxygen concentration in contact with coal raised to power 0.38. The ageing effect follows a power function of the form: $T_R = T_i\, t^{-0.006}$. The self-heating potential decreased noticeably due to pre-oxidation effects.

Conclusion

This study has shown that many factors, other than coal rank, must be considered to define the risk of coal to spontaneous combustion in coal mills such as flow rates, relative humidity, particle size distribution, nitrogen suppression, and ageing of coal. Choice of coal tested was predominantly sub-bituminous. Further study would be of value to investigate the self-heating propensity of high rank anthracite and low rank lignite coals to be able to obtain statistical correlations.

The practical application of knowledge obtained from the laboratory investigations presents an opportunity for further research. Although many of the factors that can be controlled in the adiabatic calorimeter may not be applied without problems in a coal mill, results obtained in this study could be used as a relative index to the propensities of coal to spontaneous combustion. These results will provide information to identify factors responsible for self-heating and enable appropriate design of a coal mill to minimize risk and consequent loss of calorific value.

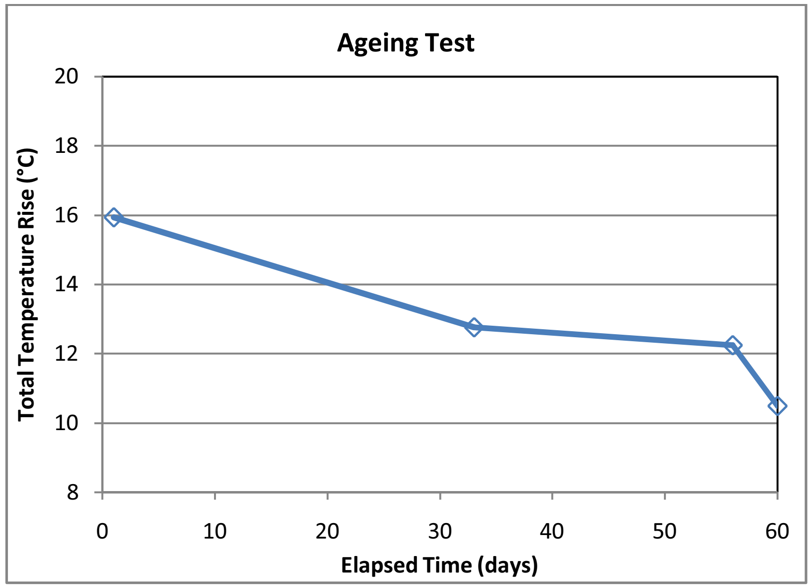

Fig. 6 Decreasing trend in total temperature rise with sample age

Acknowledgment

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Group E

- **Chemical Engineering**
- **Textile Engineering**

Developing an Alternative to Benzene in the Flame Propagation Inhibitor Formulation used in Solid Propellant Rocket Motor

A. Sreekanth[1], O. Sai Siddhartha[2], D. Gokul[3], P. Lalitha Devi[4] and P. Kanakaraju[5]

Abstract Benzene is used as a catalyst dispersant in the inhibitor formulation used in Solid Propellant for Rocket Motor. Benzene is one of the excellent industrial solvent well known for its compatibility with various organic and organo-metallic moieties. It is being used extensively in industry considering its chemical inactivity, boiling point, viscosity, commercial availability etc. However, from the pollution point of view, this solvent needs replacement as its threshold limit value (TLV) is very low thus prone to cancer. Solid rocket motor while combustion spreads the flame in all directions geometrically perpendicular to the surface of burning. Whenever a propellant designer finds locations where flame shall not approach, he needs to inhibit the burning surface. PSLV booster motor for example needs only radial burning whereas the production creates axial surfaces too. A chemical inhibitor is applied over to-be-inhibited surfaces which uses benzene as a solvent for reaction catalyst. The present paper proposes to replace benzene with relatively low toxic (higher TLV) Toluene. The paper studies the shift in the essential properties of the product and comes to the conclusion that the figure of merit accepts toluene as a catalyst solvent.

Keywords: Benzene, Inhibition, Propellant, Toluene

Introduction

Benzene is a colourless and flammable liquid, with a sweet and gasoline-like odour. Benzene is well-known solvent and a general purpose chemical in industry for many decades. A summary of its importance and places where it is being used is described in Wikipedia and many other illustrious textbooks [1, 2, 3, 4]. As per one estimate, more than half of the entire benzene production is processed into ethylbenzene, a precursor to styrene, which is used to make polymers and plastics like polystyrene and EPS. Another 20% of the benzene production is used to manufacture cumene, which is needed to produce phenol and acetone for resins and adhesives. Cyclohexane consumes nearly 10% production, which is primarily used in the manufacture of nylon fibers, which are processed into textiles and engineering plastics. Smaller amounts of benzene are used to make some types of rubbers, lubricants, dyes, detergents, drugs, explosives, and pesticides.(Fig. 1) While it is useful chemical substance, at its outset it is a toxic chemical, and continuous exposure to it can have cancerous effects. This is because benzene is a carcinogen, which means it is a chemical or agent that can potentially cause cancer.

The U.S. Occupational Safety and Health Administration (OSHA) have set a permissible exposure limit of 1 part of benzene per million parts of air (1 ppm) in the workplace during an 8-hour workday, 40-hour workweek[2, 5]. The short term exposure limit for airborne benzene is 5 ppm for 15 minutes. These legal limits were based on studies demonstrating compelling evidence of health risk to workers exposed to benzene. The risk from exposure to 1 ppm for a working lifetime has been estimated as 5 excess leukaemia deaths per 1,000 employees exposed. OSHA has also established an action level of 0.5 ppm to encourage even lower exposures in the workplace [5]. Solid rocket motor while combustion spreads the flame in all directions geometrically perpendicular to the surface of burning. Whenever the propellant designer finds locations where flame shall not approach, he needs to inhibit the burning surface. The designer carefully controls the grain burn surfaces throughout the combustion of rocket motor by articulating the grain initial geometry and the inhibited or restricted boundaries. PSLV booster motor for example needs only radial burning whereas the production creates axial surfaces too. The inhibition is also a polyurethane/ polymer matrix with solid powders dispersed. The function is exactly similar to that of propellant, i.e., while application it is in liquid state whereas at the time of use it should be in solid phase that means it should develop hardness at room temperature. Coming to solids, flame resistant, i.e., those which cannot react and degrade its form at high temperatures (Propellant flame temperatures) and adverse chemical environment (Propellant oxidative flame) are used.

E-mail: [1]sreekanth.a@shar.gov.in

[1,5]Solid Propellant Space Booster Plant, Satish Dhawan Space Centre, Sriharikota

[2,3,4]Systems Reliability, Satish Dhawan Space Centre, Sriharikota

This property in general is called charring in case of carbonaceous materials and refractory in case of solid materials. The selection of polymeric matrix chemicals and solid materials is principally dependent on this criterion. The polymer matrix selected is thermosetting polyurethane and the solids are principally treated asbestos fibre and some amount of fire resistant ferric oxide. Properties that are required for an effective inhibitor are low thermal conductivity, resistance to thermal degradation, resistance to creep in the presence of gas flow, good bonding characteristics, low cost and availability. The cure reaction of selected polymer matrix in general responds to organometallics such as Fe, Sn based dilaurates and acetylacetonates although many accelerators are in vogue. The present system uses Iron acetylacetonate dispersed in benzene as the solubility of FeAA in benzene is significantly large. The catalysed cure reaction is exothermic and reaches to 20-25^{0}C more than the room temperature for a given volume. Benzene is stable even at the cure exotherm. Although it evaporates to certain extent during the catalysis it will not leave any porosity at the end of the reaction in the solid phase. The adverse effects of benzene are recorded medically at the later part of the benzene utilization history. This heritage material needs to be replaced case by case due to the OSHA standards on health of bio-systems in general and human being in particular. Toluene is now often used as a substitute for benzene. The solvent-properties of the two are similar, but toluene is less toxic (Table 1). The scope of this paper is to investigate whether toluene can replace benzene in our case. It is of particular interest to know whether toluene while evaporation at cure isotherm leaves any porosity in the solid phase, besides achieving the properties of the inhibitor and the properties of the inhibitor-propellant interface.

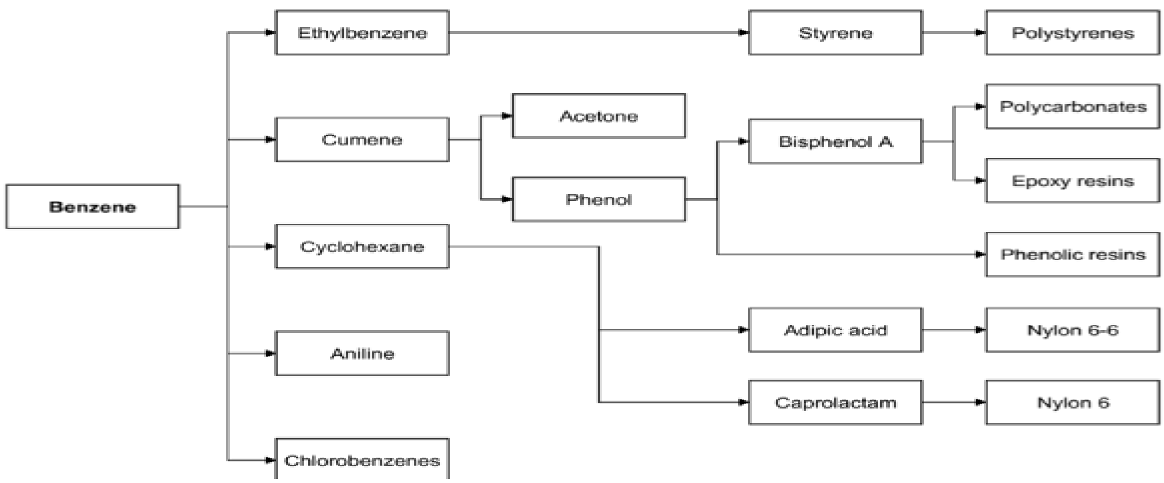
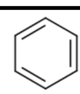
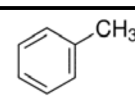


Fig. 1 Typical commercial uses of benzene

Table 1 Comparison between benzene and toluene

S. No.	Properties	Benzene	Toluene
1.	Structure		
2.	Molecular formula	C_6H_6	C_7H_8
3.	Molar mass	78.1121 g/mol	92.14 g/mol
4.	Appearance	Colourless liquid	Clear, colourless liquid
5.	Density and phase	0.8786 g/cm^3, liquid	0.8669 g/cm^3, liquid
6.	Solubility in water	1.79 g/L (25 °C)	0.053 g/100 mL (20-25°C)
7.	Melting point	5.5 °C (278.6 K)	− 93 °C (180 K)
8.	Boiling point	80.1 °C (353.2 K)	110.6 °C (383.8 K)
9.	Viscosity	0.652 cP at 20 °C	0.590 cP at 20°C
10.	Flash point	− 11 °C	4 °C
11.	TLV	1 ppm	200 ppm

Experimental Study

Process Conditions

All the experiments were carried out keeping the process conditions similar to that of the existing process of inhibition production and results were compared to remove process uncertainty in evaluating the results.

Materials and Composition

The existing inhibitor is a thermosetting polymeric matrix which has hydroxyl terminated molecules (Modified Castor Oil) as binder, 2.4-toluene di-isocyanate as the curator[6]. This reaction is promoted by Iron ferric acetylacetonate dispersed in benzene. The typical formulation of the inhibitor is given in Table-II. In general, in this plant, inhibitor is prepared in two stages, viz., premix stage made in bulk multiples of 500kg and final mix stage made in multiples of 1.0 kg. During the premix the solids are dispersed in castor oil and allowed to dry to required volatile matter. In the final mix, the premix is added with the curator and catalyst solution. The catalyst solution is a 95% w/w FeAA in benzene. The quantity required for catalysing is 0.1% w/w of polymer matrix. In the proposed experiment all the materials and composition is kept same on w/w basis except that benzene is replaced by toluene. That is in the proposed scheme also the catalyst quantity is 0.1% w/w of polymer matrix. The general scheme for qualification of the new solvent and functionality proving its applicability for use in solid motors is broadly classified into two ways namely, characterization w.r.t product and propellant. The following series of experiments were conducted to characterize the chosen solvent.

Estimation of Gelation Time

This study is carried out to determine the pot life of the final mix. For this purpose, final mix is poured into a clay mold of 150 X 150 X 5mm size and the flow ability is monitored w.r.t time. The time at which the material ceases to flow is decided as the pot life for that particular mix.

Estimation of Porosity

The porosity is visually inspected by casting an inhibitor slab (150 X 150 X 40mm). 40 mm thickness is selected because the total inhibition thickness at any surface is about 20 mm. Several thickness slabs were made and dissected for visual inspection of porosity/voids or any other abnormal observations.

Fig. 2 Process of pouring and preparing the sample for gelation study

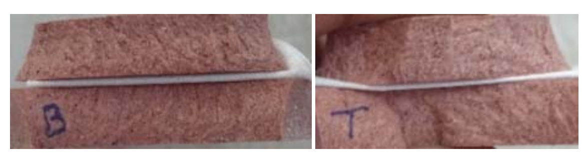


Fig. 3 Preparation of porosity samples and inspection of dissected surfaces

Table 2 Typical composition of the existing inhibitor including curator

S. No.	Ingredients	%(Wt.)
1.	Castor Oil	50-55
2.	Asbestos	30-35
3.	Ferric Oxide	0.4-0.5
4.	Anti-oxidant	<1
5.	TDI	10-15

Estimation of Uniaxial Mechanical Properties and Density

The mechanical properties are measured using the universal testing machine (INSTRON make). A sample of size 5mm is mounted on the machine and held in position by pneumatic grips and the load is gradually applied. The stress strain curve is plotted by the machine. The mechanical properties like Ultimate tensile strength, maximum elongation at break are obtained from this plot. The test samples are generally conditioned in a desiccator at controlled humidity to remove moisture content from the sample. The surface hardness of the cured inhibition slab is determined using the durometer on A scale. The density is measured based on Archimedes apparatus.

Study of Ablation & Estimation of Char Rate

The very important property needed for inhibitor is not to soften, yield and melt drop-wise at flame temperature. This nature is generally called ablative property. Char rate is another measure of combustion rate expressed in mm/s. Generally, an ablative property is qualitative whereas char rate is measured as a consumption of material in cylindrical form where the cross-sectional area is constant and symmetric at 300 W/m^2 equivalent to flame temperature of propellant. Charring is a chemical process of combustion of carbonaceous material into carbon even in oxidative atmosphere. That is the polymer matrix instead of becoming CO_2/CO forms C(Amorphous). In certain scenarios this process is also called graphitization and is generally carried out in the absence of oxidative atmosphere. The inorganic fillers will be embedded in this amorphous carbon without spalling.

Estimation of Inhibitor-propellant Interfacial Strength

Since the inhibitor is applied in the liquid form onto the propellant surface and allowed to cure to solid state the bonding between inhibitor and propellant becomes significant. If the bond is not sufficiently strong, while rocket is travelling against gravity propellant tries to debond from inhibitor creating enormous surface for flame to approach and burn. The general interface property that is characterized is tensile bond strength even though other interface failure modes are important. A 25 X 25 X 50mm propellant block was bonded with the inhibitor (25 X 25 X 15mm) on either side of the propellant block. This sample is bonded with metallic supports to fix to the INSTRON.

Results & Discussion

The results of various experiments carried out to determine the suitability of toluene as a replacement for benzene are tabulated below. Table 3 describes the results of the gelation studies, mechanical and interface properties and density whereas Table 4 provides the char rate. Ablative characteristics are described qualitatively in Fig. 1 that the material given under oxyacetyleneflame couldn't soften, melt or spalled out. The results clearly illustrate that all the properties of inhibitor prepared using toluene as catalyst solution w.r.t product as well as propellant are comparable with the results obtained using benzene as catalyst solution.

Table 3

Gelation Studies	% Catalyst Solution per 100gm of premix(ml)	Benzene	Toluene
		Pot life, minutes	
	0.5	209	215
	1.0	130	145
	1.5	101	115
	2.0	88	99
Mechanical Properties	Tensile strength, ksc	16.6	17.7
	Elongation,%	59	61
	Hardness, Shore A	72	72
	Density, gm/cc	1.26	1.26
Interface property	Tensile bond strength, ksc	8.72	9.85

Table 4

Property	Benzene	Toluene
Char rate, mm/s	0.33, 0.32, 0.29	0.31, 0.32, 0.29

Fig. 4 Ablative characteristics study

Conclusion

The replacement of benzene at one side reduced the risk of operator by many fold as seen in TLV. It has not adversely interfered with the properties required for a good inhibition for ISRO solid rocket motor. This was seen in gelation time which talks about the processability, mechanical properties needed for withstanding the forces on inhibitor while rocket travel, the ablative property which is needed to prevent flame propagation during flame combustion.

Acknowledgements

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Doped Metal Oxide Heterostructures (N, S-TiO_2/Fe_2O_3) for Electrochemical Crystal-Violet Dye Degradation Studies

Dilip Kumar Behara[1], Pooja Sree Palukuru[2] and Vishnu Priya Devangam A.[3]

Abstract Textile industries causes severe environmental pollution due to release of large volumes of dye effluents into water bodies without treatment. These dye effluents are rich in organic matter, and dissolved salts having high concentration of COD. To avoid the dangerous accumulation of dyes in the aquatic environment which hinders the penetration of oxygen, current research efforts are underway to develop powerful oxidation techniques for their removal in textile wastewaters. Present research focuses on the synthesis, characterisation and electrochemical degradation of crystal violet dye using doped metal oxide heterostructures (N, S-TiO_2/Fe_2O_3). The rationale in choosing the above materials (TiO_2, Fe_2O_3) as well as dopants (N, S) in present study will not only account stability, non-toxicity, and high oxidation power but also facilitate the fast charge carrier movements during electrochemical treatment by forming Type-I heterostructure (N-S-TiO_2/Fe_2O_3) with proper band edge alignments. Further, the added dopants (N, S) into host matrix TiO_2 will not only decrease the band gap but also improve the electronic conductivity by occupying the interstitial sites/oxygen vacancy sites. The fabricated heterostructure electrode on Ti substrate (Ti/N-S-TiO_2/Fe_2O_3) shows better electrochemical activity in degrading crystal violet dye in comparison to all other electrode assemblies. Further, the same electrode assemblies were used for 4-nitrophenol to 4-aminophenol catalytic reaction studies.

Keywords: Type-I Heterostructure, TiO_2, Fe_2O_3, Crystal Violet Dye, Doping

Introduction

Electrochemical oxidation is a promising and powerful technology for degradation of organic pollutants from waste water [1]. The main driving force in this process involves generation of hydroxyl radicals ($^{\bullet}OH$) at the anode surface which act as powerful oxidizing agent and destruct the complex molecules into smaller molecules such as CO_2, water and inorganic ions [2-5]. It is mainly preferred over other conventional methods owing to specific characteristics such as environmental compatibility [6], strong oxidation power [7] and versatility, provides safety as it operates under mild conditions, easy handling [8] and cost effective [9]. However, the rate of degradation is slow and low due to inherent catalytic limitations of the catalyst used as anode material. Therefore, the performance of these processes can be improved by proper selection of anode materials which act as better catalysts in degradation of pollutants [10]. The outstanding anode material should be stable, non-toxic, economical, good conductivity and should exhibit good electrochemical activity [11-12].

Semiconductors Metal Oxides as anode materials received a great attention due to their extensive catalytic, electro/photoelectric applications such as water splitting, water purification, fuel cells, electrolytic cells and air purification [13-15]. In recent times, a combination of materials in the form of composite or heterostructure were employed as potential anode materials. The heterostructure assembly will facilitate fast charge carrier transport due to proper band alignment at the heterojunction of the two phases [16]. Among the existing semiconductor materials, TiO_2 and Fe_2O_3 can be chosen as they possess unique and specific characteristics such as strong oxidizing power, non-toxic, highly stable, abundantly available [14, 17-18]. However, TiO_2 suffers from high band gap and faster recombination rate. The optical absorption of TiO_2 material can be improved by doping with suitable non-metals such as Nitrogen or Sulphur [19-20]. The added dopant will occupy either interstitial or oxygen vacancy sites and create mid gap energy states [21]. It is also reported that high surface area and enhanced electro-catalytic activity is attained by co-doping of nitrogen and sulphur atoms on titania lattice (i,e N, S codoped TiO_2) compared to pristine TiO_2 [22].

Herein, we report Doped Metal Oxide Heterostructures (N, S-TiO_2/Fe_2O_3) for Electrochemical Crystal-Violet Dye Degradation Studies. The proposed work comprises synthesis, characterization and fabrication of Type-I

E-mail: [1]dileepbh.chemengg@jntua.ac.in, [2]ppoojasree@gmail.com, [3]vishnu.devangam@gmail.com

[1,2,3]Department of Chemical Engineering,
JNTUA College of Engineering, Anantapur, India

heterostructure (TiO_2/Fe_2O_3) assembly on Titanium substrate for electrochemical degradation of crystal violet dye. Ti substrate is chosen because of its stability, good conductivity and low cost. UV-Vis Spectroscopy was used to analyze and interpret the electrochemical results. Preliminary experimental results predicts that N, S-TiO_2/Fe_2O_3 heterostructure assembly shows better electrochemical performance over all other electrodes.

The outcomes of this proposed work will not only help to understand the degradation mechanism of complex dye molecules but also fetch to design low cost catalysts for better electrocatalytic performance. Further, the same electrode assemblies were used for catalytic reaction studies of 4-nitrophenol to 4-aminophenol conversion, the experiments are under progress.

Methodology

Materials and Methods

Titanium isopropoxide [$Ti\{OCH(CH_3)_2\}_4$], Iron(III) nitrate nonahydrate ($Fe(NO_3)_3.9H_2O$), Ethanol (C_2H_5OH), Ammonia (NH_3), Thiourea ($(NH_2)_2CS$), Sodium sulphate (Na_2SO_4) and Iso propyl alcohol (C_3H_8O) purchased from Sigma Aldrich Chemicals (India) Ltd. Nafion (10%) liquid solution is purchased Dupont Chemicals, USA. Crystal violet dye purchased from Sigma-Aldrich is used as model pollutant in present study. All the reagents were analytical grade and used as received without further purification. All solutions were prepared with distilled water.

