Volume 11 September 2022

The Institution of Engineers (India)
8 Gokhale Road, Kolkata 700020
A Scientific and Industrial Research Organisation
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Government of India
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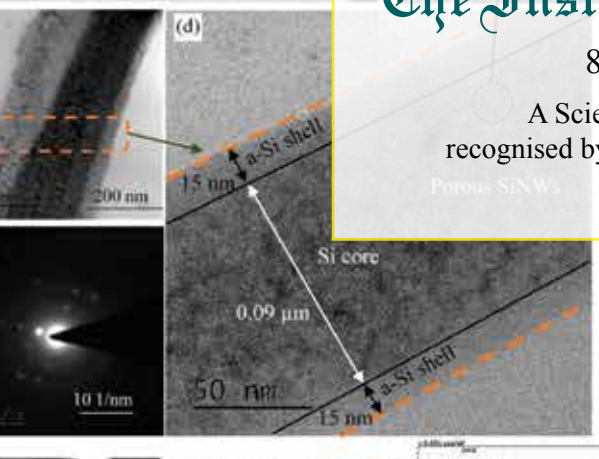

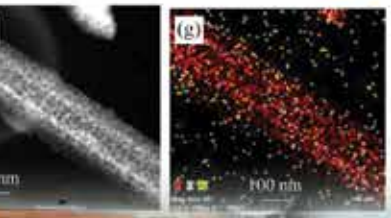

Compendium on R&D Projects

under the grant-in-aid-scheme

The Institution of Engineers (India)

Notification for

R&D Grant-in-Aid

To promote appropriate technology, assist in building up design & research talents and, most importantly, to help in nurturing potential R&D venture amongst engineering students pursuing Diploma/UG/PG/PhD courses, The Institution of Engineers (India) had instituted the R&D Grant-in-Aid program way back in 2001.

Like every year, the Institution invites applications for funding R&D projects and research initiatives aimed at improving the life-style of common people from engineering students pursuing full time Diploma/UG/PG/PhD engineering program from AICTE/UGC/NAAC approved Institutions/Colleges/Universities. The application form and guidelines are available in our website https://www.ieindia.org. The projects should be carried out under the guidance of faculty members who are Corporate Members of IEI. Membership criteria for student(s), guide(s) and Institution(s) are as follows:

Project Category	Student/Applicant Membership	Guide(s) Membership	Institutional Membership
1. Diploma	Exempted [Membership of Student Chapter is desirable]	AMIE/MIE/FIE	Not Mandatory
	Preferably 'Student Member' (SMIE)	AMIE/MIE/FIE	Applicant's Institute should preferably be an Institutional Member with valid NIRF Rank
2. UG (BE/BTech/AMIE/Equivalent)	'Student Member' (SMIE)	AMIE/MIE/FIE	Applicant's Institute should preferably be an Institutional Member with NBA / NAAC Accreditation or valid NIRF Rank
3. PG (ME/MTech/Equivalent)	AMIE/MIE/FIE	MIE/FIE	Applicant's Institute should preferably be an Institutional Member with NBA / NAAC Accreditation or valid NIRF Rank
4. PhD	AMIE/MIE/FIE	MIE/FIE	Applicant's Institute should preferably be an Institutional Member with NBA / NAAC Accreditation or valid NIRF Rank

The soft copy of the duly filled-up applications (in editable format), as per the proforma available in our website www.ieindia.org, should be sent through email to research@ieindia.org and one printed copy of the same should reach the following address:

Director (Technical)

The Institution of Engineers (India), 8 Gokhale Road, Kolkata 700 020

Applications received in format other than that available on our website will not be accepted. Application should be forwarded through the Guide, Head of the Department or Head of the Institution. Please note that preference will be given to project proposals received from Institutions who are members of The Institution of Engineers (India) and with NBA / NAAC Accreditation or valid NIRF Rank. Kindly go through the guidelines (visit link https://www.ieindia.org/webui/IEI-Activities.aspx#RnD-Initiative) carefully before filling up the application.

The grant is not intended for the faculty members who have access to other avenues of research funding. Proposals received will be scrutinized and the recipients of R&D Grant will be informed accordingly.

Message from the

President

I am happy to note that the Volume 11 of the Compendium on R&D Projects under the IEI Grant-in-Aid Scheme is being published.

The initiative to provide R&D Grant-in-Aid to the UG, PG and PhD Students was taken in 2001 with an objective to encourage the students to participate in the Research and Development activities and infuse in them the interest for Research & Development. Through R&D, the institutions can really inculcate critical innovation skills in their students. Ability to think critically will lead to innovation and will spur young minds to pursue research as a career option.

The Institution of Engineers (India) recognized as a "Scientific and Industrial Research Organisation" (SIRO) is proud to present the Volume 11 of the Compendium which showcases the effort of students engaged in research activities within and / or beyond the formal curriculum.

Dr H O Thakare, FIE
President, IEI

Message from Chairman
Committee for Advancement of Technology and Engineering

I am pleased to note that the Volume 11 of the compendium for R&D Grant-in-Aid is being published. The R&D Grant-in-Aid is provided to the UG, PG, PhD students of various engineering colleges by IEI with special emphasis to UG students. This is a unique feature of the R&D Grant-in-Aid scheme that it is also extended to the UG students. This is being done to inculcate among the budding engineers the essence for Research & Development which is the key to development of any nation.

The compendium contains the outcome of the research work of the students conducted utilising the IEI R&D Grant in Aid which makes this book very interesting and informative.

I hope this compendium will encourage more students to come forward for benefitting from the R&D Grant-in-Aid scheme of IEI.

Dr G Ranganath, FIE
Chairman, CATE, IEI

Message from Chairman
Research & Development Committee

I am very much happy that the Volume 11 of the R&D Compendium of Institution of Engineers (India) is being published as an e-copy during 2022 duly overcoming all ill effects of the Bio-Disaster and its challenges surfaced in COVID Pandemic for over two years. The individual R&D project reports of UG,PG and PhD students supported by the IEI in the form of Grant- in-Aid have been collated in the current issue duly highlighting the outcome of each R&D Project.

The Institution of Engineers (India) has been recognized as a "Scientific and Industrial Research Organization" (SIRO) recognizing its vast technology contribution as an Institute and also supporting the technocrat students in Research & Development activities under R&D Grant-in-Aid scheme.

I am confident that this Compendium will be a game changer to the student's community in inspiring to enhance their capabilities in Research and Development activities. I therefore request the Technocrat Students community to be more enthusiastic in utilising the benefit of R&D Grant-in-Aid provided by IEI not only serving their career but also the Nation being future builders of our India.

Dr I Satyanarayana Raju, FIE
Chairman, RDC, IEI

सूचना का अधिकार
RIGHT TO INFORMATION

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(आईएसओ 9001:2008 प्रमाणित विभाग)
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सत्यमेव जयते

भारत सरकार
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वैज्ञानिक और औद्योगिक अनुसंधान विभाग
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GOVERNMENT OF INDIA
MINISTRY OF SCIENCE AND TECHNOLOGY
Department of Scientific and Industrial Research
Technology Bhavan, New Mehrauli Road,
New Delhi - 110016

F.No. 11/97/1988-TU-V

Date: 28th April 2022

The Secretary & Director General
The Institution of Engineers (India),
8, Ghokhale Road,
Kolkata – 700020, West Bengal

Subject : **Registration of Research Institution, other than a Hospital, for the purpose of availing Customs duty exemption in terms of Government Notifications No. 51/96-Customs dated 23.07.1996; No. 24/2007-Customs dated 01.03.2007; No. 43/2017-Customs dated 30.06.2017; No. 45/2017-Central Tax (Rate) & 47/2017-Integrated Tax (Rate) dated 14.11.2017; No. 9/2018-Central Tax (Rate), No. 09/2018-Union Territory Tax (Rate) & No. 10/2018-Integrated Tax (Rate) dated 25.01.2018; and State Tax (Rate) as applicable and all notification, as amended from time to time.**

CERTIFICATE OF REGISTRATION

This is to certify that **The Institution of Engineers (India), Kolkata, West Bengal** is registered with the Department of Scientific and Industrial Research (DSIR) for the purpose of availing Customs duty exemption in terms of Government Notifications No. 51/96-Customs dated 23.07.1996; No. 24/2007-Customs dated 01.03.2007; No. 43/2017-Customs dated 30.06.2017; No. 45/2017-Central Tax (Rate) & 47/2017-Integrated Tax (Rate) dated 14.11.2017; No. 9/2018-Central Tax (Rate), No. 09/2018-Union Territory Tax (Rate) & No. 10/2018-Integrated Tax (Rate) dated 25.01.2018; and State Tax (Rate) as applicable and all notification, as amended from time to time. The Registration is subject to terms and conditions mentioned overleaf.

This Registration is valid upto **31.03.2025.**

Please acknowledge the receipt.

Yours faithfully,

(Dr. P.K. Dutta)
Scientist - 'F'

The Institution of Engineers (India)

8 Gokhale Road, Kolkata, West Bengal, India – 700020

(Established in 1920, Incorporated by Royal Charter 1935)

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A Century of Service to the Nation

The Institution of Engineers (India)

Volume 11, September 2022

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Compendium on R&D Projects under IEI Grant-in-Aid Scheme

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Development of A High Performance Digital Controlled Reduced Switch Multilevel Inverter for Photovoltaic System

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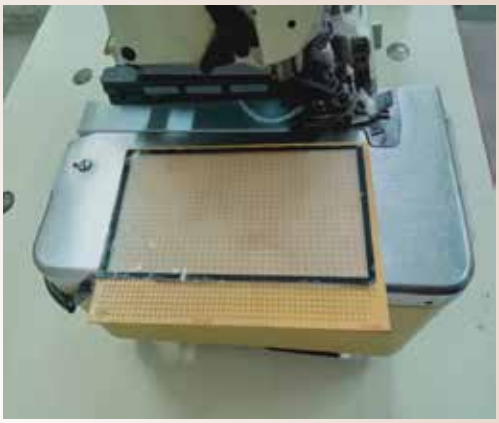
Reduced switch multilevel inverter (7-level)



Capacitance sensor and base fabricated and fixed over working area of over lock sewing machine

OBJECTIVES

1. To design and develop a touch sensor based hand operated over lock sewing machine suitable for orthopedically handicapped people who are devoid of lower limbs.
2. To design a hand operated resistive touch sensors to control and monitor the sewing process.
3. To eliminate the foot operated levers and modify the operating platform of over lock sewing machine using new hand operated sensor bed and facilitate easy sewing operation by hand.
4. To develop a speed control device to enable the user (handicapped persons) to operate the machine at optimum speed.
5. To provide sewing training session adopting this newly developed technique for orthopedically handicapped persons.

ACHIEVEMENTS

In this project, a sensor based assistive device suitable for orthopedically handicapped people to operate the overlock machine was designed, developed and tested. An overlock is a kind of stitch that sews over the edge of one or two pieces of cloth for edging, hemming, or seaming. Usually an overlock sewing machine will have a trimmer to cut the edges of the cloth as they are fed through. The foot pedal mechanism of overlock

Speed Control and User Interface unit

User interface digital display to calibrate and set preset/set values

Sewing garment using sensor based over lock for Orthopedically Handicapped people

Sewing garment cotton towel raw edges are trimmed and over lock stitches were made

sewing machine was eliminated. A capacitance touch sensor and base material were specially fabricated for this purpose and ergonomically placed over the working area of overlock sewing machine. The working area of overlock sewing machine consists of a flat rectangular metal plate of dimension 3 * 8 Inches and the operator sew garment over this area. Generally, in overlock sewing machine the operator hand will guide and feed garment over working area and foot pedal lever will operate the sewing machine motor.

The orthopedically handicapped people with the lower limb disability (foot) cannot operate the foot pedal for sewing. To overcome this constraint we developed a touch sensor based hand operated mechanism suitable for orthopedically handicapped people to operate overlock sewing machine. The newly fabricated capacitance touch sensor and base are fixed over the steel plate in working area of overlock sewing machine. The orthopedically handicapped people operate the sewing machine by applying gentle pressure over the sensor. The sensitivity of the sensor is adjusted as per the user's convenience. Also the startup speed, sewing speed, stop speed can also be set as desired by the user. The sensor based assistive device was developed and fitted in overlock sewing machine. This overlock sewing machine has a 5 thread input and thread trimmer facility.

At the start of the sewing process using overlock sewing machine a garment is placed over the capacitance sensor work area. By using hand operated take-up lever the raw edge of the garment is held by the presser foot lever. When the user applies gentle hand pressure over the garment the capacitance sensor below is activated by pressure and sewing motor is operated. At first the protruding yarn from the raw edges of the unfinished garment called the selvedge yarn is trimmed by the trimmer device. Simultaneously, the garment is moving forward over the working area and pulled forward by the feed dog. As the garment move inside the sewing area the edges are sewn using five thread lock stitch and edge of the garment is finished. There is no need for turning, folding and curve form stitching in ovelock sewing machine. Hence, it is ergonomically and professionally suitable for orthopedically handicapped people. This overlock sewing machine is a versatile machine which is mainly used in both knitted and woven garment manufacturing industry (in India itself more than 3000 garment industries).

Such industrial sewing machines are normally operated by use of the feet but this proposed modification of customized design would eliminate the operation of the sewing machine by the feet, and thus allow orthopedically handicapped people to easily run the machine by hand (touch sensor based hand operated sewing method) during the garment production process. It is used to perform sewing operations such as side seam, arm hole, sleeve and inseam.

The orthopedically handicapped persons can deliver the same level of work efficiency (using our new methodology) at par with other healthy operators (normal persons). By this the orthopedically handicapped people can earn their livelihood.

PUBLICATIONS

Presented a paper of title “Design and Development of electro-mechanical reverse lever actuator for assistive sewing machine suitable for differently abled persons” in ASTMLS-2020 International Virtual Conference on Applied Science, Technology, Management and Language Studies.

Legacy of IEI

Hon’ble President of India, Mr Ram Nath Kovind and Mr Banwarilal Purohit, Hon’ble Governor of Tamilnadu at the Valedictory Session of the 32nd Indian Engineering Congress, Chennai, December 2017

Study of Heat Transfer Enhancement with the Application of Various Nano Fluids in a Differentially Heated Cavity

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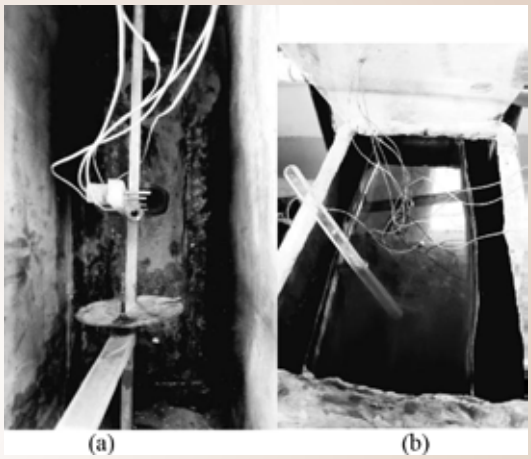
Experimental Setup



(a) Thermocouple arrangement
(b) Top view of cavity

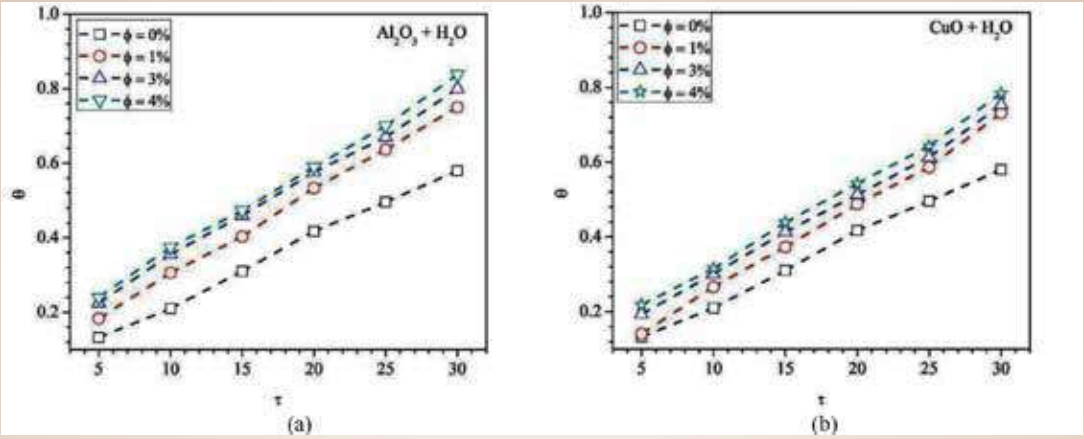
OBJECTIVES

The objectives of the experimental study are listed below:

- To investigate heat transfer enhancement with the application of Al_2O_3 and CuO nanofluids in a differentially heated cavity.
- To investigate behaviour in free convection heat transfer based on three different mass fractions, ϕ (1%, 3% & 4%) of Nanoparticle concentration.
- To investigate natural convection in a differentially heated cavity using nanofluids within different temperature ranges.

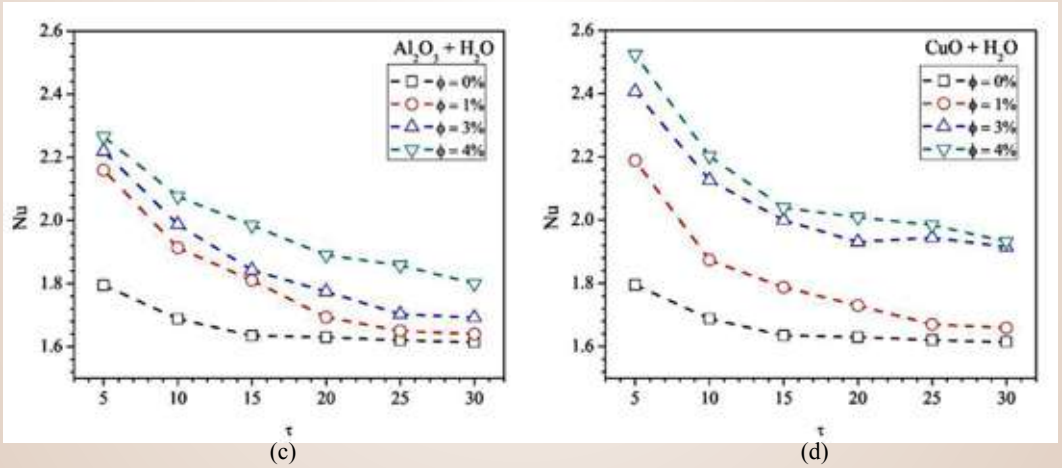
ACHIEVEMENTS

The experiment was conducted with 1%, 3%, and 4% fractions of mass concentration of Nanoparticles. And at a different fraction of mass concentration of nanoparticles, the three-time experiment was conducted. After taking an average data of all the processes, non-dimensional temperature (θ) vs time(τ) graph has been plotted for the study of percent enhancement of heat transfer. When the non-dimensional temperature comes close to one then it means that the system is coming close to an equilibrium state. As faster the non-dimensional temperature comes close to one it means the heat transfer rate in a differentially heated cavity is high.