Synthesis of N, S co-doped TiO_2/Fe_2O_3 Nanocomposite

150 ml of ethanol and 3.72 ml of distilled water stirred for half an hour. 9 ml of TTIP (Titanium tetra isopropoxide) was added dropwise to the homogeneous mixture and ammonia [2.5 ml], thiourea [5.4 g] was added to the solution and stirred for 4 h at 85˚C followed by centrifuge, drying and calcination at 400˚C for 3 h [23]. Then 10mg of obtained N, S-TiO_2 nanoparticles and 4 g of Fe (NO_3).9H_2O was dissolved in 100 ml of distilled water and was stirred for 30 min. 1.5 g of gelatin was added to 100 ml of distilled water and stirred for 30 min at 60˚C. Then the gelatin solution was slowly added to the iron nitrate solution and stirred for 1 h. Then the obtained gel was dried in hot air oven at 60˚C for 6 h and calcination at 600˚C for 1 h to get N, S-TiO_2/ Fe_2O_3 nanocomposite as shown in Fig. 1.

Electrode Fabrication

40 mg of (N, S-TiO_2/Fe_2O_3) nanoparticles was mixed with 2 ml of isopropanol and 20 µl of nafion solution. It was sonicated for 1 h and the slurry was applied onto the Ti plate (effective electrode surface area~ 1cm^2) and dried at 60˚C on hot plate.

Results

XRD Analysis

To study the crystal structure of synthesized nanoparticles XRD analysis was performed using X-ray diffractometer with Cu K_α radiation (λ = 1.5406 Å). XRD patterns of TiO_2, Fe_2O_3 and N, S-TiO_2/Fe_2O_3 is shown in Fig. 2. The intense peaks at 2θ values of N,S-TiO_2/Fe_2O_3 was observed at 24.3˚, 25.48˚, 30.2˚, 35.76˚, 37.8˚, 43.4˚, 47.8˚, 53.8˚, 62.6˚, 62.8˚ which corresponds to atomic planes of (012), (101), (104), (110), (004), (202), (200), (105), (214), (024) respectively. The diffraction peaks of composite matches with index planes of TiO_2 anatase phase (JCPDS 21-1272) [21, 24-25] and α-Fe_2O_3 (JCPDS 03-0800) [26] which confirms the formation of N, S-TiO_2/Fe_2O_3 nanocomposite.

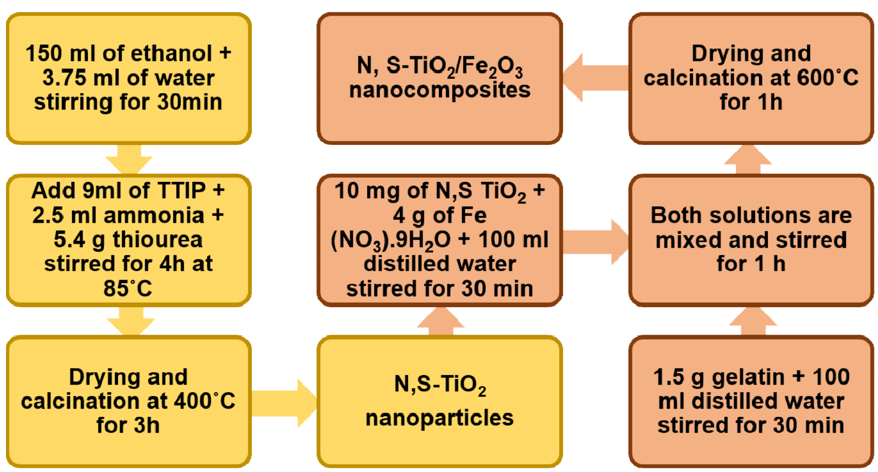

Fig. 1 Schematic representation of synthesis procedure of N, S -TiO_2/Fe_2O_3 nanocomposite

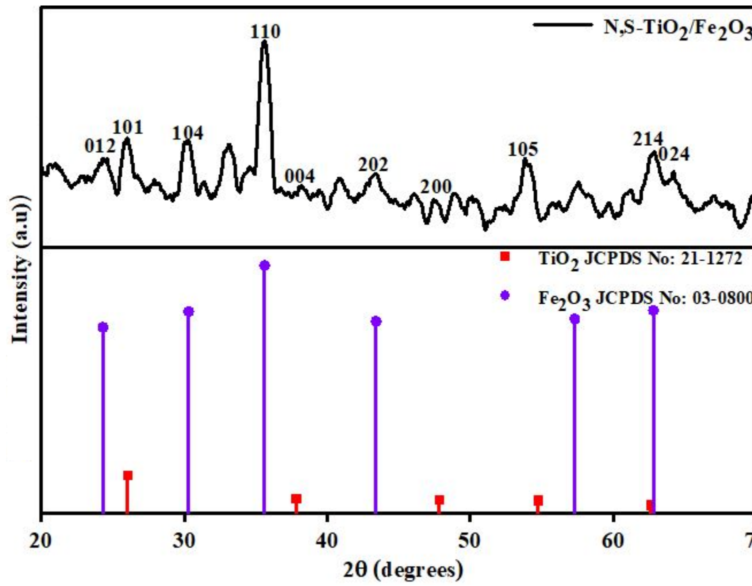

Fig. 2 XRD spectra of N, S-TiO_2/Fe_2O_3 nanocomposite

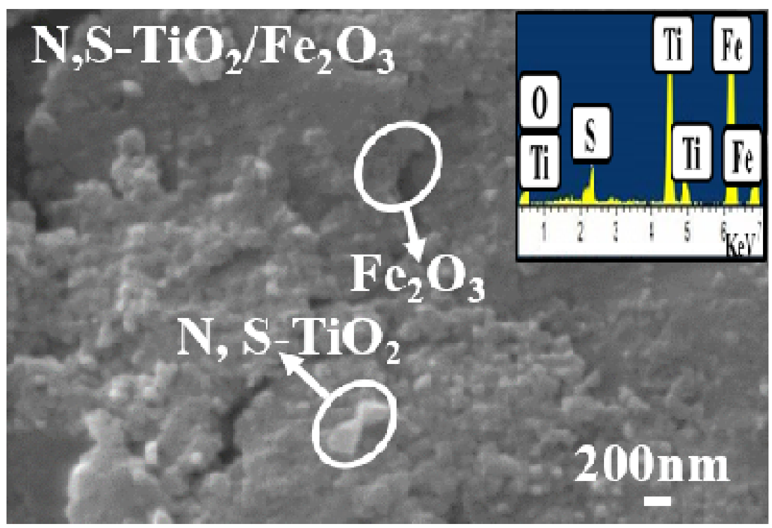

Fig. 3 SEM and EDX (inset) image of N, S-TiO_2/Fe_2O_3 composite assembly

SEM and EDX Analysis

To know the surface morphology and elemental composition of synthesized sample SEM and EDX analysis was performed using Field Emission Scanning Electron Microscopy integrated with Energy Dispersive X-ray Spectroscopy. Fig. 3. represents FESEM and EDX spectra of synthesized N, S-TiO_2/Fe_2O_3 nanoparticles. The irregular shape of N, S-TiO_2/Fe_2O_3 was observed from Fig. 3 which may be due to destruction of crystal lattice upon doping. EDX spectra shown in inset Fig. 3 confirms the presence of Ti, O, Fe and S. Nitrogen was not detected in spectra may be due to the less amount of doping concentration in the sample.

FTIR Analysis

To detect the functional groups present on the surface of sample FTIR analysis was performed (Fig. 4). The band at 665 cm^{-1} corresponds to Ti-O bending mode and the band at 2020 cm^{-1} represents the deformative vibration of Ti- OH stretching modes of TiO_2. The broad band observed at 3483 cm^{-1} signifies the symmetrical and asymmetrical stretching of O-H bonds of TiO_2. The band at 2782 cm^{-1} implies the -NCS stretching vibrations indicates the presence of nitrogen and Sulphur linkages on the surface of N, S-TiO_2 sample [19, 27]. The peak at 583.54 cm^{-1} indicates Fe-O stretching mode, and the band at 1834 cm^{-1} assigned to C-O stretching vibrations, the band at 3452 cm^{-1} represents O-H stretching vibrations of α-Fe_2O_3 as shown in Fig. 4 [28].

UV-Visible Analysis

During the electrochemical decolourization process, the change in absorbance characteristics of the crystal violet dye is observed at different intervals of time by using UV-Vis absorption Spectra analysis. The spectra of crystal violet dye shows a maximum absorbance at 576 nm in the visible region represents the presence of auxochrome groups –N (CH_3) which is accountable for strong color of crystal violet dye. The absorption spectra is collected at different intervals of time during electrochemical treatment. Initially, cyclic voltammetry (CV) curves were generated in order to note down the oxidation/ reduction peaks during electrochemical treatment. The potential (V) applied on electrode surface for electrochemical crystal violet dye degradation was chosen based on cyclic voltammetry (CV) curves. The peak gradually decreases with time indicates degradation of dye molecules upon electro-chemical treatment. The true driving force for degradation of dye molecules is $^{\bullet}OH$ radicals which are generated on electrode surface by the application of potential. N, S-TiO_2/Fe_2O_3 nanocomposite fabricated on Ti substrate is observed to be taken 9 hours for complete degradation of dye. The decrease in absorbance peak upon electrochemical treatment confirms the mineralization of the crystal violet dye as shown in Fig. 5(a). Further, the decolourisation efficiency calculated by using the following formula

$$\% \text{ Decolourization} = (A_0 - A) / A_0 \times 100 \tag{1}$$

Where A_0 and A are the absorbance at the maximum wavelength, λ_{max} of dye solution before and after electrochemical treatment. The percentage (%) decolourisation of crystal violet dye by using N, S-TiO_2/Fe_2O_3 nanocomposites is about 93% and is achieved in 9 hours. The better performance of this sample can be attributed to improvement in electrochemical active surface area (ECSA) [23].

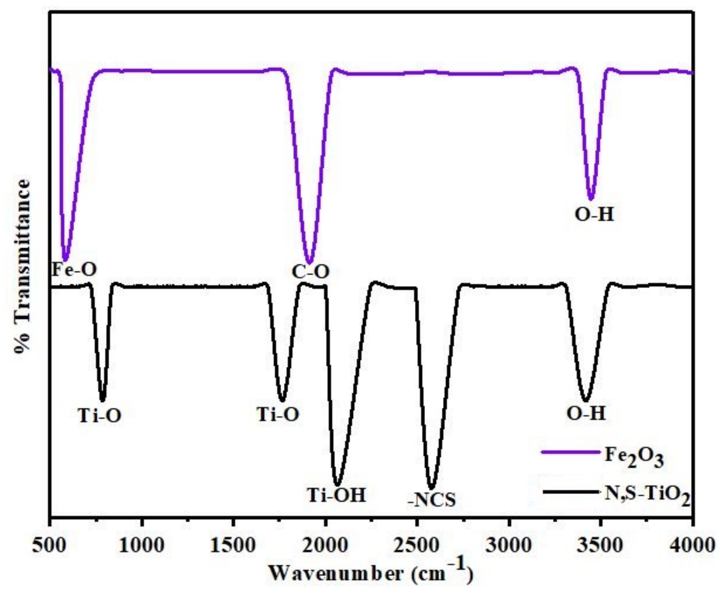

Fig. 4 FTIR spectra of Fe_2O_3 and N, S-TiO_2 nanoparticles

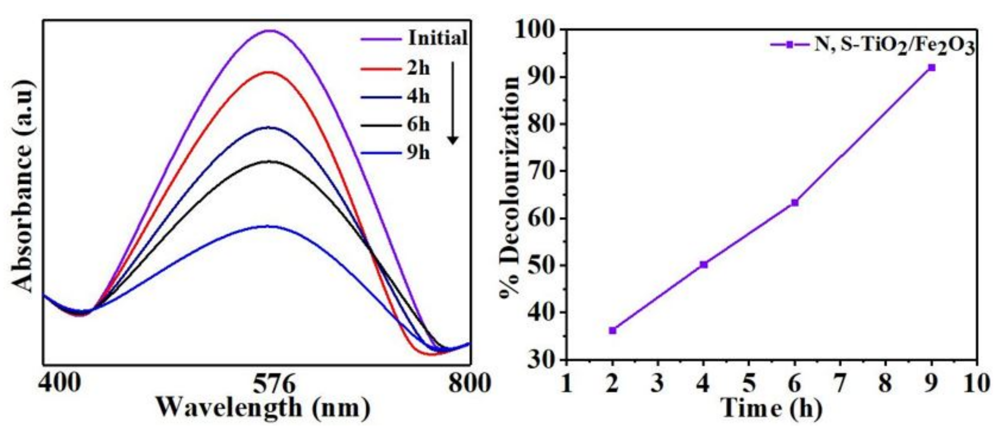

Fig. 5 UV spectra for N, S-TiO_2/Fe_2O_3@Ti and decolourization (%)/Time (h) for N, S-TiO_2/Fe_2O_3@Ti

Conclusions

Present work reports N, S co-doped TiO_2/Fe_2O_3 metal oxide heterostructure assemblies electrochemical performance on degradation of crystal violet dye. The synthesized composite was confirmed using XRD, SEM and FTIR analysis. Electrochemical measurements shows that N, S-TiO_2/Fe_2O_3 performs better in comparison to all other electrode assemblies. The formed Type I heterostructure assembly facilitates free charge carrier flow path and improves the electrochemical performance. Further, the same electrode assemblies were used to carry out the catalytic reduction of 4-nitrophenol to 4-aminophenol reaction and the experiments are under progress.

Acknowledgement

The authors wish to thank Department of Chemical Engineering, JNTUACEA for providing powder X-ray diffractometer facilities for XRD analysis of our samples. Authors, convey special thanks to D. Hima Bindu, for assisting in taking SEM images of our samples at IIT BHU. Further, authors wish to acknowledge OTRI-JNTUA and RIPER for providing UV-Vis and FTIR characterizations of our sample analysis.

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Doped Metal Oxide Heterostructures (N, S-TiO_2/ZnO): Catalytic/ Electro-Catalytic Studies

Dilip Kumar Behara[1], Vishnu Priya Devangam A.[2] and Pooja Sree Palukuru[3]

Abstract Textile/ Leather industries are major pollution causing sources to environment due to release of large amount of untreated wastes having high toxicity. The stringent environmental regulations lead to high cost treatment of industrial effluents before they let into water bodies. The most-economic way of treating the effluents is by utilizing the existing semiconductors in a more rational way. Herein, we report doped metal oxide heterostructures (N, S-TiO_2/ZnO) for catalytic/electro catalytic studies. The rationale in choosing the above materials (TiO_2, ZnO) as well as dopants (N, S) in present study will not only account stability, non-toxicity, and high oxidation power but also facilitate the fast charge carrier movements during electrochemical treatment by forming Type-II heterostructure (N,S-TiO_2/ZnO) with proper band edge alignments. Further, the added dopants (N, S) into host matrix TiO_2 will not only decrease the band gap but also improve the electronic conductivity by occupying the interstitial sites/oxygen vacancy sites. 4-nitrophenol to 4-aminophenol reaction is chosen as model for catalytic studies. The reaction kinetics with temperature as well as the rate limiting mechanism is reported. Further, the same electrode assemblies were used for electrochemical crystal violet dye degradation.

Keywords: Type-II Heterostructure, TiO_2, ZnO, Crystal Violet Dye, Catalytic, Doping

Introduction

Semiconductor Metal Oxides are considered to be most appropriate for catalytic, electro-catalytic and photo-electro catalytic applications [1]. In contemporary research, they are extensively used for dye degradation, wastewater and other pollutant treatment studies [2, 3]. The specific properties of semiconductor materials such as high oxidation power, non-toxic, stable, and low cost make these materials feasible for different applications [4]. In recent times, a combination of materials in the form of composites or heterostructures shown to perform better than individual material phases [5]. The formed heterostructure will reduce the charge carrier recombination rate by facilitating faster charge carrier transport across material interfaces [6]. Therefore, it is essential to choose proper band alignment materials to harness required properties for specific applications. Among the existing metal oxides, TiO_2 and ZnO materials are preferred electro-catalysts owing to specific properties such as chemical inertness, strong oxidizing power, non-toxicity, environmental benign and long-term stability [7, 8]. However, material like TiO_2 suffers from high band gap and faster recombination rate. The band gap of this material can be reduced by doping with suitable non-metals such as Nitrogen or Sulphur [9-12]. The added dopant will occupy either interstitial or oxygen vacancy sites and create mid gap energy states and shifts the optical absorption to visible region [13].

Herein, we report Doped Metal Oxide Heterostructures (N, S-TiO_2/ZnO) for electro-catalytic studies. The model reaction we chosen in this work is electrochemical degradation of Crystal-Violet Dye. The proposed work comprises synthesis, characterization and fabrication of Type-II heterostructure (TiO_2/ ZnO) assembly on Ti substrate. Titanium (Ti) substrate chosen because of its stability, good conductivity and low cost [14]. N, S-TiO_2/ZnO nanocomposites fabricated on the Ti substrate, which act as anode. During the electrochemical treatment, hydroxyl radicals ($^{\bullet}$OH) are formed at the anode surface, which are used to break the complex dye molecules into smaller molecules such as CO_2 and H_2O [15-18].

UV-Vis Spectroscopy along with Cyclic Voltammetry (CV) was used to analyze and interpret the electrochemical dye degradation results. Preliminary experimental results predicts that N-S TiO_2/ZnO heterostructure assembly shows better electrochemical performance than all other electrodes in degrading crystal violet dye. Further, 4-nitrophenol to 4-aminophenol reaction is chosen another model reaction for catalytic studies. The reaction kinetics with temperature as

E-mail: [1]dileepbh.chemengg@jntua.ac.in, [2]vishnu.devangam@gmail.com, [3]ppoojasree@gmail.com

[1,2,3]Dept. of Chemical Engineering, Ananthapuramu, India

well as the rate limiting mechanism is under progress. The outcomes of this work will not only help to understand the degradation mechanism of complex dye molecules but also fetch to design low cost catalysts for better electrochemical performance.

Methodology

Materials and Methods

Titanium tetraisopropoxide [Ti{OCH(CH_3)$_2$}$_4$], zinc nitrate ($Zn(NO_3)_2.6H_2O$), Potassium Hydroxide (KOH), Ethanol (C_2H_5OH) Ammonia (NH_3), Thiourea ($(NH_2)_2CS$), Sodium sulphate (Na_2SO_4), and Isopropyl alcohol (C_3H_8O) purchased from Sigma Aldrich Chemicals (India) Ltd. Nafion (10%) liquid solution is purchased DuPont Chemicals, USA. Crystal violet dye purchased from Sigma-Aldrich used as model pollutant in present study.

Synthesis of N, S-co-doped TiO_2/ZnO Nanocomposite

Ethanol (150 ml) and 3.75 ml of de-ionized water was taken and stirred for half an hour to get a homogenous mixture. To this solution, 5 ml of Ammonia, 5 gm of Thiourea and 9 ml of TTIP was added and kept in agitation for 4 hours at 85ºC. The obtained solution centrifuged at 2000 rpm for 30 min followed by drying and calcination at 400ºC for 3 hours in muffle furnace to get N, S-TiO_2 nanoparticles [19].

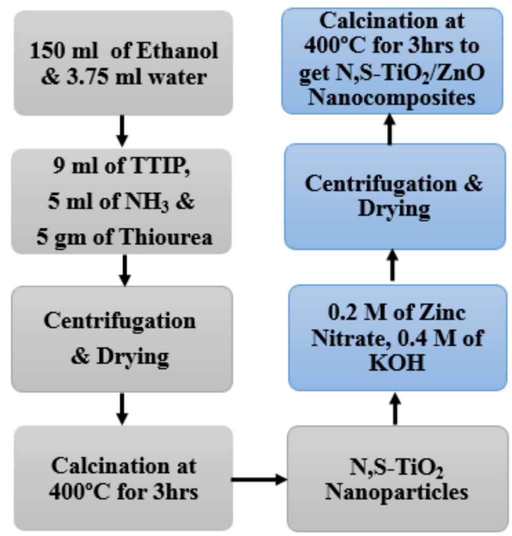

Fig. 1 Schematic representation of synthesis of N, S-TiO_2 and N, S-TiO_2/ZnO nanocomposite

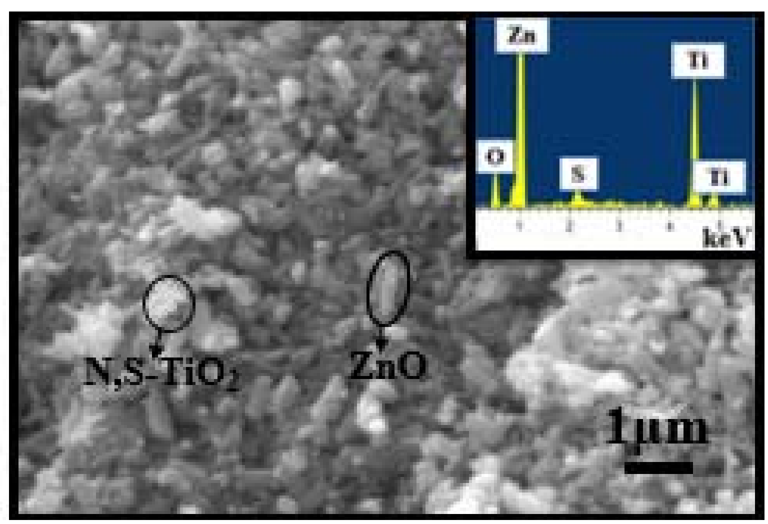

Fig. 2 SEM and EDX (inset) image of N, S-TiO_2/ZnO composite assembly

To synthesize N, S-TiO_2/ZnO nanocomposite, 10 mg of Nitrogen, Sulphur co-doped Titanium dioxide (N, S-TiO_2) is added to 0.2 M of Zinc Nitrate (Zn $(NO_3)_2.6H_2O$) and 0.4 M of Potassium Hydroxide (KOH). To the Zinc Nitrate and N, S-TiO_2 solution, KOH solution was slowly added drop wise at room temperature under vigorous stirring and white suspension formed. The obtained solution centrifuged at 5000 rpm for 20 min followed by drying and calcination at 500ºC in air atmosphere for 3hours to get N, S-TiO_2/ZnO nanocomposite as shown in Fig. 1.

Electrode Fabrication

40 mg of (N, S-TiO_2/ZnO) nanoparticles was mixed with 2 ml of isopropanol and 20 µl of Nafion solution. It was sonicated for 1 hour and the slurry was applied onto the Ti plate (effective electrode surface area ~1cm^2) and dried at 60ºC on hot plate.

Results

SEM Analysis

Scanning Electron Microscopy (SEM) has performed to determine the surface morphology of synthesized nanoparticles. Fig. 2. ZnO and N, S-TiO_2, N, S-TiO_2 does not possess any definite shape. Agglomeration was observed in most parts of the image and this may be due to doping which distorts the crystalline lattice of TiO_2. However, ZnO shows hexagonal shape. In order to confirm the presence of elements and their composition Energy-Dispersive X-ray Spectroscopy (EDX) has performed. The sharp signals of Zn, O, S and Ti confirms the presence of elements in composite sample. However, Nitrogen (N) was not detected and it may be due to low doping concentration used in synthesis.

FTIR Analysis

In order to know the surface functional groups, Fourier Transform Infrared Spectroscopy (FTIR) has performed. In Fig. 3, broad peak was observed at 3534.65 cm^{-1} corresponds to the OH stretching vibration. The peak at 660 cm^{-1} clearly indicates Zn-O stretching and the peaks at 1568.07 cm^{-1} and 1418.84 cm^{-1} were attributed to the C-O stretching and OH bending vibrations respectively [20]. Further, the peak observed at 665.87 cm^{-1} corresponding to Ti-O bending of TiO_2, the broad peak at 2019.01 cm^{-1} represents deformative vibration of Ti-OH stretching mode. The peak at 2728.05 cm^{-1} corresponds to N=C=S stretching of S-TiO_2 and at 3483.44 cm^{-1} was assigned to asymmetrical and symmetrical vibration of hydroxyl group -OH of TiO_2 [10, 21,22].

XRD Analysis

X-Ray Diffraction (XRD) analysis was performed to find the crystalline (or) amorphous nature of synthesized nanoparticles. These patterns were indexed by comparing with JCPDS data file. For N, S-TiO_2/ZnO the major peaks observed at 25.48º, 31.79º, 34.44º, 36.27º, 47.69º, 55.43º, 57.42º, 63.11º, 68.22º that corresponds to the atomic planes of (101), (100), (002), (101), (012), (211), (110), (013), (112) as shown in Fig.4. This configures TiO_2 and ZnO as tetragonal anatase TiO_2 and hexagonal wurtzite ZnO respectively (JCPDS card no. 21-1272 & 36-1451) [10, 23, 24].

UV-Vis Spectra Analysis

During the electrochemical decolourization process, the change in absorbance characteristics of the crystal violet dye is observed at different intervals of time by using UV-Vis absorption Spectra analysis. The spectra of crystal violet dye shows a maximum absorbance at 576 nm in the visible region represents the presence of auxochrome groups –N (CH_3) which is accountable for strong color of crystal violet dye. The absorption spectra is collected at different intervals of time during electrochemical treatment. Initially, cyclic voltammetry (CV) curves were generated in order to note down the oxidation/ reduction peaks during electrochemical treatment. The potential (V) applied on electrode surface for electrochemical crystal violet dye degradation was chosen based on cyclic voltammetry (CV) curves. The peak gradually decreases with time indicates degradation of dye molecules upon electro-chemical treatment. The true driving force for degradation of dye molecules is $^{\bullet}OH$ radicals which are generated on electrode surface by the application of potential. N, S-TiO_2/ZnO nanocomposite fabricated on Ti substrate is observed to be taken 8 hours for complete degradation of dye. The decrease in absorbance peak upon electrochemical treatment confirms the mineralization of the crystal violet dye as shown in Fig. 5(a). Further, the decolourisation efficiency calculated by using the following formula:

$$\% \text{ decolourization} = \frac{A_0 - A}{A_0} * 100 \quad (1)$$

Where A_0 and A are the absorbance at the maximum wavelength, λ_{max} of dye solution before and after electrochemical treatment. The percentage (%) decolourisation of crystal violet dye by using N, S-TiO_2/ZnO nanocomposites is about 92% and is achieved in 8 hours.

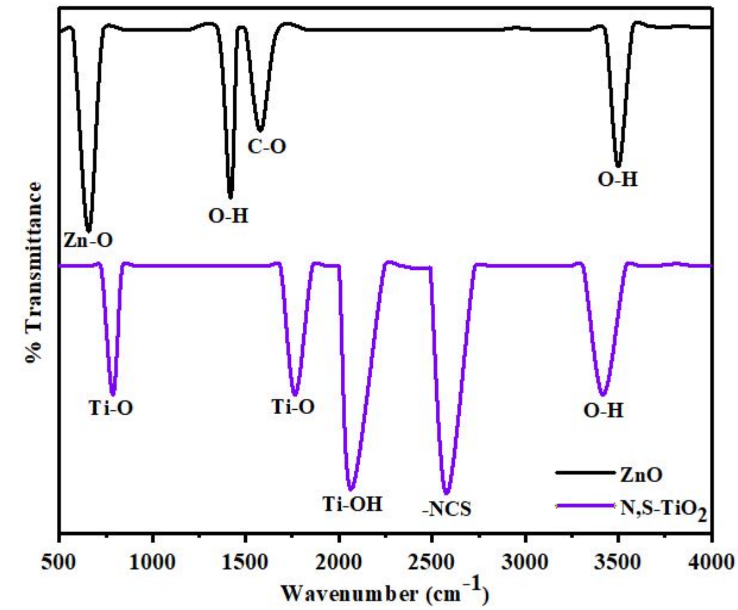

Fig. 3 FTIR spectra of ZnO and N, S-TiO_2 nanoparticles

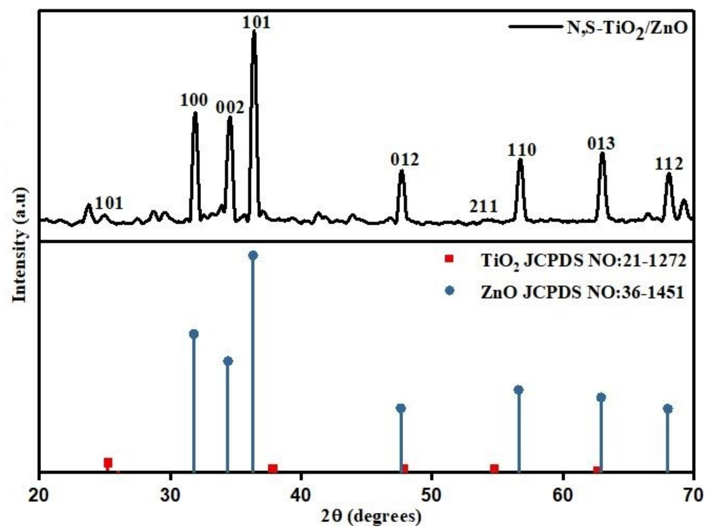

Fig. 4 XRD pattern of N, S-TiO_2/ZnO

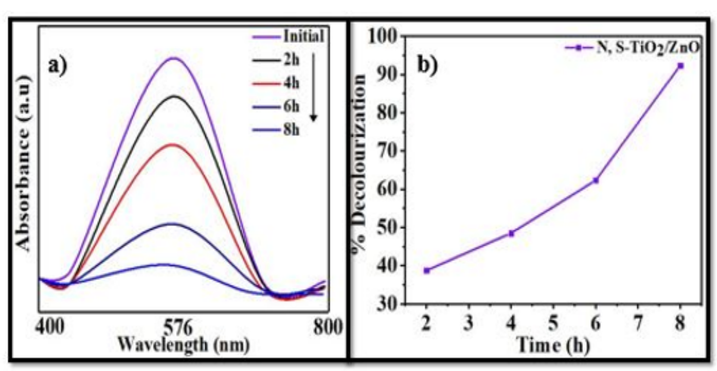

Fig. 5 N, S-TiO_2/ZnO nanocomposite a) UV-Vis Spectra analysis and b) % decolourization

Conclusion

Present work aimed to understand doped metal oxide heterostructures (N, S-TiO_2/ZnO) for electrochemical dye degradation of crystal violet dye. The synthesized nanocomposites were characterized using SEM, EDX, FTIR, XRD, and UV-Vis analysis. Electrochemical measurements shows that N, S-TiO_2/ZnO nanocomposite performs better in comparison to all other electrode assemblies. The formed Type II heterostructure assembly facilitates free charge carrier flow path and improves the electrochemical performance by reducing the charge carrier recombination rate. Further, the same electrode assemblies were used to carry out the catalytic reduction of 4-Nitrophenol to 4-Aminophenol reaction and the experiments are under progress.

Acknowledgment

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Enhancement of Heat Transfer Rate using Hybrid Nanofluids: A Review

Chitra Boobalan[1], Parthiban Rangasamy[2], Sainiwetha Saikrishnan[3] and Solai Natarajan[4]

Abstract Research on nanofluids has been increased rapidly and reports reveal that nanofluids are beneficial heat transfer fluids for engineering applications. Thermal conductivity of nanoparticles, particle volume concentrations and mass flow rates are the key factors for the heat transfer enhancement of nanofluids. The heat transfer enhancement only depends on the thermal conductivity of the nanoparticles provided the particle volume concentrations and flow rates are constant. The thermal conductivity of nanoparticles may be enhanced by preparing composite nanoparticles. Hybrid nanoparticles are defined as nanoparticles composed by two or more different materials of nanometer size. The fluids prepared with hybrid nanoparticles or with two different nanofluids are known as hybrid nanofluids. The motivation for the preparation of hybrid nanofluids is to obtain further heat transfer enhancement with improved thermal conductivity of these nanofluids. This review summarizes the synthesis and thermal properties of hybrid nanoparticles. The review also demonstrates that hybrid nanofluids are more effective heat transfer fluids than single nanoparticles based nanofluids or conventional fluids. Review showed that proper hybridization may make the hybrid nanofluids very promising for heat transfer enhancement, however, lot of research work is still needed in the fields of preparation and stability, characterization and applications to overcome the challenges.

Keywords: Hybrid Nanofluids, Thermal Conductivity, Stability, Heat Transfer

Introduction

One of the main challenge faced in industries is high performance cooling. To improve the heat transfer, the surface area for heat exchange and the residence time of the heat transfer fluids can be increased but it is impractical to increase the size of the system. Alternatively, solid crystalline particles with high thermal conductivity are added to the conventional fluids to enhance the heat transfer [1]. The millimetre or micron size particles encounter serious problems like rapid settling down of particles and high pressure drop. Corrosion in pipelines might occur because of the abrasive action of the particles. Because of these drawbacks, milli size or micron size particles are not widely used. Choi first introduced the particles in nanometer dimensions as a suspended solution [2]. The small particle size and their low volume fractions prevent particle clogging and decrease in pressure drop. Stability is increased and sedimentation is reduced because of the large surface area of nanoparticles. Because of the reduction in particle size, the heat transfer efficiency is improved since heat transfer takes place at the particle surface [3]. Large saving in pumping power can be accomplished if high thermal conductivity increase can be achieved with a small volume fraction of nanoparticles. The suspension of these nanoparticles in base fluids like water, ethylene glycol or oil was named as nanofluids by Choi in 1995 [4]. Nanofluid is a sol colloid involving nanoscale less than 100 nm sized particles dispersed with a base fluid. Nanofluids have the ability to achieve ultra-high performance cooling and thus they have the potential to be considered as next generation coolants.

To enhance the thermal conductivity, solids are dispersed in heat transfer liquids as suggested by Maxwell. Solid particles are added since solids conduct heat much better than liquids. The major problem in dispersing large size particles is that these particles settle rapidly in fluids. Other problems include abrasion and clogging. These problems can be overcome by dispersing nano sized particles in liquids. Nanoparticles remain suspended for a longer time when compared to large sized particles and also possess a high surface area. The surface to volume ratio is 1000 times larger when compared to micro particles. Since heat transfer occurs on the surface of the particle, the high surface area enhances the heat conduction of nanoparticles. Because of its stability and high thermal conductivity, nanofluids are highly desired in heat transfer processes. Stable nanofluids can be produced by one and two step method. Synthesis and suspension of non-agglomerated and

E-mail: [1]chitrab@ssn.edu.in, [2]parthibanr@ssn.edu.in, [3]sksn1996@gmail.com, [4]solai96@gmail.com

[1,2,3,4]Department of Chemical Engineering, Kalavakkam, India

nearly monodispersed nanoparticles in liquid is the key step for the enhancement of thermal properties of nanofluids [5].

Hybrid nanoparticles are a combination of nanoparticles that gives a wide range of thermo physical properties [6]. Hybrid nanofluids are nanoscale fluids which is a combination of two disparate materials. A hybrid nanomaterial is a substance that combines both physical and chemical properties of different materials simultaneously in a homogeneous phase [7]. The development of hybrid nanoparticles has been a revelation in the research field. Recent research studies show the use of hybrid nanofluids with possible applications in almost all fields of heat transfer [8]. The main objective of using hybrid nanofluids is to improve the heat transfer characteristics further and to combine the properties of metals, metal oxides, carbon nanocomposites etc. Studies reveal that hybrid nanofluids have high heat transfer enhancement than single nanoparticle based nanofluids. Nevertheless, the study on hybrid nanofluids is very limited.

The objective of the review is to get an overview of synthesis methods used and properties of hybrid nanofluids. In this paper, the synthesis and thermophysical properties of different hybrid nanofluids carried out by different researchers have been reviewed.

Synthesis of Hybrid Nanofluids

Hybrid nanofluids are synthesized by suspending dissimilar nanoparticles either in mixture or composite form in base fluid and by using hybrid nanofluids, heat transfer was furthermore increased and good pressure drop characteristics. This section summarizes some of the researches on synthesis, thermo physical properties, heat transfer and pressure drop characteristics. Hybrid Nanofluids can be prepared either by dispersing two or more nanoparticles in base fluid or dispersing composite nanoparticles in base fluid.

Botha *et al*. [9] synthesized silica and silver nanofluids by one step method using a high temperature pathway. Silica was first mixed with base fluid by magnetic stirring at 130 ºC followed by introducing silver nitrate to the silica and base fluid. At 130ºC, reduction of Ag^+ ions to Ag by electron transfer reaction occurs. Oil-based nanofluids containing silver nanoparticles with particle size distribution of 5.5±2.4 nm supported on silica have been successfully prepared. Small silver particles were deposited uniformly on the silica support.

Jana *et al.* [10] synthesised gold and CNT nanofluids suspended in water. CNT Nanofluids and gold nanofluids dispersed in water were prepared separately. Gold nanoparticle suspension was then added to CNT suspension to achieve gold and CNT suspension. They have also synthesized copper and CNT suspension using deionized water as base fluid. Laurate salt was added to achieve stability of copper nanofluids. The prepared gold nanofluids were then added to CNT suspension to produce hybrid nanofluids.

Suresh *et al.* [11] used thermochemical synthesis method for the preparation of alumina-copper composite powder. The steps involved in thermochemical synthesis method are spray drying, oxidation of precursor powder, reduction by hydrogen and homogenization. Nitrates of copper and aluminium soluble in water, Cu $(NO_3)_2.3H_2O$ and Al $(NO_3)_3.9H_2O$ was first prepared followed by spray drying to obtain the precursor powder. Mixture of copper oxide and stable Al_2O_3 were formed by heating precursor powder in air atmosphere. To obtain a homogeneous alumina-copper Nano composite powder, the mixture was ball milled. Alumina –copper nanofluids were prepared by dispersing specific amount of alumina-copper nanoparticles in water with sodium lauryl sulphate as surfactant using ultrasonic vibrator.

Baghbanzadeh *et al*. [7] synthesized silica-multi walled nanotube (MWNT) in water using wet chemical method. To functionalize MWNTs, COOH functional groups have used. Sodium silicate was suspended in water followed by dispersion of functionalized MWNT to the solution using ultrasonic bath. Cetyl trimethyl ammonium bromide (CTAB) and dimethyl formamide were added to the mixture by magnetic stirring. The products were then filtered, washed and dried to form gray powder and these powder are then suspended in water to form hybrid nanofluids.

Abbasi *et al*. [12] used solvothermal process for the synthesis of alumina-MWNT nanofluids using ethanol as base fluid. Aluminium acetate powder was first diffused in ethanol followed by addition of pure MWNT and functionalized MWNT using ultrasonic water bath. Ammonia solution was then added and transferred to Teflon lined stainless steel autoclave mixture to perform solvothermal synthesis and hybrid γ- Al_2O_3 /MWNT nanomaterial was prepared. Hybrid nanofluids were prepared by dispersing hybrid nanomaterial in deionized water using Gum Arabic as dispersant in ultrasonic water bath.

Nine *et al*. [13] synthesized copper (Cu) - cupric oxide (Cu_2O) in water nanofluids using wet ball milling process. Ball milling is used to hydrolyse copper nanoparticle to convert to cupric oxide nanoparticle at a temperature higher than ambient temperature. Three steps are involved during the synthesis process viz., (i) oxidation of copper to cupric oxide (ii) Formation of Cu_2O on Cu particle and (iii) breaking cupric oxide layer into smaller particle by 20 nm size.

Munkhbayar *et al*. [15] prepared silver/MWNT hybrid nanofluids using pulsed wire evaporation instrument. 0.05% MWNTs nanofluids were poured into an exploding bottle and installed in the main part of the pulsed wire evaporation instrument. Further, silver nanoparticles were synthesized by the pulsed wire evaporation method and made direct contact with the base fluid inside the chamber wall. A water based silver/MWCNT nanofluid was finally obtained without any surface contamination.

Aravind and Ramaprabhu [16] used green synthesis methods using focused solar electromagnetic radiation to synthesize graphene and graphene-multiwalled carbon nanotube (MWNT) composite. A fine powder of graphene oxide (GO) – MWNT composite was made by refluxing a 1:1 ratio of GO and MWNT in nitric acid for 2 h followed by washing and drying. Further, stable nanofluids were prepared by dispersing the nanomaterials in polar base fluids.

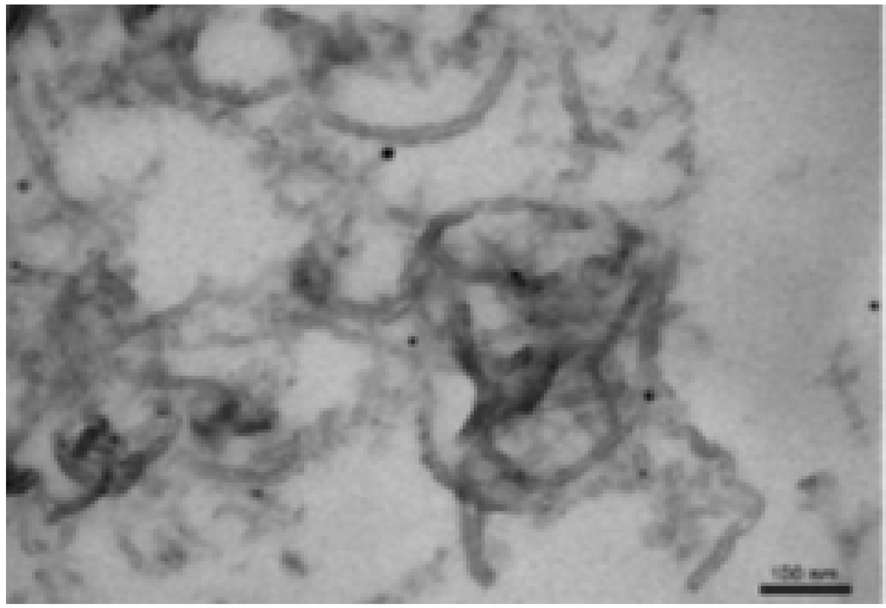

Fig. 1 TEM image of AuNP–CNT suspension [10]

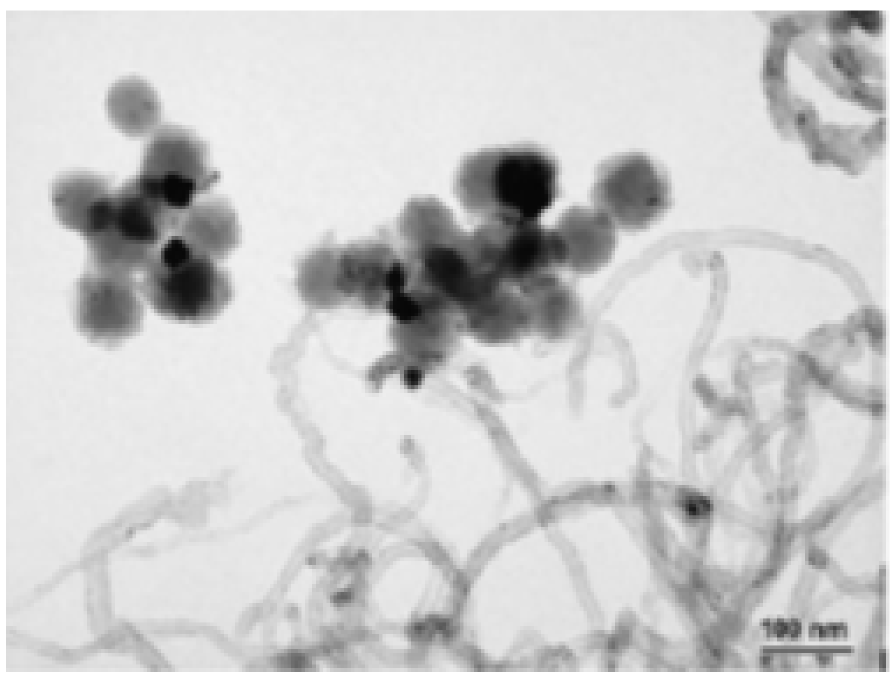

Fig. 2 TEM image of CuNP–CNT in water suspension [10]

Properties of Hybrid Nanofluids

Botha *et al*. [9] studied Nanofluids containing Ag supported on silica showed a lower viscosity compared to the nanofluid containing unsupported silica. This could be due to the immobilization of silver nanoparticles on the silica, preventing the formation of the three-dimensional network that silica is known to form. An enhancement in thermal conductivity of 15% was observed when 0.60 wt% silver was supported on 0.07 wt % silica. Thermal conductivity was found to increase with an increase in silver concentration.

Jana *et al*. [10] studied the thermal conductivity of water based CNT-gold nanoparticles and CNT- copper nanoparticles and observed that the CNT did not increase the thermal conductivity for both hybrid nanofluids. The thermal conductivity rather decreased because of either lack of interaction between gold–CNT nanomaterials or the addition of CNTs to copper nanoparticles reduces the dispersability which results in agglomeration of nanoparticles.

The experiments done by Suresh *et al*. [11], thermal conductivity is increased for Al_2O_3 – Cu /water hybrid nanofluids for 0.1 % to 2% volume fraction. They have also measured the viscosity of hybrid nanofluids for various volume concentration and showed that the effective viscosity increases with volume concentrations and the experimental results of viscosity were higher than those predicted by the theoretical models.

Paul *et al*. [14] studied the thermal conductivity ratio of Al-5 wt.% Zn dispersed in ethylene glycol as a function of concentration of nanoparticles and showed that the thermal conductivity ratio non-linearly increases with increase in particle concentration. They also showed that the thermal conductivity increased linearly with temperature.

Baghbanzedh *et al.* [7] measured the thermal conductivity of water based silica- MWNT hybrid nanofluids and the enhancement of thermal conductivity of hybrid nanofluids is in between the increase of MWNT nanofluids and Silica nanofluids. They have showed CNT was the reason behind increase in thermal conductivity and also showed that addition of surfactant causes negative effect on thermal properties.