Non-dimensional temperature vs Time Graph of (a) Al_2O_3 + H_2O and (b) CuO + H_2O nanofluid

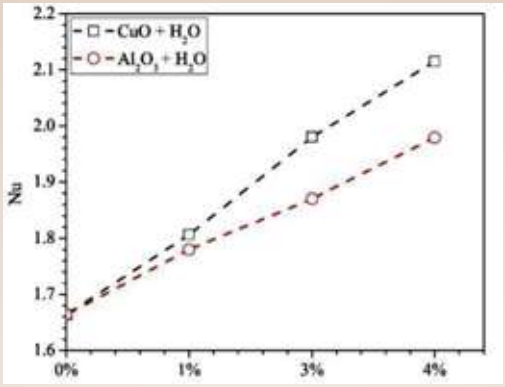
As shown in figure, it is a graph of non-dimensional temperature (θ) vs time (τ) of Al_2O_3 + H_2O and CuO + H_2O nanofluid at a different fraction of nanoparticle concentration. And it was compared with a normal fluid to know the percentage enhancements of heat transfer. As shown in figure 4 (a), The Non-dimensional temperature θ of ϕ = 1%, 3% and 4% Al_2O_3 nanofluid are increased by 37.46 % ,72.61% and 84.61% compare to ϕ = 0% at a 5-minute time. The θ of ϕ = 1%, 3% and 4% CuO nanofluid is increased by 6%, 45.7% and 64.90% compare to ϕ = 0% at a 5-minute time as shown in fig 4(b). The θ of ϕ = 1%, 3% and 4% Al_2O_3 nanofluid are increased by around 29.31%, 37.93%, and 44.4% compare to ϕ = 0% at 30-minute. The value of θ of ϕ = 1,3 and 4% CuO nanofluid are increased by 26.03%, 29.758%, and 35.23% compare to ϕ = 0% at a 30-minute time. As the time



Nusselt number vs Time (min) for (c) Al_2O_3 and (d) CuO + H_2O

passes, the increment in the percentage of θ is decreased because the temperature difference between hot fluid and cold fluid decreases. Figure (c) and (d) shows the variation of Nu with time (min.) for both nanofluids. As time passes flow stabilization takes place and the temperature difference between the fluid in the proximity of hot and cold wall decreases.

This results in the fall in heat transfer rate between the hot and cold wall and hence Nu decreases with time. The Figure (e) is a graph of comparison between the average Nusselt number Nu of Al_2O_3 and CuO concerning



(e)

Average Nusselt Number vs Nanoparticle concentration ϕ

the different values of ϕ (1%, 3% & 4%). For both the nanofluids, the value of the Nu is increase with the increase in ϕ. And for the same ϕ, Nu of CuO-based nanofluid is higher than Nu of Al_2O_3-based nanofluid. When ϕ increases by 1%, Nu increases approximately by 12%, When ϕ increases by 3% the increment in Nu is approximately 22%, and when ϕ increases by 4%, Nu increases approximately by 25% for CuO-based nanofluids. When ϕ increases by 1%, Nu increases approximately by 10%; When ϕ increases by 3% the increment in Nu is approximately 12%, and when ϕ increases by 4%, Nu increases approximately by 19% for Al_2O_3-based nanofluids. Overall, the following outcomes can be inferred from the above study:

1. Nu increases with an increase in ϕ. It means that convective heat transfer increase with the increase in ϕ.
2. The experimental results show that nanofluids have better convective heat transfer than a base fluid and the heat transfer improvement increases with the temperature difference and percentage concentration of nanoparticles to the base fluid.
3. As ϕ increase, the system is coming close to an equilibrium state faster. Its means that the overall heat transfer of the system is increased.

PUBLICATIONS

1. M. Tech Thesis

   Title : Study of Heat Transfer Enhancement with the Application of Various Nanofluids in a Differentially Heated Cavity

2. ME@75 Research Frontiers Conference at Indian Institute of Science Bengaluru, from 29th June 2022 to 1st July 2022.

   Title: Study of heat transfer enhancement with the application of various nanofluids in a differentially heated cavity.

Investigations on Wear Characteristics of NiCrBSi Overlay Surface on 304 SS with and without Tungsten Carbide Reinforcement

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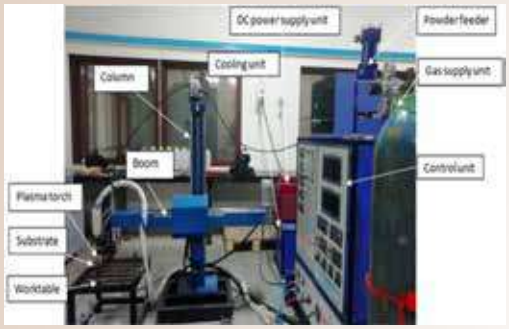
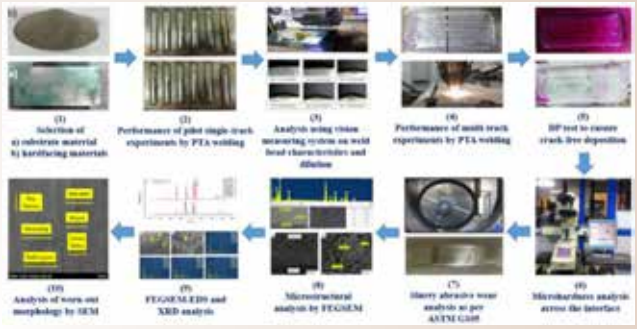


Actual set-up of plasma transferred arc welding available at SVNIT Surat



Research methodology adopted for the research project

OBJECTIVE

Slurry pipelines are safe and most reliable mode of transportation used by industries since it is economical with less environmental impact. Slurry pipelines are widely used for transportation of solid-liquid mixtures in mining industries, hydraulic power plants, etc. Presence of abrasive particles and oxides leads to slurry abrasive wear of components such as centrifugal slurry pumps, extruders, pipes, earthmoving equipments, etc. AISI 304 SS is widely used for fasteners, piping, turbine blades, control valves, impellers, pump suction side liners, pipes, casings, pipe elbow and bend, etc. However, it has comparatively less slurry abrasive wear resistance which leads to premature failure of these components which in turn significantly increases the downtime cost of the industries. To overcome this issue proposed research work aims to consider NiCrBSi overlay material due to its superior wear resistance. It is also proposed to add WC reinforcement particles in NiCrBSi which may further improve wear properties & hence the objective of this research work is to compare the slurry abrasive wear characteristics of the obtained overlay surface with and without addition of WC reinforcing particles in NiCrBSi hardfacing material deposited on 304 SS. The comparative analysis is performed with various mechanical and microstructural characterizations such as microhardness measurement, slurry abrasive wear analysis, scanning electron microscopy equipped with energy dispersive spectroscopy, X-ray diffraction, etc. In order to fulfill above mentioned tasks, following objectives were proposed and successfully completed:

1. To analyze the slurry abrasive wear characteristics of NiCrBSi coating on 304 SS.
2. To examine the suitability of WC as reinforcement particles in NiCrBSi coatings on 304 SS.

3. To analyze the effect of WC reinforcement in NiCrBSi coatings on slurry abrasive wear characteristics.
4. To compare the slurry abrasive wear characteristics and microstructure of NiCrBSi coatings with and without addition of WC reinforced particles on 304 SS.

ACHIEVEMENTS

The project entitled "Investigations on Wear Characteristics of NiCrBSi Overlay Surface on 304 SS with and without Tungsten Carbide Reinforcement" is successfully completed. The comparative analysis in terms of slurry abrasive wear resistance along with microstructural characterizations of NiCrBSi hardfacings with and without addition of WC reinforcement is performed. It is revealed that the NiCrBSi hardfacing with WC reinforcement showed 2.5 times improvement in slurry abrasive wear resistance as compared to NiCrBSi hardfacing without WC reinforcement. Hence, the NiCrBSi hardfacing with WC reinforcement is recommended. The work related to various research aspects of the project is accepted for publications in reputed SCI/ESCI/Scopus indexed journals. The outcomes of the research project work in terms of the improvement in slurry abrasive wear resistance would be beneficial to avoid the premature failure of the identified components such as impellers, pump suction side liners, casings, pipe elbows, bends, slurry pipelines, etc. used for hydraulic transportation of ores and minerals in mineral processing industries.

PUBLICATIONS

Journal Publications

1) Wanare S. P. and Kalyankar V. D. (2021) "Influence of Fe dilution and W dissolution on abrasive wear resistance of NiCrBSi-WC composite hardfacing deposited by plasma transferred arc hardfacing", Journal of Advanced Manufacturing Systems, DOI: 10.1142/S0219686722500251

2) Kalyankar V. D. and Wanare S. P. (2021) "Comparative investigations on microstructure and slurry abrasive wear resistance of NiCrBSi and NiCrBSi-WC composite hardfacings deposited on 304 stainless steel", Tribology In Industry, DOI: 10.24874/ti.1075.03.21.05

3) Kalyankar V. D. and Wanare S. P. (2022) "Microstructure evolution and its correlation with slurry abrasive wear behaviour of NiCrSiB hardfacing deposited on 304 SS by plasma transferred arc welding", Practical Metallography (Accepted Manuscript).

Conference Publications

1) Wanare S. P. and Kalyankar V. D. (2020) "Effect of powder feed rate on weld bead characteristics and dilution of Colmonoy 6 hardfacing on 304 steel by PTAW process", 6th Asian Conference on Heat Treatment and Surface Engineering (2020), organized by ASM International Chapter, Chennai, during 5th to 7th March, 2020.

Engineers participate in the activities which make the resources of nature available in a form beneficial to man and provide systems which will perform optimally and economically."

L. M. K. Boelter

Reduction of Carbon Footprint with By-products Utilization for Different Sustainable Applications

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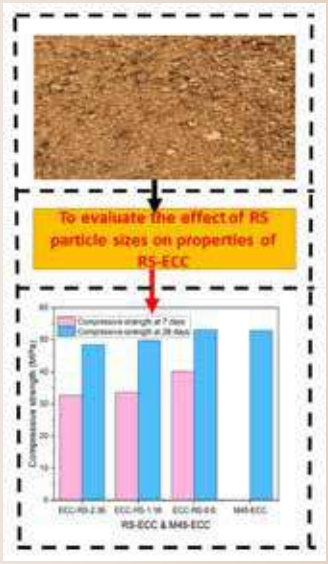
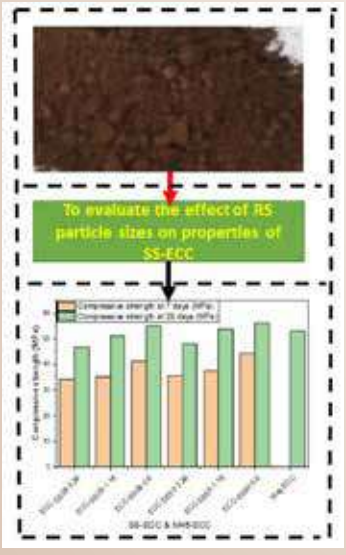
OBJECTIVE

Sustainability awareness is increasing in the construction industry, and significant attention is being paid on the cementitious composite sector to improve the sustainability of its materials. The huge detrimental impact of the construction industry in terms of its sustainability is a result of its high Ordinary Portland cement (OPC) consumption coupled with the degradation of the environment and carbon dioxide emissions as result of aggregates retrieval. One of the promoting cementitious materials that will be used in significantly large quantities in the next coming years by the construction industry is Engineered Cementitious Composites (ECC). ECC are unique type of fiber reinforced composites (FRC) capable of exhibiting higher tensile strength and strain. ECC is mainly made with ultrafine silica sand (USS) with a maximum size of 250 microns and the average size of 110 microns. However, the USS used for ECC is expensive and not readily available compared with the conventional sand used for other cementitious composites (i.e., concrete, mortar and grout). Also, the production process of USS which is energy-intensive combined with its transportation increases the overall energy and carbon footprint of ECC. This project aims to reduce the carbon footprint with by-product Utilization for different sustainable applications. A special fiber-reinforced cementitious composites (FRCC) exhibiting high ductility under tension and named as Engineered Cementitious Composite (ECC). Portland cement, as the key ingredient in concrete, involves 0.87 kg of carbon dioxide (CO_2) emission per 1 kg production. The cement production contributes up to 8% of the overall anthropogenic CO_2 emission. Due to the lack of coarse aggregate in the ECC design, a high amount of cement is needed. Shrinkage, hydration heat, and cost are all increased when the cement content is high. Furthermore, such a mix will result in higher carbon and energy footprint. The environmental effect can be reduced by using industrial by-products in ECC.



RS-ECC



SS-ECC

In this study, industrial by-products such as fly ash and Electric arc furnace (SS) slag are considered for sustainability point of view. The current report consists

of the experimental studies (properties such as flowability, compressive strength and Ultrasonic Pulse Velocity (UPV) related to the river sand ECC (with fly ash to cement ratio of 1.2) instead of USS to reduce the overall energy and carbon footprint.

ACHIEVEMENTS

Initially the experimental study starts with the use of natural river sand (RS). The cost of RS is comparatively low as compared with USS used generally in ECC, and it is a commercially available product. Due to this the cost of the ECC will be higher, in view of sustainability and cost we have preferred to used RS. Flowability tests are conducted for different particle size distribution of RS (RS-2.36mm, RS-1.18mm and RS-0.6mm). The decrease in the spread flow of RS-ECC with gradation of RS-2.36mm to RS-0.60mm is due to the high specific surface area of finer RS (0.60 mm), the flowability of RS-ECC decreases with the reduction of particle size of RS.

The use of RS resulted in an increase in the compressive strength with decrease of particle size from RS-2.36 mm to RS-0.60 mm. The strength of RS-ECC is similar compared with M45-ECC produced with ultra-fine silica sand.

UPV of the RS-ECC increases when the gradation of sand gets finer from ECC-RS-2.36 to ECC-RS-0.60. ECC-RS-0.6 mix achieved better properties in terms of strength and durability parameter (UPV test).

Secondly, the as compared with RS the cost of SS is lower and it is also available as an industrial by-product. So in production of ECC, SS is used as partial replacement for RS. Flowability of the fresh SS-ECC mixes (particle size distribution of SS (SS-2.36mm, SS-1.18mm and SS-0.6mm) was measured using the flowability test. As the particle size of SS decreases, the flowability of SS-ECC decreases, when SS replaced the RS by 25% and 50%. The decrease of the flowability is due to angular and rough surface texture of SS.

The testing results show an increase in the compressive strength with the decrease of SS particle size at 25% and 50% replacement after 7 and 28 days. The mix with RS-0.6 mm SS particle size recorded the highest increase in compressive strength at both 25% and 50% replacement.

The UPV of the SS-ECC was measured at different ages of curing. From the results it can be clearly seen that it is increasing when the gradation of SS gets finer from ECC-RS-2.36 to ECC-RS-0.60. The increase in UPV is observed for the increasing SS content (25% to 50%). The increased values can be due to the lower presence of pores. Another reason could be better bonding due to lower pores in the SS-ECC.

Overall, the properties achieved with the use of industrial by-product (SS) is better and comparable with the RS. It is not only beneficial in view of sustainability but also reduces the cost as well.

PUBLICATIONS

1. S. Naveen & Govardhan Bhat. Usage of Fly Ash and Slag as Supplementary Cementitious Materials in Engineered Cementitious Composites (ECCs): A Review. International Journal of Concrete Technology. 2021; 7(1): 44-55pp (Published).

2. Paper accepted on “An Exhaustive Review on the development of the role of Supplementary Cementitious Materials in Ductile Engineered Cementitious Composites (EDCC)” in 12th Structural Engineering Convention [SEC-2021] at MNIT Jaipur, India, 19-22 December 2021.

Electrical Characterisation and Modelling of Porous Silicon Nanowire Based Lithium-Ion Battery Electrode

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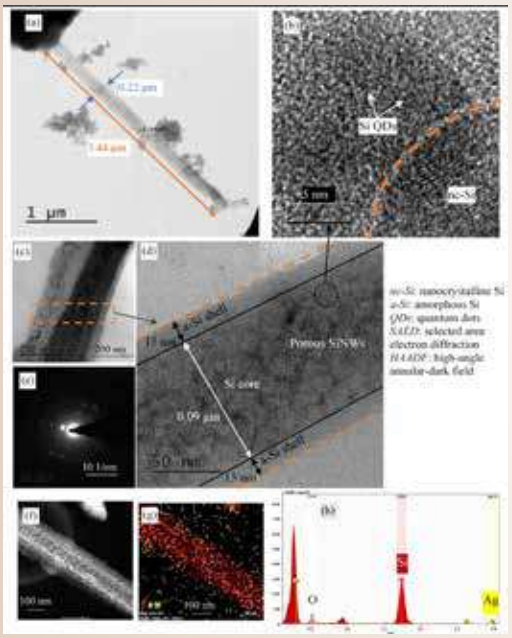
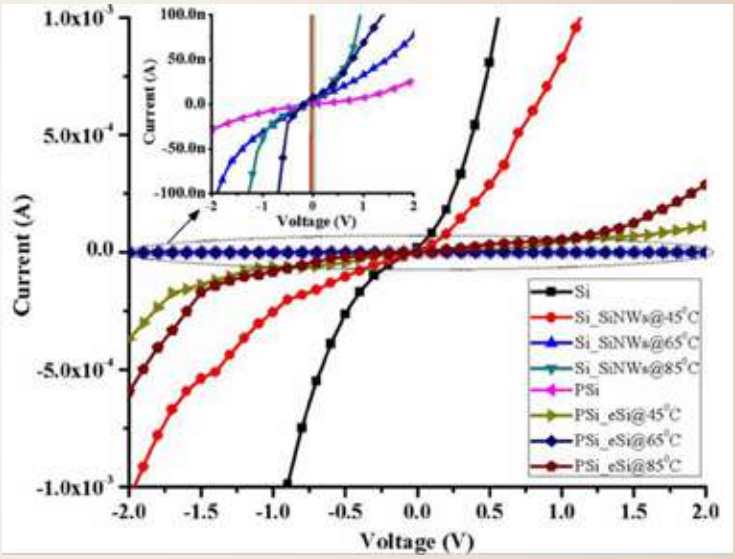