Batmunkh *et al*. [18] calculated the thermal conductivity of Ag/TiO_2 – water nanofluids for various weight concentrations at various temperatures. Hybrid nanofluids showed an increase in thermal conductivity with increase in temperature and thermal conductivity can be improved by introducing flattened Ag particles to the TiO_2 based solution

Aravind and Ramaprabhabhu [16] investigated the thermal conductivity of graphene wrapped MWNT in water and ethylene glycol (EG) base fluids. A thermal conductivity enhancement of 11.3 % and 97.5 % was attained for a very low volume fraction of 0.04% in Water based graphene wrapped MWNT at 25°C and 50°C as shown in Fig.3. Ethylene glycol based nanofluids exhibit a thermal conductivity enhancement of 13.7% and 24 % at 0.04% volume concentration of nanoparticles at 25°C and 50°C (Fig.4).

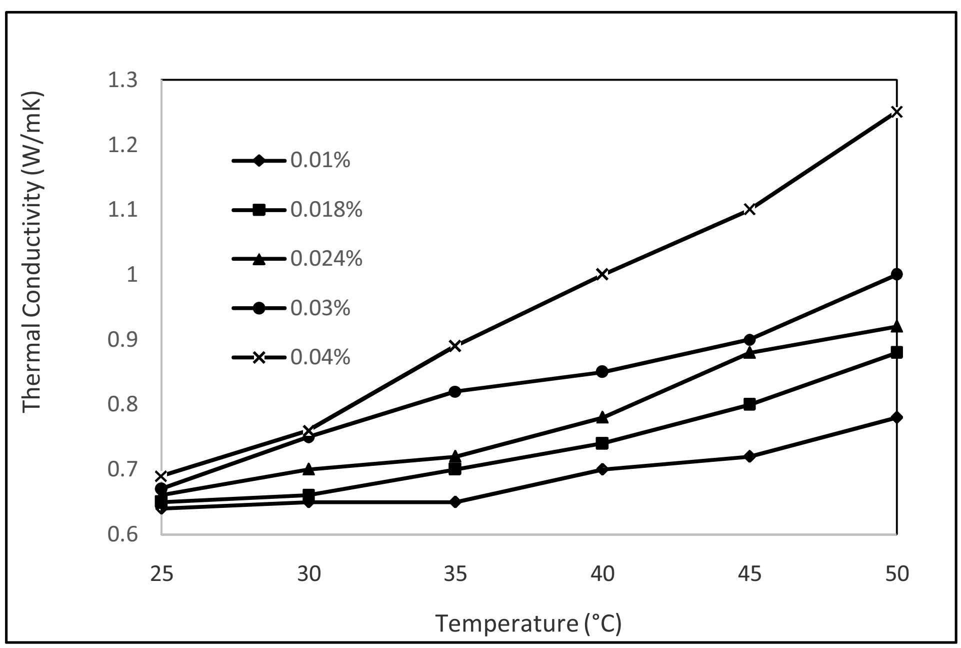

Fig. 3 Thermal conductivity of GC in DI water base fluids [83]

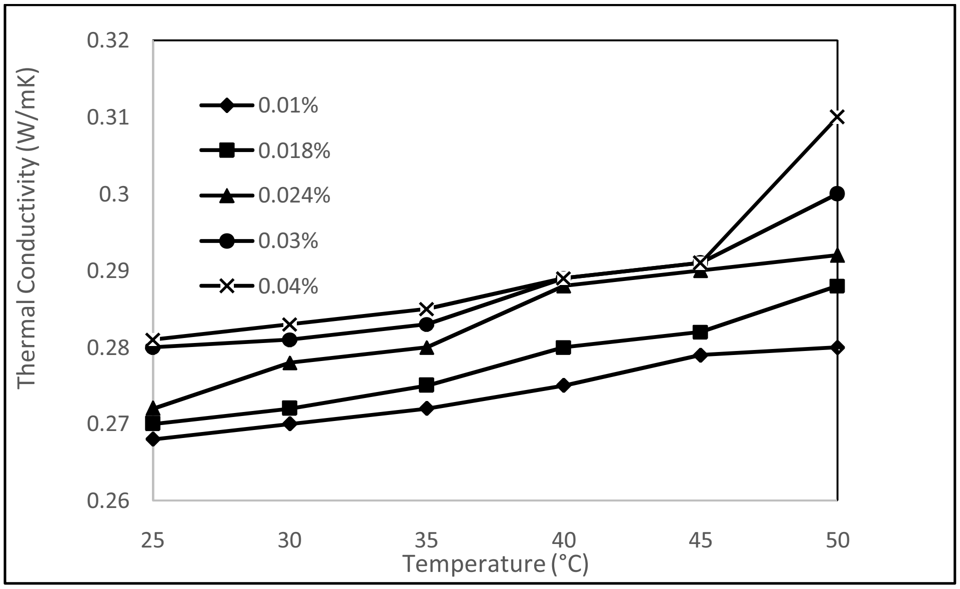

Fig. 4 Thermal conductivity of GC in EG base fluids [83]

Conclusion

The hybrid nanofluids are a fairly new group of nanofluids on which a lot more research work needs to be done before their practical applications in the industries. It has been found that for improved performance in different applications, the improvement in thermal conductivity of nanofluids is one of the driving factors. The emphasis of most of the studies on hybrid nanofluids is mainly on thermal conductivity and in few cases on viscosity; and other thermophysical properties have been neglected. So, a more detailed study to test the stability and other thermophysical properties of hybrid nanofluids, would be needed to ascertain its usefulness in practical applications. Present review reveals that the hybrid nanofluids containing composite nanoparticles yield significant enhancement of thermal conductivity as well as heat transfer coefficient. However, the long term stability, production process, selection of suitable nanomaterials combination to get synergistic effect and cost of nanofluids may be major challenges behind the practical applications and substantial researches are still needed to identify and overcome many challenges for different applications.

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Group F

- **Interdisciplinary**

Heat Dissipation in CPU with CFD Simulations: A Review

R. Parthiban[1] and G. Sudha[2]

Abstract Heat removal rate techniques are one of the important factors in the proper functioning of the electronic devices. At any given time the temperature should be within the operating temperature limits. Some of the Heat removing techniques includes the usage of heat sinks, fans for air cooling, and other forms of cooling such as liquid cooling. Reliability and premature failure can be prevented in the electronic devices, if the heat is be dissipated effectively. If the heat is not dissipated properly, hot spots may be developed in the Integrated circuits such as CPUs, graphic card, chipset and hard disk, which may lead to permanent temporary malfunction or failure. As a result, effective cooling of electronic devices remains a challenge in heat transfer mechanism. The primary objective of this paper is to review the various heat sinks for efficient cooling of CPU. These Heat sinks can be instrumental in removing the excess heat generated. The fin heat sink geometric parameters viz., height, length, thickness, number of fins, thickness of base plate, space between fins and its shape/ profile, material, plays a very significant role to find the optimized fin geometry etc.

Keywords: Fins, CFD, CPU, Surface Area

Introduction

Amer Al-Damook *et al* (2015) [1] showed multiple perforations of the experimental heat sink. Authors also showed the effect of various parameters on perforated fin design. Five perforations of pins are presented are shown to have 11% larger Nusselt number [1] than for corresponding solid pin cases. These enhancement of heat dissipation arise not only due to the increased surface area but also due to the increase in heat transfer near perforations through the formation of localized air jets. When an analysis with respect to the CPU cooling is performed, a conjugate heat transfer mechanism shows that heat transfer enhancement with pin perforations translates into considerably reduced processor case temperatures with an additional reduction in the heat sink pins weight.

Youmin Yu *et al* (2013) proposed a heat sink employing an agitator plate inside the channels which can improve the heat transfer. These agitator plates create turbulence all along the agitator plate as it moves intermittently in a diagonal direction to the air flow. The channel side walls were fins of the heat sink fin array. The agitator plate was placed within the channel. Heat transfer is increased by 61% by agitation for a specific situation [2]. The heat transfer induces more by 33% than a corresponding flapping operation for the translational operation.

Another proposed method for effective heat dissipation is to use cooling vapor chamber. The effective operation of vapour cooling was studied and the results are presented. It was found that the average Hard disk drive (HDD) temperature is 15.21% [3] was lesser when vapor chamber cooling techniques was used. Significant effect on the thermal cooling of a HDD was observed due to the vapor chamber cooling technique. This study was of technological importance for the effective and proficient design of cooling systems of personal computers/ electronic devices in order to increase the cooling performance.

Another significant technique is the usage of heat spreader, encompassing the two important main features. The design of heat spreader and its thermal characteristics was analyzed, especially addressed to electronics cooling. In this design a small diameter pipe was used as a heat transfer surface filled with a phase change material (PCM). High heat transfer surface due to large number of pipes and high thermal capacity which results from the use of PCM [4] are the two main features of this design in heat spreader. This has an advantage of maintaining and stabilizing the temperature of the cooling element in the cases of fast deviations of heat transfer conditions.

Heat spreaders of this sort can disperse couple of several watts keeping microchip's temperature at the level beneath 50°C [5]. At the same time, due to the PCM

E-mail: [1]parthibanr@ssn.edu.in, [2]sudha@svce.ac.in

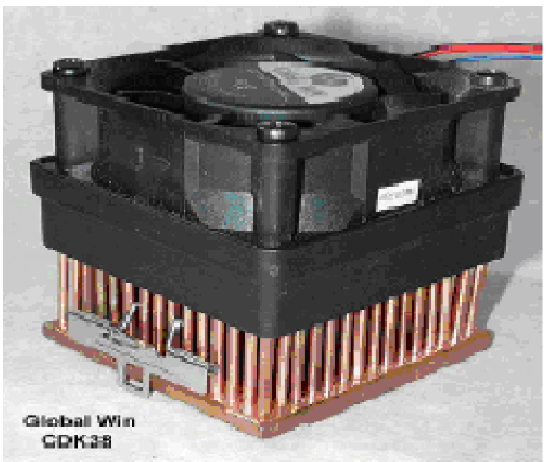
[1]Dept. of Chemical Engg, SSN College of Engineering, Kalavakkam, Tamilnadu, India

[2]Dept. of Chemical Engineering, Sri Venkateswara College of Engineering, Tamilnadu, India

content, they can shield chip from overheating if there should be an occurrence of fast varieties of warmth stack. Furthermore, if there should arise an occurrence of unintentional fan disappointment they significantly back off the ascent of temperature. Such a decent attributes in flimsy states are accomplished with generally little measure of PCM. Be that as it may, thermal exchange to the PCM was extremely productive and about entire measure of stage change material assimilates abundance warm quickly after thermal unsettling influence. The various operating parameters with reference to fin are pinch, thickness and material type at the air side which is varied and analyzed for its heat removal capabilities. In this simulation was carried out using Fluent software and it was validated with experimentations for various conditions.

The effects of on thermal characteristics of fin-plate thermo syphon (FPT) were presented with various air flow velocity from 1.0 m/s to 4.0 m/s. There was a good match between the numerical results and the corresponding experimental data. Increasing the fin space results in the heat transfer efficiency and pressure drops of FPT for plain fins.

As predicted, the cooling performance of FPT with serrated fins showed an enhanced performance than the plain fins for the same structural parameters [5].



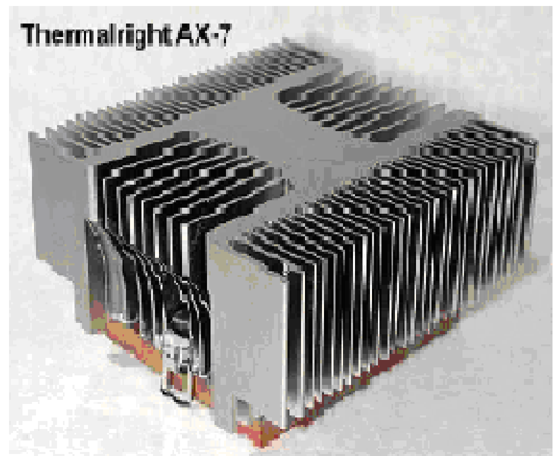


Fig. 1 Heat sink for cooling of electronic devices

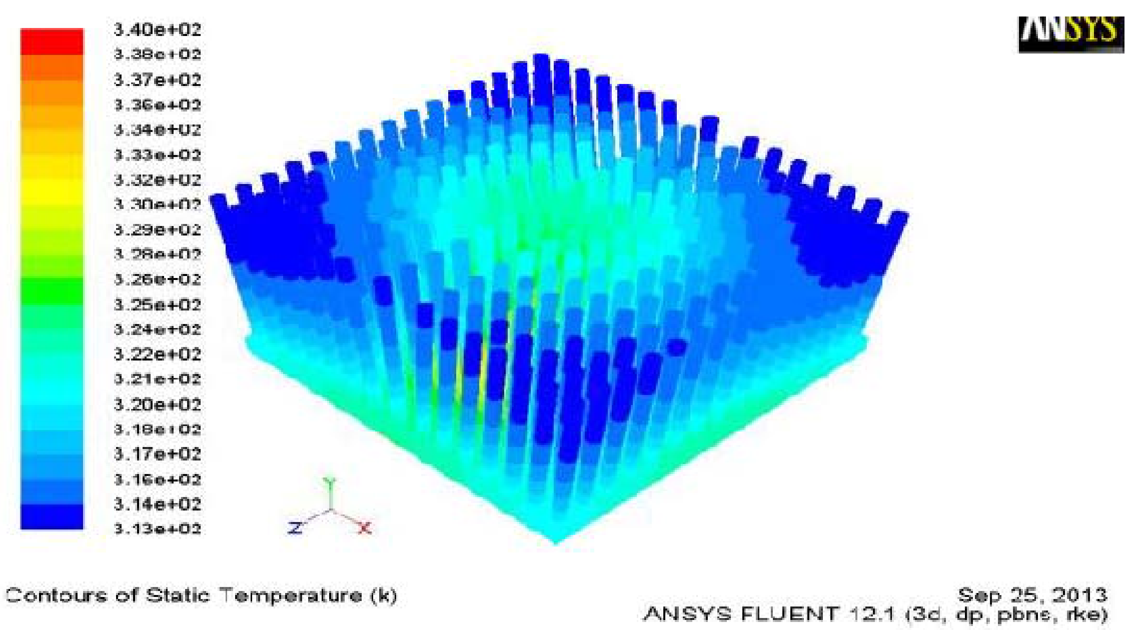


Fig. 2 Temperature contour of splayed fin

Table 1 Reference Dimensions

Quantity	Dimension
Footprint (mm^2)	52 × 52
Approach velocity (m/s)	3
Specific heat of air (J/kg^0K)	1007
Density of air (kg/m^3)	1.086
Thermal conductivity of air (W/m K)	0.0284
Absolute viscosity (Ns/m^2)	19.70×10^{-6}
Kinematic viscosity (m^2/s)	18.15×10^{-6}
Prandtl number (Air)	0.6976
Heat load (W)	130
Ambient temperature (K)	297
Base plate temperature (K)	353

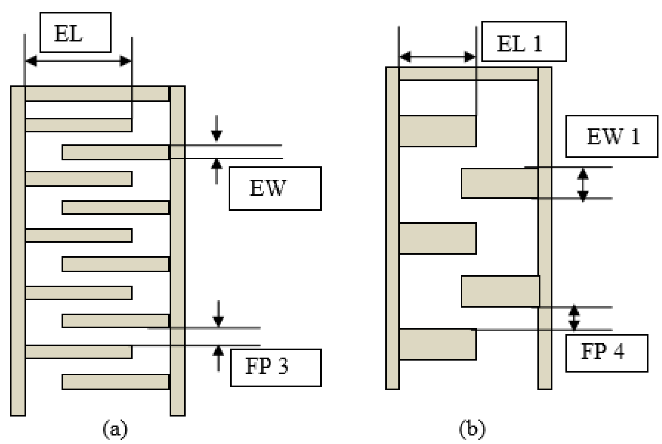


Fig. 3 Representation of two different ERF heat sink

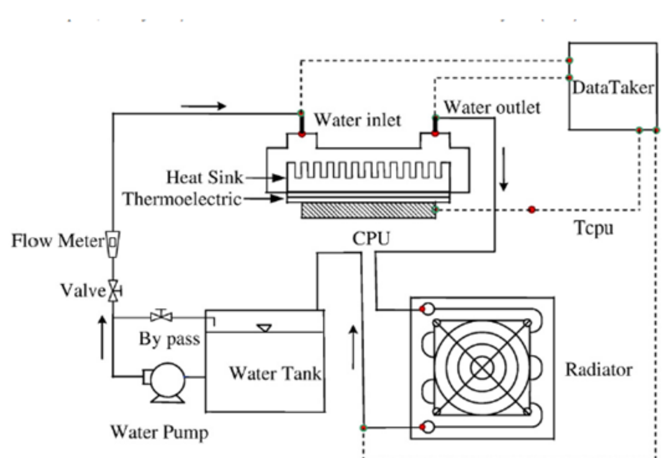


Fig. 4 Liquid based system for CPU cooling

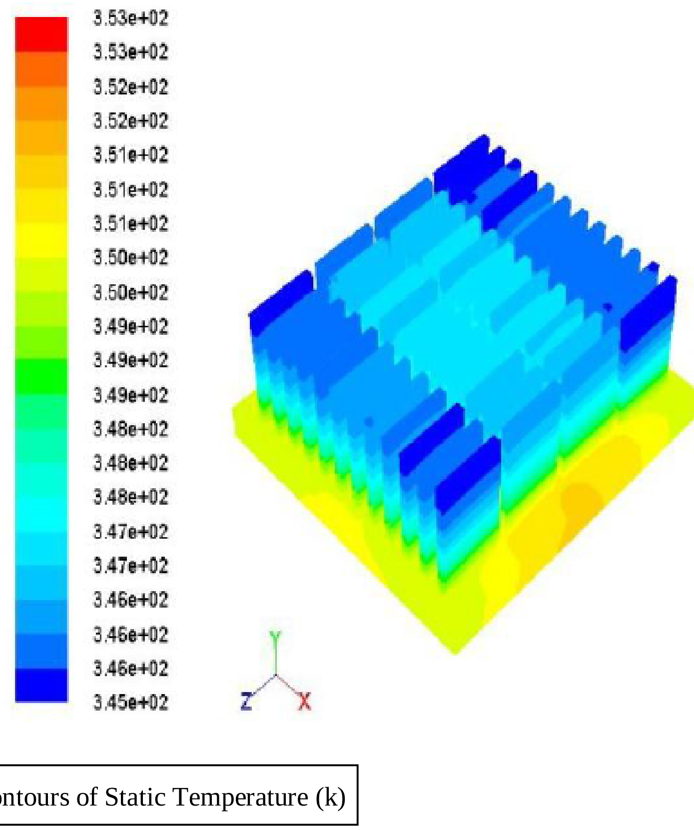


Fig. 5 Temperature contours of interrupted rectangular fins with through holes of 2m/s velocity

Paisarn Naphon *et al* [6] studied the effect of deionized water in the mini rectangular fin heat sink for CPU. The governing equation was developed for real operating condition of a PC in a full load, half load manner and at zero load conditions. He numerically analyzed the fluid flow and heat transfer in the heat sink. The finite volume method is used to solve the equations for fluid flow and heat transfer characteristics. To describe the flow structure and behavior, the standard k–□ turbulent model [11] is employed. The measured data obtained are verified with the predicted results established from the model.

Adam Neale *et al*., [7] had proposed that standard k-□ model can be helpful for computing convective heat exchange coefficients and approval. The geometric fin parameters are height, thickness, base height and fin pitch which are observed to be ideal at 48 mm,1.6 mm, 8 mm and 4mm [8] separately for a proficient heat sink configuration having maximum temperature, thermal resistance and pressure drop are found to be at 342.90K, 0.1685728C/W and 12.8 Pascal respectively.

Denpong Soodphakdee *et al*., [9] had showed various fin geometries, and proved that staggered plate fin are very instrumental in heat transfer for a given air speed of 2.5m/s and pressure drop as presented in Fig. 1.

Lakshmi Anusha *et al*., had reported (Table 1) the model based on model transport equations for the turbulence kinetic energy (k) and its dissipation rate (□) [11]. They showed the significance of junction temperature. They demonstrated the variation of temperature from fin base to its entire length. For this, they used CFD for analysis of heat transfer coefficient and its values. Increasing the surrounding fluid velocity by forced convection increases the heat transfer coefficient. The heat transfer is dependent on the stream velocities (Figure 2). Less number of thick fins is not preferred when compared to less thickness of large number of fins [12] because greater turbulence is observed which enchances the heat transfer.

Fin design plays an important role in heat transfer. Samkumar *et al*., [13] reported that in the sense of junction temperature interrupted fins are efficient than continuous

Sivaraja *et al*, [16] found a different Fin geometry (Figure 3) called "*Extruded Rectangular Fins*" using Aluminium as fin material. It is seen from the outcomes that maximum cooling is accomplished by the Heat sink containing surface region of 160.44 cm2 and the maximum temperature on the fin surface is 329K at velocity 2.5 m/s

B.P. Whelana *et al*, [17] developed a liquid CPU cooler and tried to accomplish a cooling limit of 200 W for a surface area of 8.24 cm^2, comparable with the coordinated heat spreader with same dimensions of an Intel Pentium 4 processor. Essential target plan was to create thermal hardware components that can be made price effectively. A miniature jet array water block and a tube bundle remote heat exchanger were employed. The overall thermal resistance of 0.18 K/W requires 1.5 W of hydraulic power for disseminating the required heat load with reference to the framework described in Figure 4.

Sanjay Kumar Sharma and Vikas Sharma, [14] had reported that CFD tool is good approach to analysis thermal behaviour (Figure 5) of any thermal device. “The average heat transfer coefficient, average Nusselt number variations decreases along the flow direction due to growing boundary layer thickness [15] and extremely high at the entrance region due to the very thin local boundary layer”. They demonstrated the rise of average heat transfer coefficient and average Nusselt number for constant pressure drop when heat flux is increased.

Five different heat sinks with fin spacing of 0.2 mm, 0.5 mm, 1.0 mm, and 1.5 mm along with a flat plate heat sink were investigated for effective thermal management of high heat generating microprocessors

In this, heat dissipation rate was found with various fin spacing but water is used as a heat transfer coolant. At a heater power of 325 W, the lowest heat sink base temperature of 40.5°C was achieved by using a heat sink of 0.2 mm fin spacing which was about 9% lower than the best reported base temperature of 44°C using a nanofluid. For the fin spacing of 0.2 mm the overall heat transfer coefficient was found to be 1297 W/m^2 K and 2156 W/m^2 K [18] respectively. There was also about two-folds enhancement compared to the former.