(a) HRTEM image, (b) nanocrystalline Si core, (c, d) core-shell structure, (e) SAED pattern, and (f, g, h) HAADF image, mapping element, and pattern of SiNWs fabricated using PSi+MII



I-V measurement of SiNWs and eSi fabricated for various MACE temperature using Si and PSi substrate

OBJECTIVE

- Various combinations of substrates (Si or PSi) and electrolyte compositions are studied in MACE to control the morphology of synthesized NWs such as length, strain, hydrophobicity, and crystallinity.
- The PSi+MII combination results in the highest amorphous Si phases (i.e., 35.79%), suitable for LIB anode.

- The DC biasing of SiNWs array or eSi results non-linear I-V curve due to metal-semiconductor junctions.
- The forward/reverse biasing resistance decreases on increasing the biasing voltage because at higher biasing condition the charge carriers cross the junction barriers smoothly allowing higher current and vice-versa.
- The electronic properties of SiNWs deviate from the bulk-Si due to quantum confinement effect, stress, strain, and amorphous phase present in the NWs.

ACHIEVEMENTS

The MACE successfully fabricated SiNWs using Si substrate and eSi using the PSi substrate for various MACE temperatures. The PSi substrate fabricates core-shell PSiNWs structure where the shell-part consists of a-Si, poly-Si, and PSi, and solid-SiNW forms the core.The MACE fabricates the SiNWs at 25°C using various combinations of substrates and methods, i.e., Si+MI, Si+MII, and PSi+MII, whereas PSi+MI produces etched-Si of HPL and LPL. The Si+MII combination produces the highest crystallinity (i.e., 84.91%) and length of SiNWs (i.e., 23.3 μm), which is more suitable for solar cell application compared to other combinations. The PSi+MII combination results in the highest amorphous Si phases (i.e., 35.79%), suitable for LIB anode. The MACE can vary the amorphous content or amorphous phase (~15-35%) in SiNWs. The PSi+MI combination results an etched-Si (eSi) at room temperature. At 45°C, a high porosity layer (HPL) and a low porosity layer (LPL) were formed, whereas, at higher temperatures (> 45°C), only one porosity layer was present while the other layer was wiped away. The length (thickness) of SiNWs (eSi) decreases on increasing MACE temperature. The I-V measurement depends on the average length/thickness of SiNWs/eSi. In the core-shell structure of porous SiNWs fabricated using PSi+MII combination, the formation of poly c-Si core, a-Si shell, and outer oxide layer allows lower current (in pico-ampere range) to pass through the NWs. The SiO_2 layer formed on eSi/SiNWs renders the current flow through them. The larger surface area produces thicker SiO_2 insulating layer, to satisfy the dangling bond of Si surface, causing lower current flow. The forward or reverse biasing resistance decreases on increasing the DC biasing voltage at which charge carriers overcome the barriers easily.

A Si substrate exhibits a hydrophobic surface (contact angle, CA = 90.2°), and upon anodization, the PSi also possesses a hydrophobic surface (CA = 142.4°). An array of SiNWs (eSi), fabricated by MACE of Si (PSi), acts as a super hydrophobic surface (i.e., contact angle > 150°) without using any functionalization material. Trapped air, present among the conical tips of the densely formed SiNWs array, reduces the solid-liquid contact area and improves the de-wetting behaviour. The trapped air increases on increasing the length of the SiNWs, which further enhances the de-wetting behaviour. The MACE uses Ag metal as a catalyst, whose remanence, after cleaning, may act as a functionalization material to lower the surface energy and responsible for the super hydrophobic surface. The de-wetting behaviour depends on the morphology, especially the tip-structure of the SiNWs, and the pore depth and diameter of the etched-Si. The super hydrophobicity increases by increasing the length (thickness) of SiNWs (eSi) depending on the MACE parameters. The wetting behaviour changes to hydrophobic/hydrophilic depending upon the oxidation that changes the conical/dendrite structure of the SiNWs/eSi surface.

PUBLICATIONS

1. Mihir Kumar Sahoo, Paresh Kale, "Control of Silicon Nanowires Crystallinity using Metal Assisted Chemical Etching of Silicon and Porous Silicon Substrate," Materials International, Vol. 2, 391-401, 2020.
2. Mihir Kumar Sahoo, Paresh Kale, "Role of Secondary Etching of Silicon Nanowires towards Quantum Confinement Effect," Superlattices Microstructures, Vol. 156, August 2021, 106949, 2021.

Enhancement of Surface Durability by NiTi Plasma Coating on Low Grade Steel in Aero-Vehicle Compressor Blade

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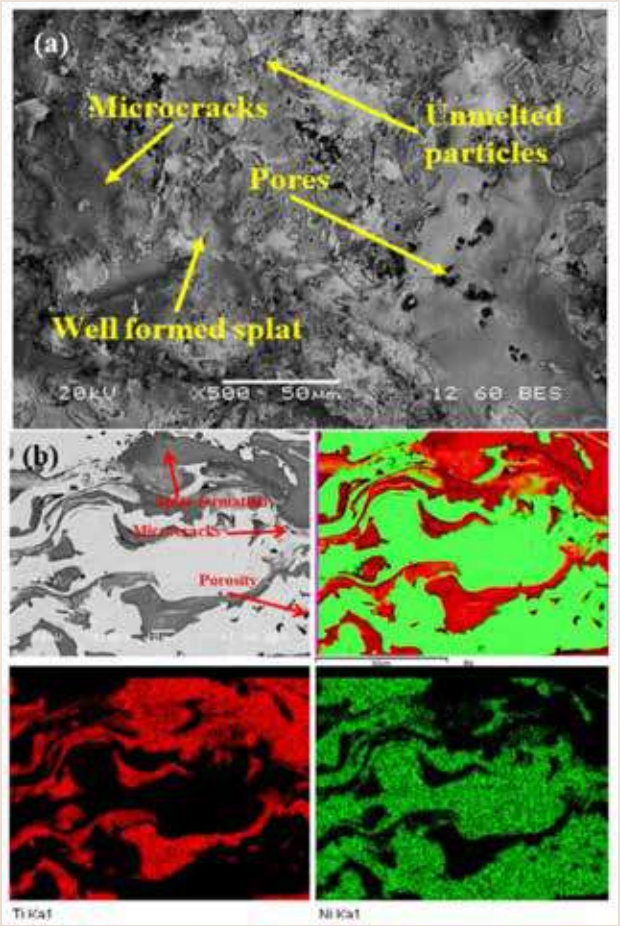
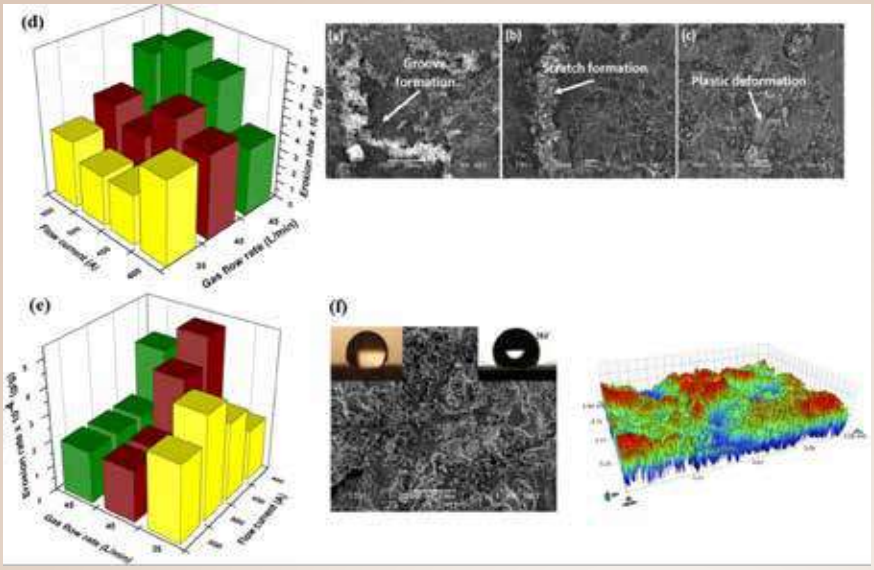


SEM image of (a) surface and (b) interface with elemental mapping of atmospheric plasma sprayed NiTi coating

OBJECTIVE

- Investigation of Physical characterization of atmospheric plasma spray coating of NiTi on mild steel substrate including surface topography analysis, interface analysis, porosity analysis, and X-ray diffraction analysis.