M. Nazari *et al* [19] done a comparison between heat sinks using water, alumina and CNT nano-fluids. In the preparation of nano-fluids two base fluids were used (ie) ethylene glycol and water. The volume fraction of the Alumina/water nano-fluid was considered as 0.1, 0.25 and 0.5 (%w/w). The volume fractions of carbon nano tube in the base fluid are 0.1 and 0.25 (%w/w). The Ethylene Glycol with the volume percent of 30% and 50% have been also used for the cooling process. Experiments are carried out for different flow rates. There was a 4% and 6% increase in the convection heat transfer coefficient in the case of Ethylene Glycol (30%) and 0.5% volume fraction of Alumina nano-fluid respectively [19].The best heat transfer improvement (about 13%) was related to CNT nano-fluids with the flow rate of 21 mL/s and a volume fraction of 0.25% for.

Conclusions and Discussion

This paper gives a detailed description of various types of geometries that can be used to Heat transfer. Extruded fin enhancement geometries have been developed in order to make CPU cooling more efficient and compact. Currently air cooling with aluminum fin materials is very common used. This review paper discusses the numerical and CFD work along with the considerable experimental investigations carried out so far, which has been done on heat transfer growth through fins.

Further research is required to be conducted at a large scale on considerable Fin geometry, and hybrid fin and liquid cooling systems. Number of fins and their spacing, fin material and base plate thickness are explored for improving the heat dispersal rate from CPU. Upgrades on heat sink plans are conceivable by the utilization of CFD. It is conceivable to design another heat sink with appropriate base plate which has better heat removal and uses less material utilizing CFD as a tool. The heat sink base thickness is also a significant factor for increased performances. In the event that base plate material is chosen to be CCC (11) as opposed to copper or aluminum, at that point the thermal resistances of the heat sink is diminished.

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A Framework Model for Technology and Innovation Support Centers to Enhance Intellectual Property Rights

C. Vijayalakshmi[1], N. Raja Rajeswari[2] and Mandip Kaur[3]

Abstract To channelize and tap the creativity and innovation in India, the Union Cabinet approved the National Intellectual Property Rights (IPR) Policy in May 2016. World Intellectual Property Organization (WIPO)'s Technology & Innovation Support Centres (TISCs) are designed to provide innovators in developing countries with access to locally based, high technology information and related services helping them to exploit their innovative potential and to create, protect, and manage their Intellectual Property Rights[1]. The Cell for IPR Promotion and Management (CIPAM) has been designated as the National Focal Point (NFP) for establishing and developing TISCs all over India in the upcoming years, in collaboration with the WIPO. Recently, India has established TISCs at Patent Information Centre, Punjab and Anna University, Chennai. In this paper, a framework model for coordinating TISCs in Tamil Nadu is proposed and a similar networked approach can be taken on a national level for developing a well balanced IPR system in India. The demands for TISCs are growing worldwide and hence the proposed framework model can help in building a sustainable TISC network in India. In order to propose the model, the WIPO's TISC reports have been considered.

Keywords: Technology and Innovation Support Center (TISC), World Intellectual Property Organization (WIPO), Cell for IPR Promotion and Management (CIPAM), State Council for Science and Technology.

Introduction

India's National IPR Policy supports creativity and innovation. It helps to nurture IPR in the country, create IP awareness, commercialization and enforcement.

E-mail: [1]hellomurasaki@gmail.com, [2]arrnadhi@yahoo.co.in, [3]mandip17@gmail.com

[1,2,3]Trainee, Women Scientist–KIRAN IPR, Intellectual Property Office, Chennai

TISCs foster innovation by building on the rich set of technology information disclosed in patent documents, of which over 90 million have been published to date and in scientific and technical publications [4].

The Cell for IPR Promotion and Management (CIPAM) identifies potential host institutions, assess their capacities and support them in joining the TISC project [2]. CIPAM also acts as the main intermediary between WIPO and TISC host institutions and coordinate all the activities of the national TISC network. WIPO supports the effective operation of TISCs by (a) Facilitating access to patent databases and other scientific and technology resources (b) Training local users through on-site and distance learning (c) Providing information and training materials (d)Supporting awareness-raising activities (e) Disseminating best practices and experiences among TISCs [1].

WIPO's global infrastructure sector's Access to Information and Knowledge Division is responsible for facilitating access to patent information, scientific and technical literature, search tools and databases, and for building capacity in developing countries to effectively provide services for innovation support in the field of access, search and analysis of technology information [4]. Its activities include (i) Developing effective and sustainable TISCs; (ii) Facilitating access to specialized technical content through the Access to Research for Development and Innovation (ARDI) and Access to Specialized Patent Information (ASPI) programs; (iii) Preparing Patent Landscape Reports (PLRs) in various fields of technology; and (iv) Providing and facilitating access to legal status information of patent applications[4].

Activities of TISCs

TISCs offer services to help the inventors, researchers and entrepreneurs to unlock their innovative potential. According to TISC Report 2016, 59 countries have signed Service Level Agreements to develop national TISC network from 2009 to 2016. Over 517 TISCs have been established according to the data provided to the TISC directory [4].

Stages of TISC Establishment

WIPO's TISC implementation guide outlines four main stages involved in setting up and running a successful TISC [5]:

Stage 1: Project Planning
Stage 2: Project Initiation
Stage 3: Resource Development
Stage 4: Provision of TISC Services

In Stage 1: Project Planning–(a) Formal request submitted to WIPO by the interested governments (b) Assessment of user needs & capacity (c) Identification of focal points (d) Identification of potential host institutions (e) Implementation plan.

In Stage 2: Project initiation–(a) Sign Service Level Agreement (SLA) between WIPO and the designated government authority, which details the contributions and responsibilities of each party (b) Exchange of national institution agreements

In Stage 3: Resource Development–(a) Allocation of human resources (b) Provision of training and resources (c) Coordination between stakeholders

In Stage 4: Provision of TISC Services–Provide Basic & Additional services.

Finally 'Monitoring and Evaluation' step is performed after the above stages to meet the challenges faced by TISCs. The key stakeholders are involved in establishing a national network of TISCs each with specific roles and responsibilities. Fig. 1 shows the role of key stakeholders.

Resources and Tools

WIPO supports TISCs to receive the access to technology information and has developed training materials, publications, platforms and tools to assist TISCs.

Tech in Formation

ASPI-Access to Specialized Patent Information Program: WIPO's ASPI is a public private partnership developed through cooperation with leading patent information providers [4]. TISCs in developing countries can receive free or low cost access to sophisticated tools and services for retrieving and analyzing patent data through the ASPI program of WIPO (ex: Total Patent (LexisNexis), Pat Base, Orbit, Thomson Innovation, WIPS Global, GridLogics (PatSeer), Ambercite).

Tech Information

ARDI-Access to Research for Development and Innovation Program:

WIPO's ARDI program aims to reinforce the capacity of developing countries to participate in the global knowledge economy and also support researchers in developing countries to create and develop new solutions to technical challenges faced on a local and global level. For Ex: The ARDI program is a partner of Research4Life programmes, is a public private partnership of several U.N organizations, universities and publishers to provide affordable access to critical scientific research.

Platforms & Tools

eTISC Knowledge Sharing Platform

The eTISC (Electronic TISC) Knowledge Management Platform provides social media tools to encourage the exchange of information, experiences and best practices among TISC participants [9]. The eTISC community is open to all participants in WIPO's worldwide TISC program to users of TISC services in any country [9]. Through the eTISC platform we can (i) Connect with the eTISC community nationally and internationally learn from the experiences of other members to share our ideas (ii) Access learning materials, presentations, tutorials and related documents on the use of technology information and the provision of technology and innovation support services (iii) Participate in eTISC webinars and keep up to date with upcoming event (iv) Learn about related services such as Patents landscapes (v) Keep in touch with and get support from WIPO's TISC team.

Patent Register Portal (PRP)

The PRP assists the TISCs to access the legal status information with the help of the provision of information on online presence of national & regional patent registers and online gazettes. It also aims at facilitating the search of the information providing additional info on the type of data that is available on patent registers and tips on particularities and limitations of each register [4].

Selected Achievements of TISCs Worldwide

Some of the achievements of selected TISCs are listed below. Table 1 & 2 represents some of the achievements of TISCs worldwide.

New Areas of Work & Selected Highlights

WIPO's TISCs Report gives the following info[4].

Patent Analytics–New Area of TISCs Training

Training modules for Patent analysis have been developed and workshops on patent analysis were organized to support in value-added services.

Role of Key Stakeholders

WIPO:
1. Supports participating governments in preparing project documentation
2. Helps address training and resource needs
3. Enables sharing of experiences and best practices among TISCs.

Government Authority:
1. Identify national priorities
2. Assesses user needs
3. Signs off on project documentation

National Focal Point
1. Identifies potential host institutions, assesses their capacities, and supports them in joining the TISC project.
2. Act as the main intermediary between WIPO and TISC host institutions
3. Coordinates activities of the national TISC network
4. Monitors and evaluates the progress of the TISC project

Host Institution:
1. Provides administrative and technical staff required to deliver technology and innovation support services
2. Provides facilities and infrastructure

(Ex: Academic or research institutions, chambers of commerce, science and technology parks; technology, innovation or business incubators; industry associations)

Fig. 1 Role of key stakeholders

Table 1 Rise in filing the patent applications

TISCs	Period	Patent Applications Filed	Projects Identified as Eligible for Protection
TISCs in Philippines	2010–2016	184	–
TISCs in Colombia	2016	143	305
TISCs in Morocco	2015	150	–

Table 2 Strong demand for TISC services

TISCs	Period	Technology Search Requests	Industrial Property Inquiries
TISCs in Morocco	2011	750	-
TISCs in Colombia	2016	441	3909

Manual-Open Source Tools for Patent Analytics

Powerful open source tools are used to work with patent data. The assistance for selecting the tools for patent analysis is provided by the Manual on Open Source Tools for Patent Analytics.

New Development Agenda Project on the Public Domain

New tools are being developed to support TISCs and their users in using information in the public domain. The project will deliver a set of guides to help users identify and use inventions in the public domain to generate new research outputs and products, and enhance access to legal status information through the release of newly designed Patent Register Portal.

Public-Private Partnership Expansion

New patent databases became available to developing countries subsequent to Ambercite, a contributing partner which provides access to its patent citation search and analysis tool for free or at low cost to institutions in least developed countries and developing countries.

Implementing a Sustainable Framework Model to Coordinate Tiscs in Tamil Nadu

In Tamil Nadu, TANSCST (Tamil Nadu State Council for Science and Technology)–maintains liaison between Government of India and the State government and initiates, direct and co-ordinate research activities of government departments, universities and other professional bodies with a view to aid development of Scientific Research in the State [10]. TANSCST is capable of networking TISCs in Tamil Nadu and hence the rest of the states in India can follow the proposed framework model to build sustainable TISCs to overcome challenges faced by other TISCs in member states of WIPO.

The services of TISCs, locations of TISCs, networking the TISCs, generating revenue & human resources for TISCs, training/ awareness programmes of TISCs are discussed in the following sections.

Figure 2 represents the proposed network for networking TISCs in India and Fig. 3 represents the Detailed Framework for networking the key TISCs in all the states of India.

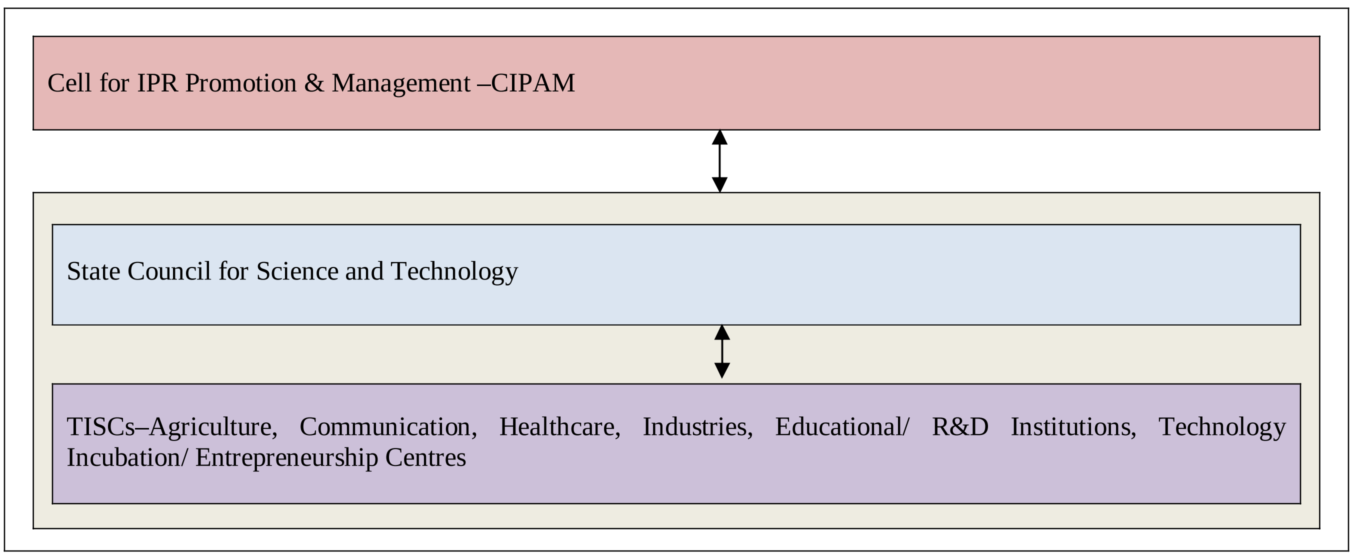

Fig. 2 Proposed framework for networking TISCs in india

Services of TISCs

Support services are provided by trained local staff and designed to promote access and effective use of valuable sources of technical & commercial information such as patent information, scientific & technical journals, trademark and industrial design information, etc [1].

The basic services can be made available in TISCs [1] (i) Access to online patent and non patent (scientific and technical) resources (ii) Access to industrial property related publications (iii) Assistance in searching and retrieving technology information.

Additional services provided by selected TISCs may include (i) Training in searching databases (ii) On demand searches (novelty, state-of-the-art and infringement) (iii) Technology and Competitor monitoring (iv) Basic information on industrial property laws (v) Basic information on industrial property management and strategy (v) Basic information on IP commercialization and marketing.

The patent information tools and services can be used at each stage of the national innovation processes (i) Creation and evaluation of inventions (ii) Development of products (iii) Protection of inventions (iv) Product commercialization (v) Patent enforcement and litigation.

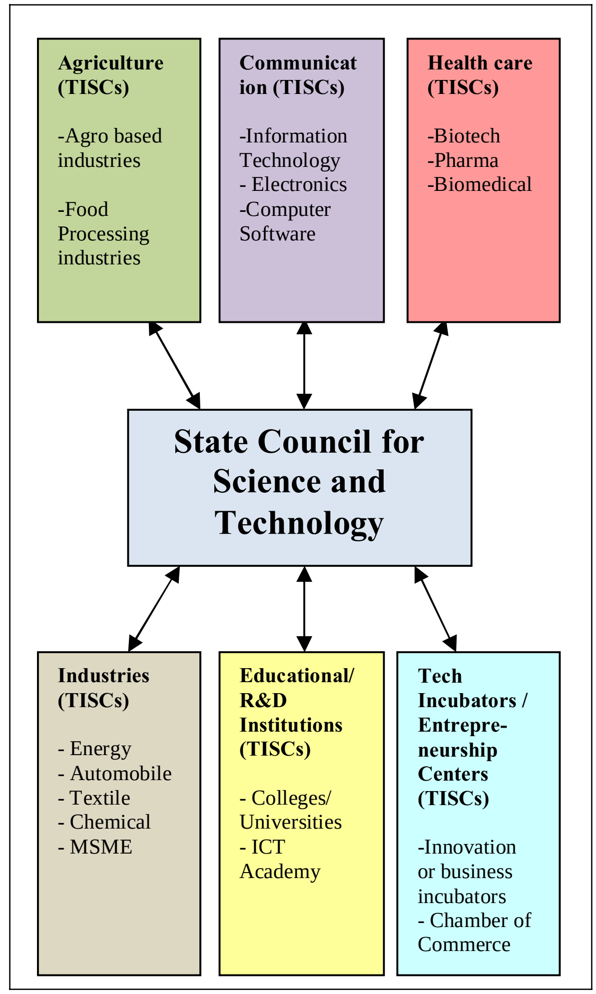

Fig. 3 Detailed framework for networking the key TISCs in all the states of india

Location of TISCs

TISCs can be established to develop the innovative & creative potential in the following six key sectors as a part of our framework model: (i) Agriculture (ii) Communication (iii) Health Care (iv) Industries (v) Educational and Research Institution (vi)Tech Incubators/ Entrepreneurship Centres. These six thematic areas are concentrated to develop and empower our society through the inventions made in the TISCs. The inventions from TISCs will foster technology, socio-economic and cultural development.

Networking of TISCs

The State Council for Science and Technology can act as a state focal point of TISCs in each state (ex: TANSCST in case of the state of Tamil Nadu). This networked approach can be followed in all the state council of science and technology across all the states in India. This approach will be helpful for individual TISCs to easily approach state council for guidance, resources and coordination of activities. The state council for science and technology can address the challenges faced by regional TISCs to CIPAM. The annual reports of the TISCs in India can be submitted by CIPAM to WIPO to get motivation and support.

Revenue for TISCs

Revenue for TISCs can be generated by the following ways (i) TISCs can generate revenue by offering basic/additional services which are offered for non-members of the TISCs. (ii) State/Central government can provide initial funding for TISCs establishment. (iii) The organization which establishes their TISC can allot fund for IP activities in their TISC (iv) TISC can try to opt for Public–Private Partnership for sustainable TISC. (v) TISCs can approach CIPAM/State Council for Science & Technology to get funding to conduct awareness programmes.

Human Resources for TISCs

Human resources for TISCs can be generated by the following possible ways (i) The intake of Women Scientists under WOS-C scheme (KIRAN IPR) can be increased to fulfil the needs of IP professionals in TISCs. (ii) The IPR training scheme can be followed by the state governments to educate and train the science and engineering graduates in IP field to make them employable in TISCs and also become IP facilitators.

Training & Awareness Programmes of TISCs

Some of the initiatives for training & awareness of TISCs are:

1. TISCs can initiate the celebration of World IP day (April 26). Awards can be given to encourage and motivate the members of the TISCs for their achievements.
2. Dedicated Conferences and workshops can be organized for promoting, as well as sharing best practices between TISCs.
3. A dedicated website for the Technology and Innovation Support Network can be developed to promote patent information services, e-learning and to hold webinars and forum/blog can be developed to motivate discussion related to IPR. E-learning courses can be created and uploaded in dedicated TISC website. (Ex: NPTEL courses conducted by IIT Madras offer free online courses like 'Patent Law for Engineers and Scientists' and 'Patent Drafting'). Information about WIPO's distance learning courses and paid courses can be informed in TISCs website. MOOCs can be developed for digital learning.
4. Information materials regarding IPR, searching technology, licensing, enforcement, etc available from WIPO and other sources can be posted in the TISC website for learning and to create awareness.
5. The officials from Intellectual Property Office and professionals from IP tool developing companies can be invited as guest speakers to give talks on IPR, to know about job opportunities in IP.
6. TISCs can approach IP professionals from industries involved in R&D to get ideas on technology transfer/licensing of IP.
7. Free Mobile App can be developed and advertised to create awareness of IPR and also to learn IPR concepts and the Patent Law and Rules too.
8. TISC can approach FICCI (Federation of Indian Chambers of Commerce and Industry), CII (Confederation of Indian Industries) to give ideas for IP commercialization.
9. TISC can make an agreement with Remote Centres of NME-ICT (National Mission on Education through Information and Communication Technology) / EduSAT to create IPR awareness for rural/urban students and teaching faculties in India.
10. TISC can contact Rajiv Gandhi School of Intellectual Property Law, IIT Kharagpur and other law schools to get the current IP law and amendments. Rajiv Gandhi School of Intellectual Property Law has a Legal Aid and Intellectual Property Facilitation Clinic (LIFC) which offers free consultation over legal and IP matters to the general public, students and IIT community.
11. Tamil Nadu (TN) MSMEs can approach TISC in Anna University, Chennai to file patent/trademark for which the TN government provides subsidies for technology development [7].

Conclusion

The proposed framework model for networking of TISCs can help the Tamil Nadu government to achieve its goals on development as mentioned in TN Vision 2023 and India's goals on Technology Vision 2035, National IPR policy and initiative of Make in India. The proposed sustainable framework model can assist all the state governments to network their TISCs and also help CIPAM to develop robust-networked TISCs in India. The proposed framework model of networking TISCs can also be followed by all the members of WIPO to enhance the IPR.

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A Survey and Recommendations on Teaching Pedagogy for New Generation Learners

Abhishek Arya[1], Jyoti[2], R. Sabarishwari[3], S.S. Krishna[4] and L. Ramesh[5]

Abstract This work aims at identifying the latest innovative teaching styles should be followed in higher institutions of learning. We have also tried to explore which teaching style in higher level educational institutions motivates a student to a greater extent. This study is based on a field work, of which population included students of a technical university. The study included convenience sample of students from the particular technical university. The team has also tried to identify the crucial traits of teaching styles based on desk research, responses received through questionnaire, and discussions with teams. This questionnaire was designed on teaching Pedagogy for New Generation Learners; it contains two main sections concerning the main variables of the study. The first section intended to Walk-through data collections. The second section designed to observe the various teaching styles through Google forms. After the several study and discussions the survey team suggested several recommendations and suggested for implementation.

Keywords: Pedagogy, Generations, Questions, Survey

Introduction

The craft of teaching is becoming increasingly complex and nowhere is this more evident than in the area of literacy. Effective teachers are capable of ensuring that an increasingly diverse group of students have the literacy skills to cope with the demands of life beyond school in their careers and/or college. Experts have been debating the best way to teach reading for over fifty years. In reality, there is no single method that will teach all students to read and write successfully. Over the years, various approaches have come in and out of favor in an effort to raise achievement. These include: tighter curricular specifications, prescribing structures for literature blocks, providing scripts for teaching and increasing accountability, all resulting in minimal impact on the learning outcomes for students. Classrooms today are complex and dynamic learning environments. Identifying the range of factors that positively impact student achievement has been a major focus of research. There is clear, documented evidence of the most effective features of practice including the degree of the teachers' influence and what they do to raise student learning outcomes. Literacy teaching can only be described as truly effective when it positively impacts student learning. Successful teachers are able to skillfully integrate a range of instructional approaches and resources to meet the diverse learning needs of their students. Keeping these things in mind the survey team has visited to the students from various fields in an educational institute of Chennai. There the survey team has managed to take the survey in two stages as: Walk-through data collections & observation through Google forms. Both the Walk-through data collections & observation through Google forms is segregated into two stages. In the stage 1 the team have managed walk through survey of students from different branches of a particular technical University of Chennai. Than after in stage 2 the Survey team entered the responses in Google form and studied the various obtained graphs. After completion of detailed audit the audit team has suggested some necessary recommendations as discussed below. After the implementation of these recommendations the students will get the outcome as Facilitating thinking and problem solving, Assisting with mastery learning, Inspiring and engaging students, Authentic learning opportunities etc. The next section is the review about the several data collections and suggested recommendations.

Methodology and Data Analysis

The Survey team has managed to take the audit in two stages as: Walk-through data collections & observation through Google forms. Both the Walk-through data

E-mail: [1]abhishekarya1309@gmail.com

[1,2,3,4,5]Dr. M.G.R Educational and Research Institute

collections & observation through Google forms is segregated into two stages. In the stage 1 the team have managed walk through survey of students from different branches of a particular technical University of Chennai. Than after in stage 2 the Survey team entered the responses in Google form and studied the various obtained graphs. The team has also tried to identify the crucial traits of based on desk research, responses received through questionnaire.[1] and discussions with teams. This study is about common issues in teaching pedagogy these days students are facing. Questionnaires were distributed in various students for data collection by using stratified random sampling technique. Approximately all questionnaires were received in complete form. There was a set of 10 questions asked with the responses to be given by circling any one of the following categories that will indicate the degree to which the respondent agrees or disagrees.[6] The responses will help the team to understand the various consumption of the respondent. The respondents have been advised to give their immediate impressions and that there are no right or wrong answers.

Some of the sample questions asked was:

1. The current teaching methods are good?
2. Mention the top 3 changes you would like to implement in teaching methods?
3. Is the teacher able to stimulate your creative thinking?
4. Mention top 3 changes that would create a better learning environment?
5. What is the percentage of activity based teaching and learning process in classroom?
6. Is class teaching is adequate for facing the exams or you need some additional support?
7. Give your 2 suggestions for improving your performance during exams?
8. Your 3 ideas on improving quality in higher education.

In the next section is shown the responses of the sampled students with the old teaching pedagogy.

The above figure is showing the satisfaction of students on the present method of teaching. The current method of teaching is the biggest challenge in the teaching pedagogy. Half of the responses are against the present teaching method, which is in percentage calculated as 50% of students are against it, whereas half of the students are satisfied with that which is 50% in numbers.

Fig (2) represents the teachers' ability to simulate the creative thinking of students which is mandatory for students to get employability nowadays. From the above mentioned graph it is concluded that 54.3% of students have agreed that their teacher are able to simulate their creative thinking. 45.7% of the students are not in the favor.

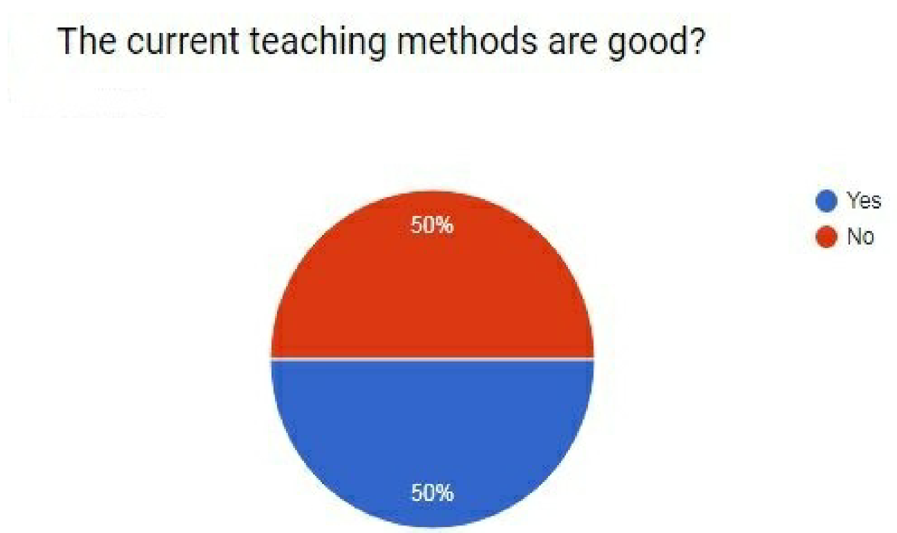

Fig. 1 Percentage Observed for Teaching Methods Satisfaction

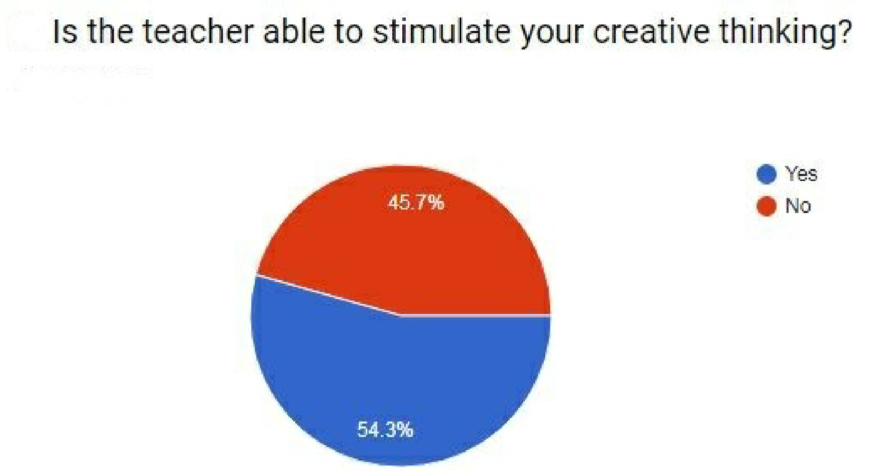

Fig. 2 Teachers' ability to simulate creative thinking in percentage

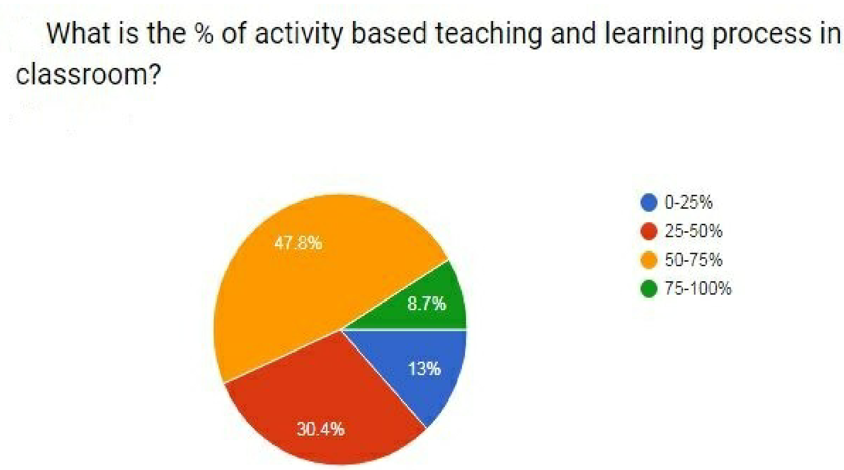

Fig. 3 Percentage of activity based teaching and learning process in classroom

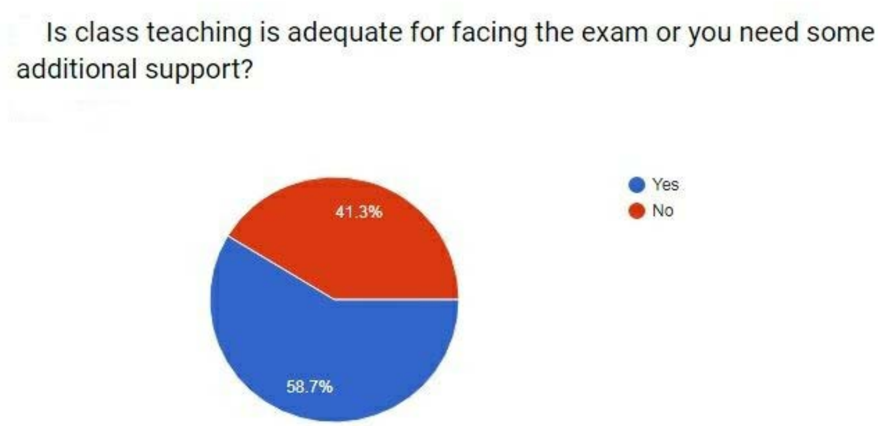

Fig. 4 Percentage of adequacy for additional support

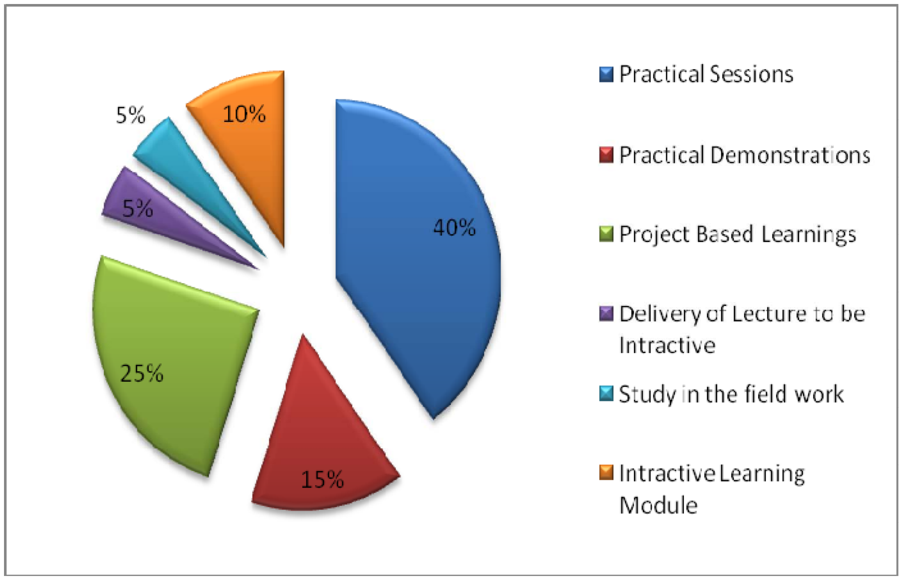

Fig. 5 Analysis of some major suggestions in percentages

The above mentioned pie chart represented in fig-(3) shows the percentage of activity based teaching and learning process in classroom. From the graph it is observed that the 47.8% of students are with 50-75%. 30.4% of students chosen 25-50%, whereas 13% of students are going with 0-25%. 8.7% of students told that they are fully satisfied with the present teaching methodology.

The above given figure represents the adequacy for additional support for facing exams apart from class teaching. It shows that the 41.3% of students not needed any additional support for facing the exams. But majority have chosen that they want some extra support for facing the examination which is 58.7 in percentage.

Suggestions and Recommendations

The Survey was conducted and the team come up with following major suggestions from the particular group of students, which observed for necessary action. These mandatory suggestions are ordered in the percentage for priority implementation.

- Outdoor Classes
- More practical session.
- Syllabus should be revised with the updates.
- E-learning
- Take ideas from students
- Teaching methodology is monotonous
- Assignments should be creative and practical.
- Practical practice in learning
- Conduct special classes for weak students
- Provide study material according to the syllabus well as for competitive exam.
- Expanding the horizons.
- Project work should be given in second year itself at the students choices (I –project).
- New software
- More research funding and equipment help
- Communication skills

After several brains storming sessions, six recommendations are suggested for implementation to improve the old teaching pedagogy. The detailed discussions are presented below.

Embedded Practicals in Theory

Recommendation suggestion to implement practical content in all the application oriented subjects with 70% theory & 30% practical. Theory paper will contain 70 marks in semester exam and practical paper will contain 30 marks and evaluation should be done by industry person or external examiner. . In the semester with theory exam has to make a working model too based on the subject. The exam marks will be given according to both models. This will cover at least 3 units of the subject. This will give theoretical as well as practical knowledge to the student regarding the subject. One example of Application oriented subject is 'Design of Electrical Machines' where above suggested module can be applied.

Practical Demonstration

Application of technology needed to convert all the classes to be laboratory. Which will represents each individual part of the equipments. In this module teachers not have to in classes instead of that students itself will come in the lab. The student will get interest in subject and better learning process. In the semester instead of theory exam has to make a working model based on the subject. The exam marks will be given by the based on project model. This will cover all the 5 units of the subject. This will give theoretical as well as practical knowledge to the student regarding the subject. One example of subject can be taken as ‘Control system’ where above suggested module can be applied.

Interactive Delivery of Lecture

According to this module the teachers have to segregate their class hours. The starting 5 min should be given on attendance. Next 15 min should be interactive delivery of lecture, such as video session, picture presentations, debate between students. Then start the next 15 min session with the students interesting topic from the syllabus and end the session with the seminar given by the students at the same topic. This will give theoretical knowledge to the students regarding the subject as well as understanding about the subject topic.

Field Work Study

The field work study will give more practical knowledge and interest on the subject. This will help to improve the problem solving skills. The field work study has a major advantage, which will lifelong remindable. An example can be taken as for civil department small construction work, for electrical department wiring in houses can be taken for field work study.

Interactive Learning Module

Teachers should have to intract with students in diffrent ways to make the studies easier and comfortable to understand. For this various new methods can be implemented like techers can show some vedios or picture and students can give their views. Teachers should come up with some interactive delivery of lectures, debate between students, seminars on current topics in class itself etc.

Outcome

With all these implementations of recommendations students will come out with several skills after completion of B-Tech as:

1. A bulk of theoretical as well as practical knowledge specially.
2. Students will be having full experience in one topic, which will be related to their project.
3. Students will be able to compete with the job market available these days.
4. Students will understand the practical things much more easily.
5. Team work skills and passion for work will increase.

Conclusion

Any teaching method without destroying the objective could be considered as innovative methods of teaching. The researchers believe that the core objective of teaching is passing on the information or knowledge to the minds of the students. There are a number of ways that teachers can bypass the system and offer students the tools and experiences that spur an innovative mindset. The related survey executed successfully with the strong recommendations. Six types of recommendations like embedded practical in theory, practical demonstrations, Interactive delivery of the lecture, field work study, and interactive learning module suggested for implementation.

Acknowledgment

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Current Issues and Challenges in Employability of Polytechnic Students and Achievable Suggestions

Karthikeyan Veerasamy

Abstract Polytechnic education imparts technical diploma courses in various disciplines of engineering and technology and polytechnic colleges are affiliated to the technical education boards of the respective states. The prime objective of the polytechnic education is to produce skilled manpower in the mid level to serve as a link between technicians and engineers. On completion of a diploma course, the students mainly opt for good placements in renowned organisations at high perks. There are many issues and challenges in the present scenario of employability of polytechnic students owing to many reasons. Hence, a study has been made on the activities of the Training and Placement Cell of a Polytechnic College in Salem. This paper aims to present the empirical research with methodologies to analyse the performance of the Training and Placement Cell which depicts the current challenges in obtaining good placements for the students with some achievable suggestions. A sample of 1087 respondents including all the stakeholders was taken through convenience sampling method and various tools were applied for analysis. The results revealed that the performance of the training and placement cell is found more effective among the students and least among the industry personnel. The findings also revealed that the challenges in fetching good placement are the lack of good communication skills, improved technical expertise, teamwork, sustainability, unwillingness to go out of state etc., Some achievable suggestions to overcome these challenges are the implementation of Value Added Courses during the pre final year itself in the areas of Communication Skills, Technical Skills, Aptitude, Soft Skills and Values and Ethics and arranging more industrial visits and In-plant trainings to gain the real time industrial issues. These suggestions would enhance the employability of the polytechnic students to fetch the right career in reputed organisations.

E-mail: [1]tptprincipal@gmail.com

[1]Principal, Thiagarajar Polytechnic College, Salem

Keywords: Polytechnic, Employability, Challenges, Suggestions, Value Added Courses

Introduction

The economic development of the nation has been greatly augmented by the polytechnic education in India. The prime objective of the polytechnic education is to produce skilled manpower in the mid level to serve as a link between technicians and engineers. Hence, the students who pass-out from polytechnic colleges play an important role in industries. Also, it is true that the diploma holders are preferred by small & medium scale industries due to their unique skills in various areas. On completion of a diploma course, the students mainly opt for good placements in renowned organizations at high perks. There are many issues and challenges in the present scenario of employability of polytechnic students. Hence, a study has been made on the activities of the Training and Placement Cell of a Polytechnic College in Salem. This paper aims to present the empirical research with methodologies to analyse the performance of the Training and Placement Cell which depicts the current challenges in obtaining good placements for the students with some achievable suggestions.

Review of Literature

The present study is attempted to analyse the current issues and challenges in employability of polytechnics and hence, study has been made on the polytechnic education and the functioning of training and placement cell to enhance the employability of the students. The diploma holders who graduated from the polytechnics three to four decades ago occupy senior positions in the industrial sector, and have contributed significantly to the industrialization efforts of the country (Palit, 1997).

The concept of employability has got diverse meanings from different authors. In order to gain employment, the relevant knowledge and skills must be attained (Reid, 2015).

Employability is the capability to get primary employment, also maintain that job and obtain new one (Hillage & Pollard, 1998). Employability is the necessary factor which helps the employers to get employee based on the future effective functioning of their organisations (Kamal, 2006). However, a few researchers consider that employability is related with employment of the graduates and measured as an educational outcome (Harvey, Lock & Morey, 2002). In addition to the technical and discipline competencies expected from the graduates, employers also expect them to display many broader skills and attributes that include communication, team-working, lateral thinking, leadership, problem solving and managerial abilities (Stuart et.al, 2011).

Many researchers have attempted to study on the Training and Placement Cell functioning in higher educational institutions. The Placement Cell always strives to achieve 100% placement. The students are kept personally and professionally updated to the unfolding dynamic environment (Swathappa, 2011; Champal, 2012; Hariharan, 2009; Mantri, Dutt & Gupta, 2007). Many surveys are conducted by government and private concerns, where the Training and Placement wing and its facts and figures play a vital role in deciding the ranking of the institute (Champal, 2012).

In the polytechnics, most courses are biased towards skills acquisition with plenty of hands-on practices and imparting skills in locating and solving workplace related problems. With changes in the economic and employment scenario, the polytechnics are also offering modules which enhance the communication and life skills of its learners. It is acknowledged that a gap exists between the level of employability skills of graduates and work requirements of new entrants (Ranasinghe, 1992; Lindsay, 2002).

Research Methodology

An empirical study was carried out, as this project mainly focuses on the current issues and challenges in employability of polytechnic students. One of the main research instruments for collecting primary data is through properly framed questionnaire like optional type questions and questions on Likert’s five point scales. The main focus of the questionnaire is on the information about the factors that influence the employability of polytechnic students and the satisfaction of all the stakeholders. The secondary data were collected from the previous benchmarking reports and the past activities of the Training and Placement Cell of the institution.

In order to perform the study, a pilot study was planned and pretested with 50 respondents initially through a well-defined scientific questionnaire in English and in the vernacular language in order for better understanding by the respondents and rated with Five Point Likert's scale ranging from 1-Unsatisfactory to 5-Outstanding. Separate questionnaires were framed for each stakeholder and distributed among them for checking the reliability and feasibility of the factors and variables considered in the questionnaire. The result revealed that the instrument has the reliability of more than 0.75 which is above the threshold limit prescribed by Cronbache's alpha value (0.5 and above). The variables for the different stakeholders are selected based on their expectations and also on their perceptions on the functioning of the Training and Placement Cell of the institution. The study results were analyzed using various statistical tools.

Sample Sizes

This study mainly considered a small representation in view of representing the total population and the sampling was drawn on the basis of Stratified Random Sampling method and the required data was collected. The 95% confidence level was used and the sample size is calculated as 145 for the population size of 230. As an example, the Industry the sample size is calculated as

$$\text{SS} = \left[\frac{1.96^2 * 0.5(1-0.5)}{.05^2}\right] = 0.9604/0.0025 = 384$$

$$\text{Hence the required Sample Size} = \left(\frac{384}{1 + \frac{384-1}{230}}\right)$$

$$= \left(\frac{384}{2.66}\right) = 145$$

N = Population size = 230

n = Required Sample size = 145

Sample size is calculated separately taking each group as population and it is presented in Table 1.

Table 1 Sample size calculation

Group	Population	(CL)95%, (CI)5%
Industry	230	145
Alumni	3532	347
Parents	745	254
Students	758	258
Faculty	105	83
Total	5360	1087

Table 2 Opinion towards the performance of training and placement cell

Factors	Requires Improvement		Satisfactory		Good		Outstanding		Mean Rank	Reliability
	N	%	N	%	N	%	N	%		
Promptness of correspondence	5	3.4	46	31.7	68	46.9	26	17.9	3.65	0.895
Support of Training and Placement Cell in campus recruitment process	11	7.6	52	35.9	56	38.6	26	17.9	3.42	
Facilities provided for conducting interviews	9	6.2	54	37.2	53	36.6	29	20.0	3.51	
Training and Placement Cell's rapport with the industry	9	6.2	48	33.1	61	42.1	27	18.6	3.57	
Students involvement during campus recruitment	17	11.7	51	35.2	61	42.1	16	11.0	3.16	
Infrastructure facilities of the institution	10	6.9	47	32.4	56	38.6	32	22.1	3.69	

Table 3 Opinion towards the programmes organized by training and placement cell

Factors	Unsatisfactory		Requires Improvement		Satisfactory		Good		Outstanding		Mean Rank	Reliability
	N	%	N	%	N	%	N	%	N	%		
Developing confidence to face the interview	7	2.2	12	3.8	42	13.2	165	52	93	29	3.16	0.929
Enhancing their communication skills	9	2.8	13	4.1	33	10.3	132	41	132	41	3.50	
Built your attitude	7	2.2	9	2.8	34	10.7	136	43	133	42	3.63	
Improving team work	8	2.5	12	3.8	28	8.8	151	47	120	38	3.51	
Adequacy to fetch a good job	10	3.1	9	2.8	34	10.7	137	43	129	40	3.53	
Moulding and shaping their career aspirations	6	1.9	17	5.3	29	9.1	122	38	145	45	3.67	

Analysis and Interpretation of Data

The data collected were systemically processed, tabulated for analysis and interpretations to fulfill the goal of the study.

Industry Personnel

In order to find the opinion of the Industry personnel towards the various factors considered under the performance of Training and Placement cell of the institution, Percentage analysis was done along with the Friedman's test and the results revealed are given in Table 2.

From Table 2, it is clearly noted that "Students involvement during campus recruitment" is found least among the 6 factors with mean rank of 3.16. Regarding the reliability of the variables considered, it is seen that the overall reliability is found to be 0.895 and thereby confirms that the variables included in the study and the scale selected were highly reliable and reflected positive relationship among them.

Opinion of industry personnel towards the performance of alumni in industries

In order to find the opinion of the Industry Personnel towards the performance of alumni in their respective industries for various factors, percentage analysis was done along with the Friedman's test and the results revealed are presented in Fig. 1.

It is noted from the Fig. 1 that the mean rank is 5.15 for the factor "Technical Skills" while the mean rank is least at 4.22 for the factor "Communication Skills". The other factors with low mean rank are "Lateral Thinking", "Application oriented knowledge" and "Leadership Quality".