(a, b, c) SEM images of eroded surface, (d, e) variation of erosion rate with gas flow rate and plasma arc current of the coatings impinged at 45 and 90°, (f) SEM, 3D profile, droplet image and contact angle image of plasma sprayed NiTi coating

- Mechanical characterization of atmospheric plasma spray coating of NiTi on mild steel substrate.
- Solid particle erosion wear resistance of coating on aero-materials has been analyzed for harsh environment (dusty).
- Electrochemical corrosion test has been conducted for the sustainability of the coating in highly corrosive environment.
- Super hydrophobic characteristic and the sustainability of super hydrophobicity in different environments have also been investigated.

ACHIEVEMENTS

In the current study, an equiatomic mixture of Ni and Ti was coated on the mild steel substrate by atmospheric plasma spray technology. The coating operation was performed by varying plasma arc current and primary gas flow rate. After successfull development of coatings, the mechanical, chemical and tribological properties of the coatings were evaluated. A proper correlation between process parameters and properties of the coating was established. In addition to the above, the microstructural analysis was performed to represent the phenomena occurred by varying the process parameters. It was noticed from the variation of microhardness and primary gas flow rate that the microhardness increases with an increase in primary gas flow rate. The aforesaid trend was due to the enhancement in molten fraction of the powder particle and increase in particle velocity due to thermal pinching effect. The variation between microhardness and plasma arc current illustrates that the microhardness value increases with increase in plasma arc current. The enhancement in enthalpy and reduction in diffused air in plasma plume resulted in above mentioned trend. It has been noticed that the adhesion strength of the coating increases with increase in primary gas flow rate. The above stated phenomenon was due to the better interlocking between coating and substrate resulted from increase in velocity and temperature of the particles. The relation between plasma arc current and adhesion strength depicts an increase in adhesion strength with an increase in plasma arc current. This phenomenon is due to the flattening of powder particles resulted from enhancement of plasma jet velocity. The investigation of the solid particle erosion performance on the plasma sprayed NiTi coating reveals that the coating deposited at higher arc current and gas flow rate exhibits more damage by erodent at 90º impingement angle, which is due to the effect of hardness and brittleness of the coating at higher arc current. Also, different erosion mechanisms (scratch formation, cutting grooves and plastic deformation) are observed from the SEM micrographs of the eroded surface of plasma sprayed NiTi coating.

A New Framework for Water Resource Management using IoT Technology

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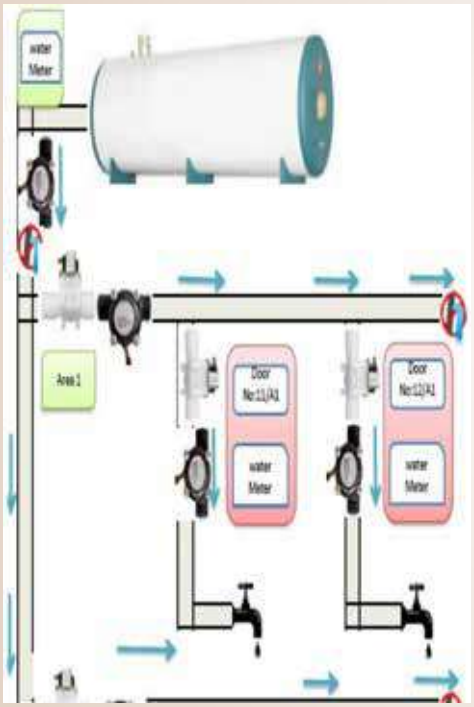

2-D View of the developed model

Demonstration of the real-time model

OBJECTIVE

The objective of this project is to design an online IoT/Cloud based system which monitors and controls the water distribution without any human intervention. In addition, the system must able to identify the leakage in the pipeline network and report the same to created cloud web page from time to time.

The designed and developed model has fulfilled the above said requirements.

ACHIEVEMENTS

- A new model for IoT/Cloud based water management system has been designed and developed which comprises of one main node, two distributed nodes and two home nodes.
- Main node model architecture has been designed and verified.
- Distributed node model architecture has been designed and verified.
- Home node model architecture has been designed and verified.
- Software for all nodes functionalities have been developed in Arduino Node MCU platform.
- Cloud-based web pages were created for water quantity allocation, gathering amount of consumption from distributed as well as home nodes with date and time and reporting leakage in pipeline network from time to time.
- The integrated model has been designed and developed finally by incorporating square metal frame with water tank, leakage nuts, square PVC pipes, water tapes, flow sensors, solenoid valves, end cups and other accessories.
- The integrated model has been tested in real-time manner. The demonstration video of the integrated model is also available.
- It is also planned to apply patent for the developed model.

PUBLICATION

Published a Paper entitled "Smart Water Management System for Apartments" in IE(I) All India Seminar n Internet of Things for Smart Applications held during August 1-2, 2019,conducted by The Institution of Engineers (India), Madurai Local Centre.

Legacy of IEI

Prime Minister Mrs Indira Gandhi cutting the Golden Jubilee Cake

Development and Processing of Hydroxyapatite (Waste Human Dental Teeth) Into Useful Composite

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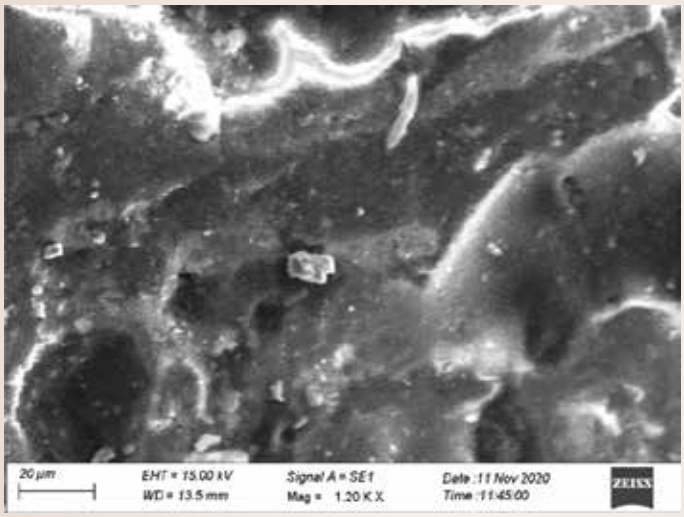
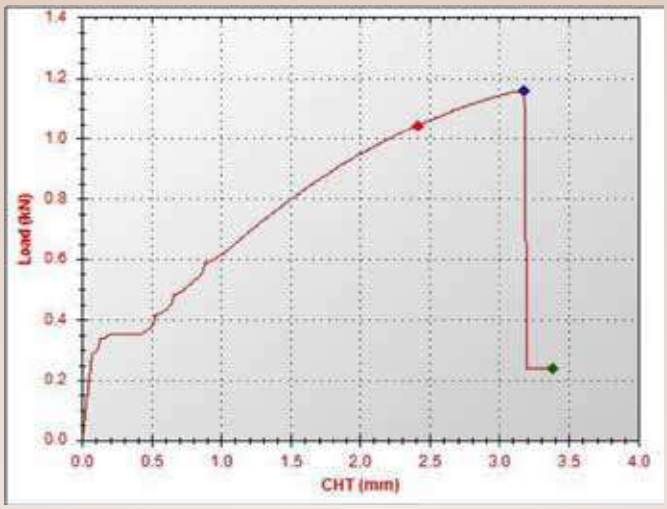


SEM image of polymer composite

OBJECTIVE

- To synthesize polymer infiltrated waste human teeth composite and evaluate the physical and mechanical properties of proposed composite for dental application.
- To produce the ceramic reinforcement for fabricating the composite from waste human teeth through grinding and ball milling process.
- To fabricate the composite through Polymer infiltrating process after curing of polymer
- To study the microstructure of the proposed composite using SEM and XRD.
- To analyze the physical and mechanical properties of the composite and compare the properties with existing dental materials.



Tensile test curve for the composite

ACHIEVEMENTS

In this work, the waste human teeth powder, used as ceramic reinforcement, were fabricated through grinding and ball milling process. Polymer infiltration was carried out then and composites were obtained after curing of polymer. The epoxy resin was used as a polymer matrix. Epoxy comprises of resin as one component and hardener as another and both will be stirred as per the ratio suggested by the manufacturer. Araldite AW106 was used as resin and Araldite HV953U was used as the hardener and mixed together in the ratio of 50:50. The fabrication methods of the composite depend upon the matrix and the reinforcement added to it. The addition of hydroxyapatite powder varied from 5wt%, 10 wt% and 15 wt% to study the property changes due to the reinforcement. Addition of the reinforcement is not to exceed 15 wt% as it leads to reduction in mechanical properties. Other than the hydroxyapatite composition, the load applied during the wear testing and the sliding distance covered by the specimen in the rotating disc were varied by 5N, 10N and 15N and 400m, 600m and 800m respectively. To produce a defect free composite, the reinforcement materials must be evenly spread over the composite and it must be homogeneously mixed together. Tribological properties of hydroxyapatite powder in various wt. % reinforced composite are investigated. Three most important factors that affect the properties of the composites were chosen and varied during the production and testing of the composites. The hydroxyapatite (HA) powder weight composition, applied load (P) and sliding distance (SD) were differed on the basis of Taguchi's experimental design. The results are fed as an input in MINITAB19 software and ANOVA was generated to study the influence of each factor on the specific wear rate (SWR). It was concluded that the HA wt. % highly influences the SWR of the composite during pin on disc testing.