Alumni

The opinion of alumni towards the programmes organized by the Training and Placement Cell was analyzed and Friedman's test was conducted and the results revealed are furnished in Table 3.

The above Table clearly depicts that the mean rank for the factors "Developing confidence to face the interview" and "Enhancing their communication skills" is found least while the mean rank for the factor, "Moulding and shaping their career aspirations" ranks the first.

Faculty

The opinion of the faculty for the factors considered towards the performance of the students during training programmes and campus interviews was analyzed and Friedman's test was conducted and the results are presented in Table 4.

It is revealed from the Table 5 that among all the factors "Students Communication Skills" was ranked the least with mean rank 2.48 followed by the factors "Students updation in Technical skills" and "Students promptness during interviews".

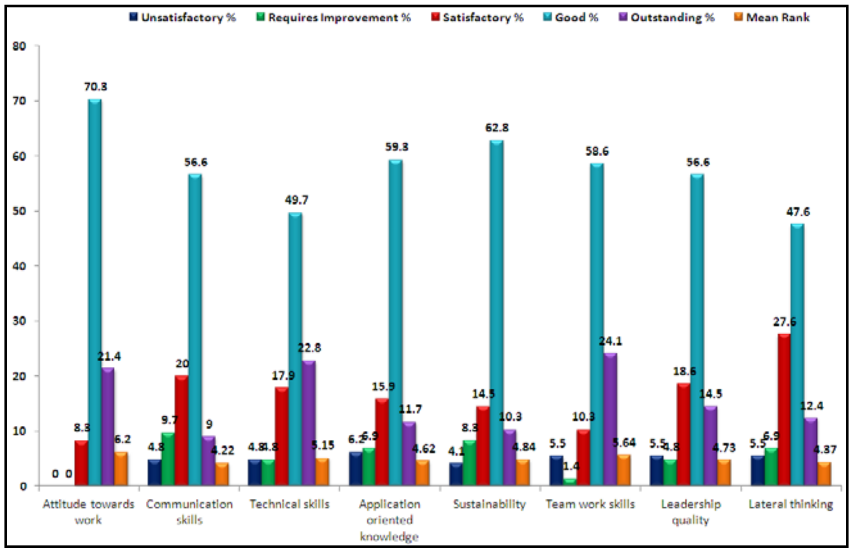

Fig. 1 Opinion of Industry Personnel on the performance of alumni

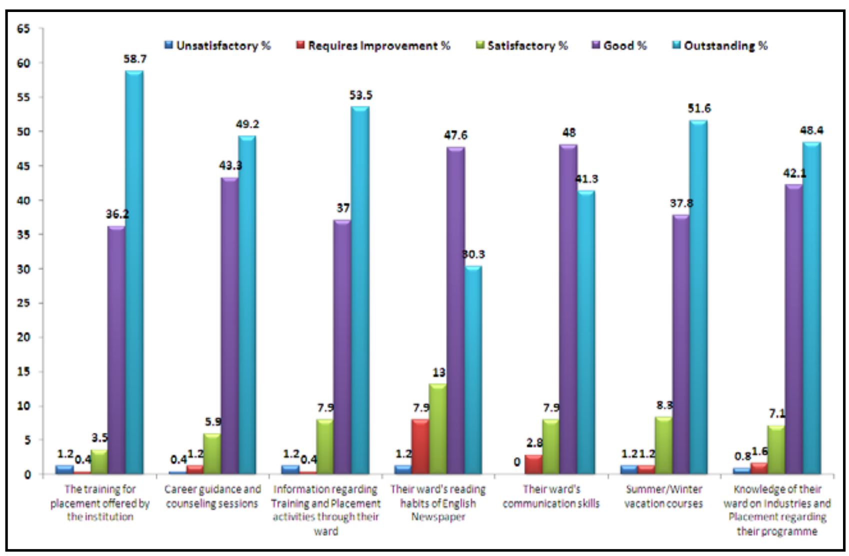

Fig. 2 Opinion of Parents towards the Training and Placement Cell

Table 4 Opinion towards the performance of the students during training programmes and campus interviews

Factors	Requires Improvement		Satisfactory		Good		Outstanding		Mean Rank	Reliability
	N	%	N	%	N	%	N	%		
Students participation in Training Programmes	5	6	9	10.47	51	59.30	21	24.42	3.70	0.684
Students updation in Technical skills	7	8	13	15.12	50	58.14	16	18.60	3.38	
Students promptness during interviews	8	9	9	10.59	46	54.12	22	25.88	3.61	
Students dress code during interviews	8	9	10	11.63	41	47.67	27	31.40	3.74	
Consistency in performance of students in academics	3	3	10	11.63	40	46.51	33	38.37	4.10	
Students communication skills	12	14	26	30.23	41	47.67	7	8.14	2.48	

Table 5 Opinion towards the training and placement cell

Factors	Satisfactory		Good		Outstanding		Mean Rank	Reliability
	N	%	N	%	N	%		
Conduct of career guidance programs through Training and Placement Cell	10	3.9	92	35.7	156	60	3.97	0.824
Short term courses offered through Continuing Education Center	6	2.3	105	40.7	147	57	3.90	
Technical/ General lectures delivered by experts	9	3.5	85	32.9	164	64	4.07	
Guidance by our institution for undergoing In-plant training	11	4.3	73	28.3	174	67	4.21	
Organization and benefits of Industrial visits	7	2.7	61	23.6	190	74	4.47	
Communication classes through English communication laboratory	17	6.6	91	35.3	150	58	3.82	

Parents

The distribution of the opinion of the respondents with respect to performance of Training and Placement Cell was analyzed through percentage analysis and the results are presented in Figure 2.

From the Figure 2, it is inferred that with respect to the performance of the Training and Placement Cell, in connection with the factors, "Their ward's reading habits of English Newspaper" and 'Their ward's communication skills', 7% and 2.8% respectively stated requires improvement.

Students

In order to find the significant association found between the training programmes organized in connection with the various factors was analyzed, Friedman's test was conducted and the results are presented in Table 5.

It is evident from Table 5 that with respect to the training programmes organized among all the factors, the mean ranks for the factor "Communication classes through English communication laboratory" was found least with 3.82 followed by the factor "Short term courses offered through Continuing Education Center".

Summary of Research Findings

In order to find the current issues and challenges of employability through the activities of training and placement cell of the selected polytechnic college, the research findings were revealed through the above study.

The industry personnel opined good for the performance of the Alumni of the institution in industries and majority stated that students should Improve their communication skills, application oriented knowledge, leadership qualities and must exhibit good involvement during campus recruitment. The data from Alumni revealed that developing confidence for facing the interviews and enhancing the communication skills need improvement.

While reviewing the opinion of the faculty on students, they have suggested that the students must improve their communication skills, update technical skills and must be prompt during interviews. The opinion of the parents revealed that their wards should develop more proficiency in English and enhance their knowledge on Industries. The students' opinion revealed that improvement is needed in developing communication skills and learn more need based short term courses through the Continuing Education Centre.

Implications of the Study

The study revealed that the current issues like communication skills, industrial exposure, technical expertise and attitude must be enhanced in order to improve the employability of polytechnic students. Hence, Value Added Courses can be conducted to the students from the pre final year, which would certainly enhance the students' competency and their placement potential. In addition, in order to gain practical and application oriented knowledge with Industrial exposure, more number of In-Plant Trainings, Industrial Visits and Technical/Guest lecture programmes by industrial experts can be organized through Industry Institute Partnership Cell which in-turn will yield definite placements to the polytechnic students.

Conclusion

This project has made an attempt to study the various issues and challenges that can affect the employability of polytechnic students. The study commenced with analysing the present status and activities of the Training and Placement Cell by seeking opinion from all the stakeholders. The results were analysed and interpreted. The findings revealed that the current issues in employability of polytechnic students are lack of communication skills, technical skills, application oriented knowledge, industry exposure and general attitude. These issues can be overcome through imparting Value Added Courses in addition to the regular diploma syllabus. Also, the students must be exposed to real time industrial situations through frequent industrial visits and technical lectures from eminent industrialists. The successful implementation of the above suggestions will certainly enhance the employability of polytechnic students.

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Strategic Alliance: A Strategic Innovation, Formation and its Challenges

Balakrishnan Nair[1]

Abstract Innovation brings in better results with new introductions on the strategies or technology. Strategic Innovation should bring transformation on the performance of organizations through different means like adding new ventures, research and experiments. Results may vary from failures to success which needs careful analysis on the effectiveness of strategy. Different forms of innovations affect business operation management in varying forms and hence should not be tied down with existing procedures and techniques alone. Various challenges crop up during execution as each organization differs from one another in different styles.

Human resources are the pillars of any industry. A proper balance should be maintained with languages, culture, diversity, ethics and functioning. In fact, outsourcing or joining hands with other individuals or organizations is also a strategic innovation as long as it falls short of registration of another new firm for its intended purpose. A strategic alliance is an organizational and legal construct where in all partners are motivated to act and share core competencies including profit. Such acts of collective involvement with clearly defined demarcations on the roles and responsibilities do bring rich dividends to all players of the alliance.

Strategic Alliances started taking shape in 1970 with focus on the performance of the product with lowest price, good technology and improved focus on the product. From the 1980s the number of strategic alliances increased dramatically aimed at building economy. It started spreading to other geographical boundaries across the world relocating to other countries with development capabilities and competencies. While various advantages like shared risk, shared knowledge, opportunities of growth, innovations on new design with advanced technology, improved incentives for faster delivery etc. many disadvantages also surfaced. These include uneven alliances, creation of new competitors, inefficient management, leakage of information, partners' unwillingness to supply key resources and hence delayed delivery of the product etc. This promoted negative behavior among employees, lack of understanding, underestimated complexity, overdependence and delays escalating into legal tangles and erosion of credibility. Risk mitigation processes shall be initiated to restore confidence to the stake holders.

Keywords: Strategic Innovation, Strategic Alliance, Risk Mitigation

Introduction

What is Strategic Management [1]? It is a management process wherein different thoughts are conceived, initiated and implemented to enhance the performance of the organizations and monitor the changes through fresh injection of ideas and thoughts. Strategic management provides a new vision and its mission for setting improved goals and targets.

Strategic Alliance [2]

Since strategic alliance involves two or more firms, different approaches can be pursued for revolutionary changes in their operations. The strategies can think of different approaches in financial management, procurement management, operation management and start up operations including technology transfer and economy specialization.

Since strategic alliance is the agreement between two or more corporations to share resources or knowledge or expertise for the benefit of all involved parties. Strategic alliances definitely do supplement operations, and it also enhances the performances of resources to the most optimum level. By this process the parties shall have access to the needed resources or processes including suppliers, customers, competitors, brand owners and other government institutions. It is an organizational act which is a legal construct where partners are motivated to act in concert and share core competencies of their organizational functions.
Some types of strategic alliances include but not limited to the following:

[1]Specialist Member, International Institution of Risk Management (U.K);
Technical Member, Institution of Occupational Safety and Health (U.K);
Life Member, National Safety Council of India;
Former Company Representative, Petroleum Development Oman

- Horizontal Strategic Alliances [3] are normally formed between organizations of similar products, processes or industries including logistics. By forming such alliances, research and development collaborations can bring in improved results.
- Vertical Strategic Alliances bring in company upstream and downstream group including supply chain group personnel. This adds up the strength including suppliers and logistics firms. By evolving such an alliance, costs as well as efficiency in delivery can be improved. Car manufacturing with its various parts suppliers come under this category.

Joint ventures [4] are also alliances where two or more firms decide to form a new company for better organizational matters and performances. The new company will then become a legal entity. They agree and finalize their equity shares and resources to be invested before the alliance is formed. Such alliances may be formed for a finite time or project. The alliance may get extended for long term business relationship depending upon the performance while control, revenue and risks are shared according to their capital contributions. These types of alliances are formed between organizations for efficient projects execution when the projects require specialized skills and also depending upon geographic locations. Such alliances can improve operation efficiency while the costs can be controlled through efficient management systems.

Historical Development [5]

While some analysts claim that strategic alliances are a recent phenomena, collaborations between enterprises did exist even earlier. The numbers were very limited at that time but of late, they have grown quickly. This is mainly due to developmental activities that have flourished in the recent times and regions. No limitations are in place for the firms to join hands across various geographical boundaries irrespective of barriers in culture, race and difficulties in logistics to promote their expertise and brands. Such arrangements brought the farthest to the nearest very close with products spreading to remotest areas of the globe.

While in the 1970s the focus of strategic alliances was on the performance of their products, in the 1980s it aimed at building economies and extending responsibilities and scope. Partners and customers always want a product of best quality which can perform efficiently with the lowest price, good quality and updated technology. The product was given its primary focus. The 1990s saw alliances spreading far and wide and this needed constant innovations in research and development leading to design of new products. Parties also started to relocate to various other regions from their countries to improve their growth as well as maintenance and services of their products. Such movements also paved the way for developing capabilities and core competencies.

In today's era, majority of the corporate operate with alliance partners. Alliances do help to enhance growth of industry with their expertise and competency. Hence it is appropriate to deploy their best resources and competence to improve the economy for the benefit of all partners and thus the serving nations. Raw materials need to be procured from original manufacturers to ensure quality and best prices before they get into contracts with responsibilities and prices firmly finalized. Household appliances like washing machines or refrigerators contain various components and these items are either procured off the shelf from other vendors or get it manufactured by reputed suppliers.

Having mentioned all the above, there are advantages and disadvantages on strategic alliances in its functioning and which may affect its life subsequently.

Advantages [5]

1. ***Shared Risk***: Risk is a big gamble which all the involved parties have to take reasonably and responsibly. As per the Safety norms, risk [6] is the combined effect of hazard and its likely consequences on the product. The risk in such alliances usually are delayed delivery and thus cost overruns which ultimately lead to accusing fingers within the alliance partners and erosion of credibility in the market as well as loss of economy. However, if the alliance partners are selected as per the merits and competence with good finance and managerial skills, then risks would be foreseen well in advance through structured reviews and discussions and risk mitigation processes can be undertaken before it turns too late to reverse the trend. This can very well safeguard the credibility, competence and core value between the partners.
2. ***Shared Knowledge***: The alliance partners would have to be finalized based on their core competency, technical knowhow, financial capability, resource deployment and finally good management skill. With talented brains it would be any easy task for maintaining wide ranging research and development on the products. The technical knowhow can be easily shared for improving product quality. The marketing sharpness can be improved with good communication skills and the alliance partners can define each organization's role and responsibilities.
3. ***Opportunities for Growth***: is another field where the partners' competency can be well utilized. It depends upon the brand image as well as the distribution network of the alliance partner. It need

to be understood that growth of an organization becomes stagnant beyond a certain stage unless it ties up an alliance with other partners and use their skills and ability to take the companies forward.

4. ***Speed to Market***: In today's world of competition, the operations of any organization are just like competing in any athletic race. The first party that touches the market grabs the initiative from all others and this skill need to be established through other partners.
5. ***Complexity***: As specialization increases, complexity also increases and it becomes difficult to manage all requirements and new challenges. Hence it would be a boost to the management to enter into alliances so that expertise and knowledge can be shared to serve the customers better on complex issues or products.
6. ***Innovation [6]***: This is one of the crucial benefits of forging alliances. Updated designs should be practiced to move away from the traditional means of execution. This will pave way for faster, better and safer modes of implementation of projects or products. Not all firms will have the capability or the resources for such improvements and enter into alliances to take feasibility studies on improving existing means of operation. One classic example is using electric winches in place of hand winches which were rampant in erection fields for placement of heavy equipments until late 1980.There were no proper studies done in 1960s on such equipment erection works, but was heavily dependent on experience of personnel in such activities. But recent trends have even replaced electric winches with cranes of varying capacities with full fledged design studies for review and approval prior to such operations.
7. ***Cost***: By entering into fruitful alliances with organizations and personnel of technical competencies, effectiveness on management can be done. Since the mindset of people focuses on economic operation, all involved will be keen to execute the projects within the allocated budget. Research and Development is the discipline that can be most sought after due to successful strategic alliances.
8. ***Technical Know-how***: By strategic alliance partnership, firms can get technical know-how and also intellectual property rights. This can benefit the organization and also result in cost reduction.
9. ***Diversification***: By professional strategic alliances and with qualified resources in the organization, management can think of diversification in their business operations and get involved in new areas of operations.
10. ***Political Access***: With fruitful alliances and new diversified product launches, it would be a tough turf for any firm to gain ground. Without political support, it would be difficult to stand upto the competitors and manage successfully or at least viably. Grand alliances with influential agencies in the political market can open up new avenues.
11. ***Improved Delivery***: With alliance partners focusing on their specialized areas of expertise, efficiency on production increases which in turn will improve delivery time and also boost economy. In the current phase of competitive market, where all customers are demanding quick product approach, strategic alliances are excellent means to enhance credibility and thus market image.

Disadvantages [7]

While a number of advantages cited as above boost operations of firms through strategic alliances, disadvantages also do exist. A few disadvantages are:

1. ***Information Sharing***: While information sharing and transparency are the basic modes in strategic alliance formation, loss of control may lead to one or more partners taking advantage to divulge critical information to competitors. This can lead to loss of business.
2. ***Creating Competitors***: By sharing of information and if the business ethics are not followed in letter and spirits, new competitors can spring up for the benefit of a few individuals of any firm.
3. ***Unbalanced Alliances***: Whenever alliances are formed, it should be ensured that the strengths and weaknesses of partners shall be verified and understood to maintain a proper balance during operation. Here, the responsibilities shall be established in clear terms. Blaming subsequently for shortfalls or non delivery is not a good sign and cracks can develop on the alliance.
4. ***Focusing on Limited Opportunities***: In most cases, the alliances focus on research and development disciplines. This leaves limited room for expansion on the business arena. While improving business operation is possible on rejuvenated design areas, other disciplines like execution and implementation may require additional costs which may prove nonviable in the long run.
5. ***Foreign Collaborators***: The work culture and differences of opinions can be deterrent factors in certain alliances. Sometimes, even to understand the local market and availabilities may take unusual time for foreign partners which may prove quite vital on the operation. This delay may turn out quite sour and despite efforts to clear up the

misunderstandings; local alliance partner may turn to the courts for litigation to reverse the credibility. In this process, not only the trust and belief is affected, but even the costs as well as production get a violent kick.

Risks Associated in Strategic Alliances [8]

Any strategic alliance has risks and limitations associated during formation, implementation and close out apart from opportunities and benefits. Failures are often attributed to unrealistic expectations, lack of commitment, cultural differences, shifting of strategic goals and targets and also mistrust between the partners. Some of the risks are listed below:

- Financial difficulties between partners
- Inefficient management
- Scope and agreement diversion
- Information leakage
- Incompetent resources
- Non maintenance of quality products
- Inability of partners to withstand competition
- No operational Control Measures
- Non maintenance of transparency
- Breach of alliance agreement

Why Strategic Alliances Fail? [9]

Having cited the advantages and disadvantages of strategic alliances, there are instances where such alliances fail. It is not necessary that all such agreements bring in desired results and successful. While numerous reasons for failures are noted, we will discuss a few here:

1. ***Lack of Shared Vision***: Strategic alliances should be finalized only with likeminded business organizations whose senior executives have a clear vision as to why such partnerships are required and also whether such associations are real worth for the efforts being taken. A great deal of efforts would be required to clearly understand the partners' views, strengths and t limitations. Frank discussions are required to put the matters in its correct perspective. Transparency is the key to the success of any alliance.
2. ***Investment Plan***: Alliance partners should clearly estimate and make a decision on the investment plan. The major partner who is seeking strategic alliance should be the driver of the team. Investment plans should be finalized only after ascertaining the capabilities of partnering firms. After finalizing the alliance, there shall not be any change in the scope and responsibilities so that undue demands shall not be placed on the partners and create stress that can lead to divisions of the alliance agreement. However, it often happens due to lack of understanding between partners and breakages happen. Partners of the strategic alliance should also invest promptly and as required per terms of agreement to avoid cracks in the alliance.
3. ***Poor Governance***: Any organization for its efficient operation should have proficient management mechanism in place. The most important function is the review and discussions that should take place in a structured manner. Such discussions should always involve key personnel of the alliance and any issues that can lead to any fissures should be identified in advance and its causes and effects should be clearly discussed for early solutions.
4. ***Lack of Trust***: Without any doubt, the primary factor should be maintaining mutual trust between the partners irrespective of their geographic locations. Trust can bring in confidence and build to boost the credibility which will further ease the operation. If this trust is lost, then management of alliance will be highly difficult. In order to manage the operations, information needs to be shared, without detrimental to the existing operation. Once an alliance is formed, then all team members should display mutual respect and responsibilities.
5. ***Lack of Adaptability***: By forging alliances between various organizations of different sectors, partnering firms may become liable for competitions. However, the partners should desist from such moves as this will shift the focus of proper management. When a partnership is no longer advantageous, it is better to divest from preventing further damages and settle all matters.

Case Study of a Failed Alliance

In Qatar, one of the reputed firms which entered into a strategic alliance with another firm in Kuwait ended in a very disappointing note. Both the firms have executed various prestigious projects in their areas of operation. But misunderstanding and mismanagement among the partners resulted in losing the credibility of the respective firms and had to disband the alliance even though the intention was for a long term business relation.

Conclusion [10]

Overall, the most important aspects of a strategic partnership are honesty and communication. We should treat the partners like good friends that deserve respect and investment for successful collaboration.

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Total Quality Management (TQM) in Education Sector and its Implementation Framework towards Sustainable National Development

Vijayan Gurumurthy Iyer[1]

Abstract Total quality management (TQM) in education sector strengthens quality and relevance of education for sustainable national development(SND). SND is a kind of development that meets the needs of the present without compromising the ability and efficacy of future generations to meet their own needs. TQM in education sector can be defined as a set of systematic activities carried by technical educational institutions (TEI) to effectively and efficiently achieve institutional objectives that satisfies customers at the appropriate time and price. TQM is a comprehensive and structured approach to an educational research management that seeks to continuously improve the educational services. TQM of an education sector that shall achieve academic and research excellence and thus lead to SND. The objectives of the study are (i) to conduct action-based and field research on TQM to present quality management (QM) ideas on education, (ii) to identify quality educational and research compliance requirements (QCRs) for an educational sector adherence to quality management system (QMS) standards based on an educational research conducted in twelve technical educational institutions and (iii) to promote sustainable policy recommendation to strengthen quality and quantity educational services. Education coupled with entrepreneurial process is an intricate SND process which is a targeted area of research to alleviate poverty from the emerging enterprising spirit. TQM processes are divided into four sequential categories such as plan, do, check, and act (PDCA cycle) for continuous process improvement. Based on this action-based and field research conducted on TQM, sustainable policy recommendation may be taken to strengthen both quality and quantity educational services concerned to both knowledge and character in educational sector. New education has been discussed that will be carried out from two methods for SND .

Keywords: Character, Knowledge, New Education, Management, Policy, Process, Product, Quality, Quantity, Research, Strength, Sustainable National Development, Teaching

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Introduction

New education has been introduced that will be carried out from two methods for SND. About 88% economic growth is created by innovation. To achieve this level, literacy rate should be high. It is necessary to take considerable steps to achieve sustainable socio-economic development by tapping educational and entrepreneurial resources. To ensure sustainable socio-economic transformation, there should be input resources in quality and quantity education coupled with entrepreneurship, sustainable development, educational research and total quality management methods. It has been investigated that there is considerable lag in quality management system right from the school education to teacher education and higher educational institutions. This dependent parameter concerns to increase the literacy level as $Y= f\ (X_1,\ X_2,\ X_3 \ldots Xn)$ which is called production function. This research paper discusses fulfilment for such lag highlighting an importance of total quality management in an education sector and its implementation framework towards sustainable national development(SND).

TQM processes are divided into four sequential categories such as plan, do, check, and act (PDCA cycle) for continuous process improvement. In the *planning* phase, educationalists define the problem to be addressed, collect

E-mail: [1]vijayaniyergurumurthy@rediffmail.com

[1]Professor, Civil Engineering and Dean (Research & Development), Narasaraopeta Engineering College (Autonomous), (Affiliated to Jawaharlal Nehru Technological University Kakinada), Chennai–600 071

relevant data, and ascertain the root cause of the academic problem; in the *doing* phase, educationalists develop and implement a comprehensive solution, and decide upon a measurement to gauge its efficiency; in the *checking* phase, educationalists confirm the result through before-and–after data comparison; in the *acting* phase, educationalists document their results, inform others about process changes, and make recommendations for the problem to be addressed in the next PDCA cycle.

The A.K economic model for certain output level of economic growth is the product of engineering or technical factor level (A) and the capital (K) [2] . Therefore, the solution is the creation of new sustainable enterprises by innovation [3]. As per the standard production function discussed in the paper, the development of new knowledge is an important factor for economic growth as certain educational innovation level is required in engineering or technical systems. The economic growth is hereby explained by three factors as given below:-

1. The natural increase in the accumulation of labour potential [4],
2. Capital accumulation or money with which a business is being started and run, and
3. Technological momentum (also called as total factor productivity (TFP) or efficiency in industrial processes.

The increase of labour and the capital accumulation be account for 12 percent of the economic growth, but the knowledge emerged that is coming from outside economy is described as technological change that is approximately account for about 88 percent [4]. The fundamental entrepreneurial momentum keeps the capital development dynamic which comes from the new enterprise creation process, new goods or service requirement from customers, the new methods of production and processes, new transportation, and new markets and new forms of an industrial organization.

Standard Production Function (SPF) is expressed as

$Y = f(C, L)$

where Y=Output, C=Capital, and L=Labour

As knowledge is an important factor for the economic growth, Process Production function, (PPF)

$Y= f(X_1, X_2, X_3 \ldots Xn)$

Standard Production Function (SPF) is modified as

$Y= A(C,L)\, f(C,L)$

'A' represents Knowledge And character on Sustainable engineering or technical system,

Y= Output,

C= Capital

L= Labour

f = Standard production function

Hence the development of new knowledge is an important factor for the sustainable economic growth. As per the given standard production function, knowledge and character are decisive production variation [5].

Objectives of this Research

The objectives of the study are (i) to conduct action-based and field research on TQM to present QM ideas on education research, (ii) to identify quality education and research compliance requirements (QCRs) for an educational sector adherence to QM standards based on an educational research conducted on quality circles (QCs) duly launched in twelve educational institutions in south India and (iii) to promote sustainable policy recommendation to strengthen quality and quantity educational services.

Associated Objectives

To comply the following academic missions [6]:

1. Interdisciplinary and integrative approach,
2. Problem focused,
3. Research oriented,
4. Experiential learning.

Materials and Methods

The author has conducted action-based and field research trials on TQM to present QM ideas for education research and quality compliance requirements (QCRs) for an educational sector adherence to established ISO standards based on an educational research conducted on quality circles (QCs) duly launched in twelve educational institutions in south India. As per educational statistics study revealed that a person receives one-fourth of education from teacher, another fourth by own intellectual efforts, another fourth from fellow people and the rest during time through life experience [6]. An entrepreneur learns from life experience of education. The subtle relationship between education and entrepreneurship is an intricate process that need to be inculcated in our educational system to benefit more from the emerging sustainable enterprises spirit [7]. Entrepreneurial process is set of entrepreneurial activities that are interacting and inter-relating each other [8]. That is quality in terms of relevance and degree of academic excellence and quantity in terms of number of elements access to these activities.

Total Quality Management (TQM) in an Education Sector

Total Quality Management (TQM) concepts consisting of institution -wide efforts to establish permanent a climate for continuously improving its ability, efficiency and values to deliver high-quality educational services to the beneficiaries [9].

TQM requirements for an educational sector adherence to established standards such as International Organizational for Standardization's ISO 9000 series as given in fig. mentioning the process approach in an educational system. It defines that TQM as a management approach of an educational institution cantered on quality, based on the participation of all its members and aiming at long term success through customer satisfaction and benefits to all members of the institution and society. Hence, TQM is a process based on quality management from the beneficiaries' point of view as shown in Fig. 1.

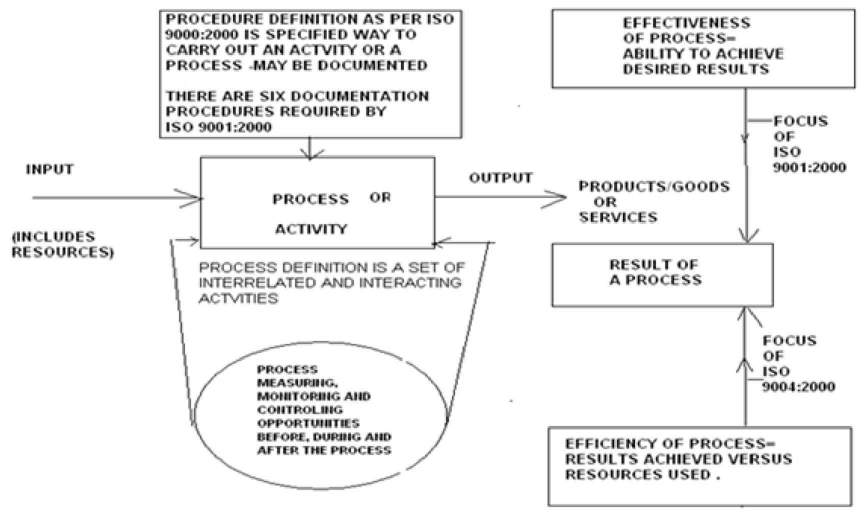

Fig. 1 Schematic representation of a process

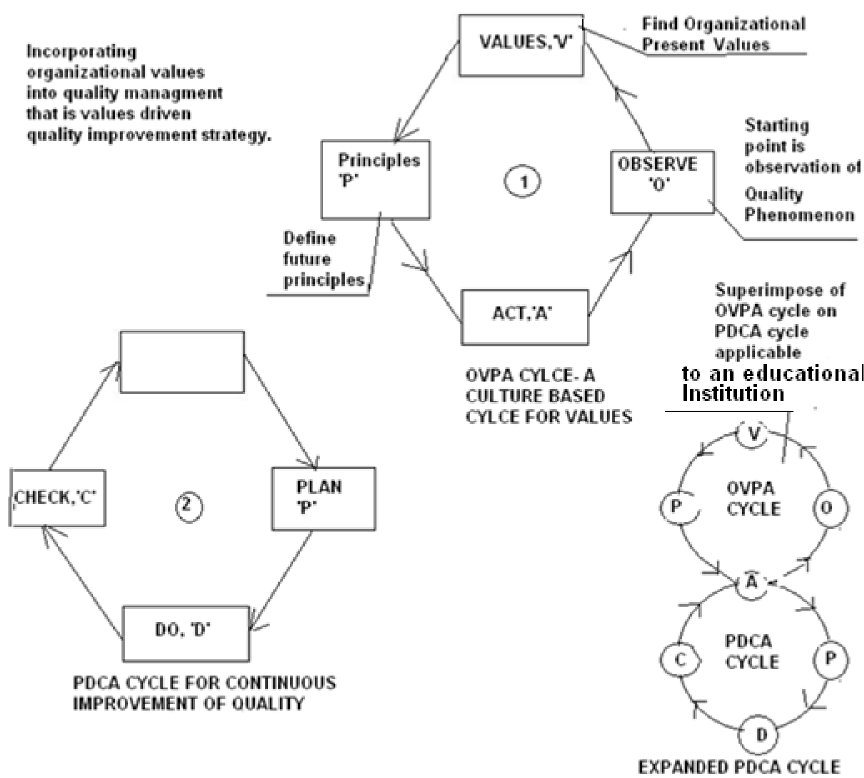

Fig. 2 Contains culture base total management (OVPA) cycle by incorporating the expanded PDCA cycle for an educational sector

TEIs must be able to implement TQM by following QM standards for sustainable educational development [10].

Quality Circles in Educational Institutions

Quality circles (QCs) have been launched in Prince Dr. Vasudevan College of Engineering & Technology (Affiliated to Anna University) at Chennai. QCs facilitate educational sectors to identify and solve the academic and research related problems. There is scope enhancement for the group based solution of academic and research related problems.

QC employs the following quality improvement (QI) tools:

1. Cause –and –Effect diagrams (Fishbone diagrams)
2. Pareto Charts
3. Data Collection through Check Sheets (Process Maps, Data gathering tools), Stratification of data.
4. Graphical tools such as Histograms, Frequency diagrams and Pie charts
5. Statistical Quality Control(SQC) and Statistical Process Control Charts (SPC) Charts
6. Scatter Diagrams and Plots and Correlation Analysis
7. Operation and Process Flow Charts

QCs have been adopted to prepare 'Total Quality People(TQP)' so as to promote SPC and SQC in academics and research for improvement of students' academic performance and personality development, teaching and learning process that include steps to improve results[11] .

The class committee serves as a' QC' for the class. The course committee serves as QC for the course. University and college class committee consists of the concerned teacher, student representatives and a chairperson who is not teaching the class be formed for each class. QCs meet on a regular basis normally at two-week intervals of time for one or two hour's durations. Four or five meetings per semester have been conducted. The functions of the class committees are to identify academic and research problem faced by the students which must be taken up on priority. Problems are solved by basic problem-solving methods. Solutions for the problems are identified and evaluated. This creates and generates number of possible alternative solutions.

Hence, the class committees function towards addressing students' problem and solution, including assignment of weightage for various course modules of evaluation, identification of weak students and improving their performance, failure mode effect analysis (FMEA) and recommending necessary corrective action and preventive action by the faculty.

The students' absenteeism is the most common problem existing in the institution for a long time. By discussion in the QC and class room using brainstorming and other TQM tools, various causes and effects are evaluated. Late coming is a problem in educational institution. An attempt has been made to solve students' late coming problem by studying causes and effects. Steps to improve academic and research performance have been evaluated.

Sustainable entrepreneurship is an integrative approach based on entrepreneurship and innovation management. It focuses in depth understanding aspects as idea generation, science, engineering and technology based entrepreneurship, marketing and markets, organization and project management, new sustainable product and process development, entrepreneurial finance, human resource development and operations [12]. This is called special education which will be encouraged to combine and apply students' creativity and innovation to design and develop science, engineering or technology and environment based idea. The objective of an educations sector is to introduce the concept, issue, and theme related to business planning, strategy, and entrepreneurship as well as the functional activities in a sustainable business venture such as guidelines to set up an entrepreneur and become a successful entrepreneur. It is necessary to explore such business planning and strategic management issues of engineering or technology driven enterprises in the early stages of development. Business analysis and planning skills are developed in this course.

The beneficiaries will be encouraged to assess and evaluate their potential for entrepreneurial careers and develop attitudes and skills that will be useful in engineering or technological new ventures.

1. Learn and understand market identification and assessment techniques
2. Guidance on how to develop new business idea and successful business plan preparation.
3. Fundamental of finance and marketing
4. Intellectual property protection
5. Soliciting funds
6. Successful business partnership
7. Preparation of Detailed Project Reports (DPRs)
8. Project implementation schedule.

"Sustainable entrepreneurship" is a kind of entrepreneurship that meets the needs the present without compromising the effectiveness, efficiency and values of future generations to meet their own needs [13]. A sustainable entrepreneur propels entrepreneurial growth through innovation. Environmental entrepreneur considers the environment in organizational planning and decision making and to arrive at actions which are more environmentally and socially compatible. The concept of sustainability is highlighted when one works in a manner that resources do not get depleted due to business endeavors. Hence, implementation of this concept enables final year undergraduate course students to become successful new entrepreneurs [14].

Educational Resource Planning (ERP) A Software for Computer based Education

Enterprise Resource Planning (ERP) is a software that helps to integrate nearly all the functions of an educational institution enabling to plan, track and see its resources in the best possible way to receive its customers [13]. The resources are (1) faculty and staff that is man power, (2) Infra structure facilities that is machine power**,** (3) sustainable educational methods, (4) educational materials, (5) capital budgeting and financial resources and (6) market to meet supply and demand of value added trained human power .

ERP effectively and efficiently integrates the islands of information within the educational institution. The sustainable methods and educational materials including self-learning entrepreneurial materials (SLEM) have been employed.

To develop faculty various innovative methods such as quality improvements (QI) programs, flexible QI programmes, faculty development programmes**,** in-house QI programmes, distance-cum-contact courses, summer and winter schools, and part-time programs must be conduct in teacher educator institutions in regular intervals of time. It has been observed that participants in such programmes are very less. Faculty must be provided with sufficient career opportunities to improve upon their qualifications through the quality improvement (QI) programs to get them imparted techno- scientific pedagogical skills and professional training requirement including research expertise. Under the quality improvement programs (QIP), a variety of short term courses need to be imparted to meet the sustainable training needs for all levels of faculty.

The educational sector should incorporate three methods, viz., [1] Total Quality Management, [2] Peer Review and Evaluation, and [3] Sustainable Assessment and Accreditation by a competent educationalist or peer organization.

Values Driven Quality Management (VDQM) System Approach

Culture must be realized for quality and productivity within an educational sector [15]. Quality management (QM) is defined as a set of systematic activities carried out by the entire institution to effectively and efficiently achieve institutional objectives to provide educational services with a level of quality that satisfies customers at the appropriate time and cost. QM is the culture of an institution committed to customer satisfaction through continuous improvement. By supplementing the QM with the culture which continuously incorporate educational values into the management of quality in an educational sector. That is by superimposing the culture cycle on the QM cycle shall create and generate the values driven QM (VDQM) cycle as shown in Fig. 2.

By implementing VDQM in an educational sector shall succeed sustainable development. VDQM is defined as values driven quality management system approach of an educational institution centered on quality and values based on the participation of all its members and aiming at long term success through customer satisfaction and benefits to all members of the institution and society. The approach is based on values driven quality management from the stakeholder’s point of view. VDQM processes are divided into eight sequential categories: plan, do, check, act, observe, values, principles, and act . VDQM will be based on the integration of *PDCA* (plan, do, check, act, observe) cycle and OVPA (observe, values, principles, and act) cycle [16].

Results

Requirements of Trained Human Power

There is a need of the hour for the education sector to identify and supply the demand of value added knowledgeable character trained human power. This requires human work force that can innovate sustainable green product designs, product green manufacturing, product marketing for sustainable organizations. Students must able to design, innovate, and create and generate in their job requirements’ change in order to meet the global competence and locally relevant (GCLR) trained human power. This need supply requirement of knowledgeable character trained human power which can be only possible from the sustainable educational sector. The entrepreneurs and employers are looking for the GCLR graduates in all basic fields with sound knowledge base in their core discipline and with abilities and efficient enough to adapt for new sustainable demands as well as in the service sector [17]. It is projected that within twenty years’ period about sixty to seventy percentage sustainable entrepreneurial and jobs shall be available in-service sector [18].

Comprehensive Academic and Research Performance

- Indicator (ARPI) System and Requirements
- for Faculty Competency Profile/
- Performance Based Academic and Research
- Performance Indicator (ARPI) index score concept

Considering the role to be played by the faculty, a competency profile consisting of ten areas have been designed and developed. There are ten more areas are under investigation [18]. By self-evaluation, one can rate the initial level of competencies [19]. Final competencies shall be achieved with respect to domain knowledge, skills and attitudes through various sustainable faculty development programs (FDPs). The following are the major areas of competency profile of a faculty member in a college or University, which can be rated for comprehensive performance based self-evaluation and appraisal method:

The Performance Based Academic and Research Performance Indicator (ARPI) index score has been calculated [19)\], [Ref. APRI Score card of the author] .

Result of Comprehensive Academic and Research Performance Appraisal System

A performance based appraisal system for faculty should be setup in educational institution well integrated with institutional functioning and this should lead to the identification of individual training and research and developmental requirements. This should also enable the identification of teachers whose performance is exemplary. Outstanding faculty should be well recognized and rewarded. All teacher educational institutions should introduce a system for performance appraisal. The performance report should comprise the data such as publication of refereed research papers of faculty, paper reading in seminars / refereed conference, publication of books, research citations, citation indexed database(CID), research contributions, biographical reference books, patents, innovations, inventions and refereed discoveries. This research management system should be followed by the management for career advancement of faculty in their institutions.

Discussions

Efficient Workload Norms of Faculty

Workload norms for faculty have been prepared. These are outcome of intensive discussions held during various seminars. Given below the workload norms for a faculty in an University to attend his or her normal duties:

1. Teaching Workload 16 hours / week
2. Preparation Time 16 hours / week
3. Research work 10 hours / week
4. Organizing Science, History, Mathematical Tutorials/ Science outdoor/ indoor activities/ Exhibitions 40 hours/week
5. Co-ordination of extra-curricular activities 6 hours/ week

Structure of the Class Room Lectures

Time duration of the elements of a class room lecture and brief description is given below:

1. Introduction - 4 min
2. Actual Lecture - 41 min
3. Summarizing - 5 min
4. Students Queries - 6 min
5. Attendance - 4 min

Introduction

1. At the start of class lecture, introduction should be made in brief and interesting
2. The introduction should give an idea about the learning in the lecture.

Actual Lecture

1. During the lecture, simple questions should be asked to the students and link their answers to the topics to be taught.
2. All students must be involved with the lecture and understand it better.
3. The phase and content of the lecture should be planned and decided such that an average student is able to grasp the contents of the lectures.
4. Direct dictation should not be given form his notes.
5. All the points of the lectures should be explained while looking in the eyes of the students.

Summarizing

1. Summarization should be good as it again highlights the points covered in the lecture.
2. References should be given for additional details on the topic of the lecture.

Student Queries

Student queries should be attended. The doubts should be cleared.

By adapting proper instructional strategy, the students are encouraged to work mentally and to increase their cognitive skills. Their attitude towards the industrial jobs increases positively. This enables them to do their interviews well. They will be also to orient themselves to suit the job requirements easily and quickly.

Educational Resources Planning (ERP) Software

Why is ERP Required?

1. Speed of the teaching-learning process,
2. Monitoring, measurement and control opportunities in educational environment,
3. Innovation in education and entrepreneurship.

Correct Approach to ERP Software

The options are dependent upon strategic planning and decision-making process and need a substantial capital investment. Right option must be selected only after evaluating the cost-benefit analysis [20].

Discussions on Quality Circles in Educational Institutions

Quality circles (QCs) facilitate educational sectors to identify and solve the academic and research related problems. There is scope for the group based solution of academic related problems.

QC employs the following quality improvement (QI) tools:

1. Cause –and –Effect diagrams (Fishbone diagrams)
2. Pareto Charts
3. Data Collection through Check Sheets (Process Maps, Data gathering tools), Stratification of data.
4. Graphical tools such as Histograms, Frequency diagrams and Pie charts
5. Statistical Quality Control(SQC) and Statistical Process Control Charts (SPC) Charts
6. Scatter Diagrams and Plots and Correlation Analysis
7. Flow Charts

QCs have been adopted to prepare 'Total Quality People(TQP)' so as to promote SPC and SQC in academics and research for improvement of students' academic performance and students' personality development, teaching and learning process which include steps to improve results .

Environmental Science and Sustainable

Development are the basis of Environmental and Social Development towards Sustainable National Development

Environmental education and research is a new multidisciplinary friend with an implemented sustainable ecological philosophy and sustainable ecological ethics, establishing New Civilization Sustainable Development through a new interdisciplinary and integrated subject called Environmental Science [20]. This signifies a new environmental education. New education is necessary that will be carried out from two methods, (i) interwoven through all professional subjects and (ii) synthetic multidisciplinary by the integrating subject-Environmental Science and Sustainable Development [21]. Based on experience in transferring the knowledge in the field of (i) Environmental Science and (ii) Sustainable Development to the students at several faculties, that the last two semesters of University education in all disciplines of science, engineering and technology should include the course "Environmental Science", Environmental Impact Assessment, Entrepreneurship Development, Total Quality Management, and "Sustainable Development" [22]. The last year of studies is most suitable because till that time the student has acquired knowledge in different domains of his profession, so with the study of Environmental science and sustainable development, the student synthesize knowledge [24]. The course should cover approximately two lessons per week and two lessons for the discussion on the preparation of the essay and individual seminar paper [25].

Conclusion

It can be concluded that total quality management (TQM) in education sector strengthens quality and relevance of education for sustainable national development(SND) . The subtle relationship between education and entrepreneurship is an intricate process that needs to be implemented in educational sector to benefit more from the emerging sustainable enterprises spirit to alleviate poverty and sustainable development.

Sustainable entrepreneurial process is set of sustainable entrepreneurial activities interacting and inter-relating each other. That is quality in terms of relevance and degree of academic and research excellence and quantity in terms of number of elements accessing to these activities. The development of new knowledge is an important factor for the sustainable economic growth. As per the given standard production function, knowledge and character are decisive production variations.

TQM processes are divided into four sequential categories such as plan, do, check, and act (PDCA cycle) for continuous process improvement. VDQM system is a culture based comprehensive and structured approach to an educational research management that seeks to improve the values and quality of educational services through ongoing refinements and incorporating educational values in response to continuous feedback. By implementing VDQM in an educational sector shall succeed sustainable development. Technical educational institution well integrated with institutional functions should lead to the systematic identification and evaluation of of individual training and research and developmental paramters.

Based on this action-based and field research conducted on TQM, sustainable policy recommendation may be taken to strengthen both quality and quantity educational services concerned to both knowledge and character in educational sector. It is need of the hour to implement new education that is discussed in this article from two methods for SND.

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