The proposed - HA reinforced polymer matrix composite materials are very useful to the dental industry because of its excellent mechanical properties. In this work, the waste human teeth powder is used as ceramic reinforcement were fabricated through grinding and ball milling process. Polymer infiltrating was carried out then and composites were obtained after curing of polymer. The developed composites will be used as teeth replacement. The tensile property of the materials was analysed using SN ratio and ANOVA analysis. The scanning electron microscope was used to analyse the morphology of the composites.

Experimental Investigation of Condensation Process in 3S Device with Precooling System

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Assembled model of 3S device

OBJECTIVE

Supersonic Separator (3S) is used for the condensation of unwanted components in the natural gas. A gas is accelerated to a supersonic velocity to achieve the dew point of those components. Convergent divergent duct or nozzle is the device that can generate the supersonic flow. A nozzle of area ratio of two is chosen for the present study. Using the one-dimensional analytical and finite difference analysis the critical operating pressure ratios like choking pressure ratio and the pressure ratio for placing normal shockwave at exit will be identified. The non-dimensional shockwave location in the divergent section will also be found and plotted. Computational fluid dynamics analysis with finite volume method will be employed to identify the flow characteristics with the viscosity. The critical ratios identified in the one-dimensional analysis will be given as input pressure ratios for the CFD analysis. The centre line Mach variation and the temperature-pressure plot will be plotted. The latter plot can suggest the condensation zone in the nozzle. An experimental model of supersonic separator will

Nozzle mounted on open jet facility

be modelled and the flow characteristics along the nozzle with the identified with the help of static ports on the nozzle. The efficiency of numerical predictions will be compared with experimental results.

ACHIEVEMENTS

Convergent divergent nozzle is the key component in the supersonic separator, which can be used to separate the unwanted components from the gaseous mixture. Nozzle converts the high enthalpy into the kinetic energy. So, reduction in temperature and pressure creates a condensation environment in the nozzle. One-dimensional analytical equations were used to get the idea of the flow characteristics at particular instant, taking the medium as air. For better understanding of flow features along, the nozzle one-dimensional finite difference analysis was also performed to identify all the properties at a time explicitly. For the prediction of normal shockwave additional numerical dissipation was introduced. The range of OPR from which nozzle is chocked and to formation of normal shockwave at exit of the nozzle was identified and was the same employed for the finite volume analysis and the experimental analysis. The computational domain of the nozzle was modelled in Solidworks CAD software and imported into ANSYS meshing. A grid independence test was also carried out. The symmetric Mach contours inside the nozzle and the centre line Mach plots are presented. The variation from the one-dimensional inviscid analysis to viscous two-dimensional finite volume analysis was compared. A huge variation between these two types of analysis was found. The pressure and temperature variations along the nozzle was also presented. This can be used to identify the condensation zone in this non-equilibrium condensation process. Experimental model of 3S device was manufactured. And the experimental study was carried on nozzle only. Using the open jet flow facility, the nozzle operated at different OPR values. The static pressure along the nozzle is measured and converted into the Mach number. The simulation results are consistent with the experimental results for most cases. And the numerical simulations capture the normal shockwave location properties and location.

Accurate Classification and Detection of Brain Cancer Cells in MRI and CT Images using Nano Contrast Agents

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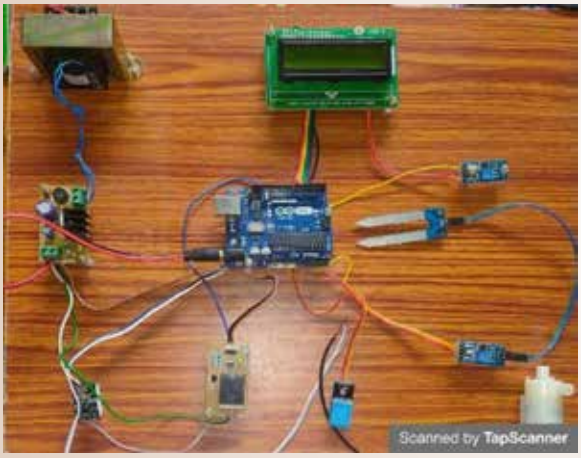
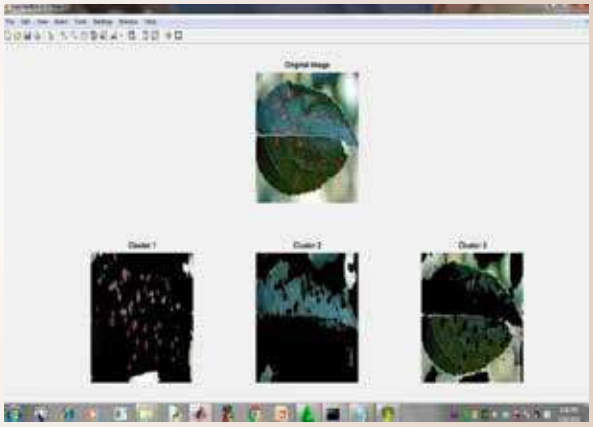


Ground Panel Circuit



MATLAB image processing

OBJECTIVE

- Provide an overview of the current situation of IoT technologies deployed in arable farming. Focusing on the current use of communication technologies and protocols, the generation and analysis of data, and IoT architectures.
- Outline the different applications and capabilities of IoT in arable farming.
- Investigate the main challenges encountered by IoT enabling technologies applied to arable farming.
- Present key potential fields of application where IoT could be employed, as well as future directions of the current trends.

ACHIEVEMENTS

Agriculture is the oldest profession of mankind. Very specifically, 80% of the Indian population is engaged in agriculture-related activities. No one can deny that farmers are losing their lives due to unmanageable debts increase due to failure of crops. Crop failures are due to various reasons. One of the main reasons for crop failures is due to manual based, very traditional and un-scientific agriculture practices. In this work, an intelligent system is developed to watch the development of crops and various other very timely parameters of crops development. The new system proposed here consists of a flying drone fitted with a camera eye to record images of crops at a scheduled time. The work involves developing an intelligent system by building a knowledge base to guide agriculturists. The knowledge base includes various cases of various crops and decisions based on crop image analysis. From captured images, the parameters that are planned for analysis by image processing are, the amount of green in leaf detection, the moisture content in the soil, save the crop from pests and water distributing with supporting IoTs etc.

The image of the plant will be acquired using the external camera eye fitted on a drone with other different sensors modules through IoT. This proposed new system has importance both practically and commercial wise.

Few significant points are listed in below :

- Better monitoring the climate conditions by various smart sensors and take corrective action depending on climate which help better farming management.
- All field files are archived all in one place in cloud. Its readable from any mobile device or desktop computer, with a detailed recording for each plot along with photos, crop type, acreage and sowing information.
- Typically, farmers use manual intervention to control the greenhouse environment. The use of IoT sensors enables them to get accurate real-time information on green house conditions such as lighting, temperature, soil condition, and humidity.
- By continuous monitoring of farms using WiFi camera and other sensors one can achieve good crop management leading to good revenue. The proposed devise can track, trace and accomplish all the daily tasks and schedules with precision.
- Use of drones along with cameras can collect all agriculture data. Drone based geo-tagging of plots ensures accurate prediction, with real-time updates to track the various stages of the crop. It provides visual confirmation, timely alerts and customized analysis on how crops performed by zone, input, and more.
- Precision agriculture and farming is all about efficiency and making accurate data-driven decisions. It's also one of the most wide spread and effective applications of IoT in agriculture. By using IoT sensors, farmers can collect a vast array of metrics on every facet of the field micro climate and ecosystem: lighting, temperature, soil condition, humidity, CO_2 levels, and pest infections.
- This data enables farmers to estimate optimal amounts of water, fertilizers, and pesticides that their crops need, reduce expenses, and raise better and healthier crops. Precision agriculture and predictive data analytics go hand in hand. While IoT and smart sensor technology area gold mine for highly relevant real-time data, the use of data analytics helps farmers make sense of it and come up with important predictions: crop harvesting time, the risks of diseases and infestations, yield volume, etc. Data analytics tools help make farming, which is inherently highly dependent on weather conditions, more manageable, and predictable.

Design, Development and Testing of Natural Composite Helmet for Various Applications

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Compact book press compression mould setup

Fabricated hybrid fiber laminate

OBJECTIVE

The main objective of the proposed project is to fabricate a specialized natural fiber reinforced composite helmet for various applications. There are numerous methods for fabricating composite components such as Resin infusion processes, Vacuum-assisted resin transfer moulding (VARTM), Resin film infusion (RFI), Book press moulding, Injection moulding, Automated fiber placement (AFP), Automated tape laying (ATL) and Centrifugal casting. Even though, these methods are used to prepare advanced composites to meet specific design or manufacturing challenges, in most of the engineering fields we are still using traditional hand layup method due to high fabrication cost involved in setting up the advanced processing equipments setup.

Hand layup is one of the most basic fabrication methods of thermoset composites. It is an open mould method suitable for making a wide variety of composites products from very small to large. Therefore, our helmet is prepared using hand layup setup along with compression moulding machine which typically consists of provision where the layer of composite fiber fabric is spreaded with Epoxy resin (Resin and hardener mixture 3:1) by hand to form a laminate stack. The male and female mould in the shape of commercially available helmet is fabricated using cement slurry and those moulds are coated with non stick gel. The natural fibers from the coconut tree involved in the chemical treatment to eliminate the unwanted dust and waste. The chemically treated fiber is dried at room temperature for 48 hours and then fibers are arranged in the mould. Finally, the epoxy resin is applied over the mould and fixed in the compression moulding machine to curing process.

Several curing methods are available. The most basic is to allow cure at room temperature. Cure can be accelerated, however, by applying heat, typically with an oven, and pressure, by means of a vacuum. After curing process the composite helmet shell was subjected to various testing processes to study its mechanical behaviour.

ACHIEVEMENTS

PUBLICATION

P Gokul, A M Hariharan, R Thanigaivelan, P Suresh, M Aravindth, J Jaffer Mohideen, V Gopinath, Won First prize in project presentation titled “Development of Natural fiber Reinforced Composite Helmet” conducted at MXCEL 2020– National level technical symposium organized by Kongu Engineering College 11th January 2020.

Design and Fabrication of Soot Collector and Filtration of Soot

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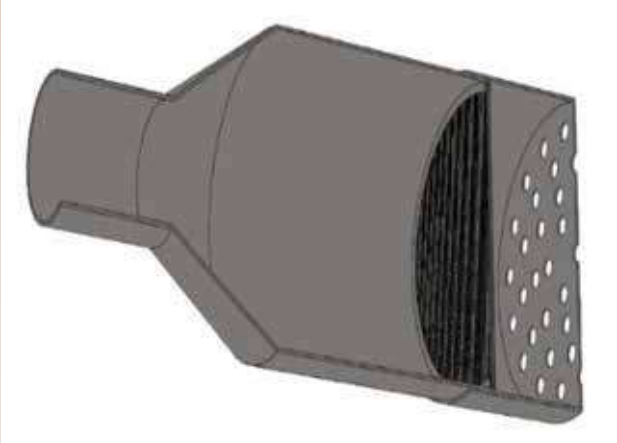
Soot Collector and heat exchanger setup

OBJECTIVE

The production of carbon black involves the thermal decomposition of hydrocarbons such as petroleum oils or coal oils or natural gas. This requires large amounts of energy. It also affects the environment and leads to the depletion of fossil fuels. The soot in exhausts that is released into the atmosphere can be collected and recycled to use in the place of carbon black. But the soot (black carbon) collected is not a pure form of carbon black. It must be treated with appropriate reagents in order to make it less harmful.

This process can be carried out by using the Carbon Soot Collector. The soot collector is a device that is designed to collect the soot that is being introduced into the atmosphere through the exhaust gases. The exhaust



Sectional view of Soot Collector

Preparation of ink from soot

Finding surface tension of the ink

gases have many sources mainly in industries and automobiles. This project was done on a single-cylinder four-stroke diesel engine. An active carbon filter was used as a filter in order to trap the soot. It was paired with a stainless-steel mesh in order to separate other large particles like dust from the soot. The soot collector was designed with reference to the design of a muffler or silencer. The soot collector was designed similar to an End-inlet and End-outlet silencer.

The project can be divided into two parts.

I. Fabrication of Soot Collector.

II. Fabrication of Ink.

I. Fabrication of soot collector: The soot collector was fabricated using AISI 304 stainless steel (UNS S30400) pipes. The soot collector is attached to a shell tube heat exchanger in order to decrease the temperature of exhaust gases. The soot collector mainly has 3 components:

1. Inlet: The inlet of the pipe is where the soot collector is attached to the outlet of the heat exchanger. The inlet is a combination of three different cross-sections. A 2" pipe and a 4"-2" tapered section and then a 4" pipe. This is designed in order to make sure there is a gradual increase in cross-section area so that there is no sudden increase in pressure or decrease in velocity.
2. Filter: The filter is having a combination of 3 parts. It consists of a metal mesh, an activated carbon filter and beading to hold the mesh and activated carbon together.
3. Exhaust: The exhaust again has a fabric filter in order to catch any extra soot that is not filtered and is suspended in the air. The exhaust section of the soot collector is a cap attached to the end where the filter is placed.

II. Fabrication of ink: The collected soot from the soot collector is carefully taken out and stored in a container. Fabrication of ink involves the following steps:

1. After treatment of the soot: the soot is first mixed with water in order to separate impurities. It is then heat-treated to improve its mixability. A small amount of oil is further added to make it into a pigment.
2. Mixing of solvents and binders: Solvents and binders are mixed together using a stirrer. They are thoroughly mixed and the pigment is then added to the mixture. The solvents then get the colour black because of the presence of the soot in them
3. Ink testing: Stalagmometry method or Drop count method. The principle of this method is to measure the weight of drops of a fluid of interest falling from a capillary glass tube and thereby calculate the surface tension of the fluid. A stalagmometer device is used in this method. Later, the surface tension of the ink is measured and compared with standard ink surface tension.

ACHIEVEMENTS

1. The experiment was carried out for two days on a single-cylinder 4-stroke diesel engine. The experiment was done two times, with a Heat exchanger and Soot collector and without a Heat exchanger and Soot Collector. The experiment was conducted on 23-04-2022 and 12-05-2022. Four different loads were applied to the setup. The trapped soot is collected and measured.
2. The total collected soot on a 40 min run of a single-cylinder four-stroke diesel engine at different loads is 430mg. The total ink that can be formed from a 0.5g of soot is 5ml
3. The efficiency of the engine without the soot collector is around 68.504% and with the soot collector is around 67.175% which shows a decrease in efficiency but not considerable. The soot collector is increasing the back pressure but it doesn't exceed the maximum allowable.
4. The surface tension of the ink that is measured by the stalagmometer is 41.21dyne/cm. The manufactured ink is water-resistant and also UV resistant.

Therefore, using the soot collector did decrease the percentage of particulate matter in the exhaust gases. The ink was successfully prepared from the collected soot. It can be said that it is feasible for a filtration process. This will decrease pollution in the environment and also safe to use for vehicles.

Modelling & FEM Simulation of DRX Microstructure for Automotive Applications

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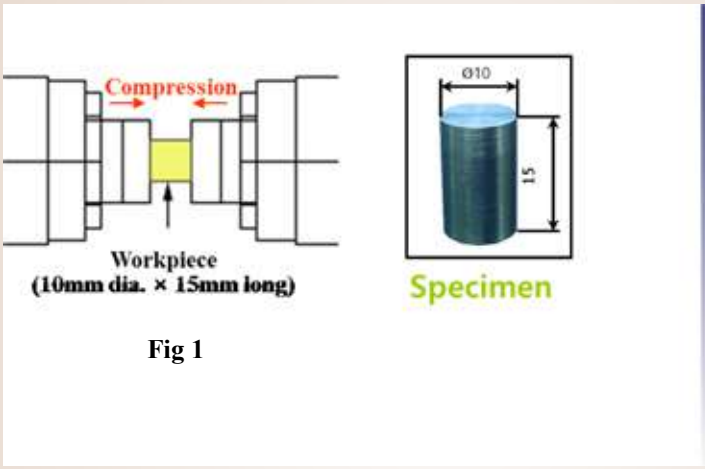

Fig 1

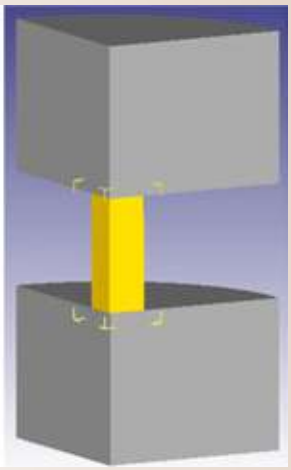

Fig 2

OBJECTIVE

FE ANALYSIS OF MICROSTRUCTURE EVOLUTION

A non-isothermal rigid-plastic FE code, DEFORM 3D was used to simulate the effect of processes variables on the distribution of state variables such as strain, strain rate and temperature. The compression test was simulated with 60% of height reduction and the distribution of state variables for each step were monitored to predict the grain size and recrystallised volume fraction distribution.

Based on the constitutive equations for the dynamic, static, meta-dynamic recrystallization and grain growth obtained from the compression tests, grain size distribution and volume fraction contour map of the forged parts were constructed with a user-defined subroutine.

EMPIRICAL EQUATIONS

Analytical results for microstructure evolution in hot forming of Si-Mn (S45C) steel will be shown in the followings. Yada and Senuma's experimental equations are used in the following numerical analysis as material data for recrystallization kinetics. These experimental equations are valid for C 0.05-0.4 wt%, Mn <1 wt%, Si < 0.5wt%, strain between 0.1 and 0.8, strain rate between 1 and 300s-1, and temperature between 1123K and 1473

K. Equations. (1) to (5) are those for dynamic microstructure change in forming pass. The unit of dislocation density is [cm-2]. The unit of grain size is [μm]. Initial grain size of the materials was taken as 400 μm.

$$\varepsilon_c = 4.76\times10^{-4}\exp\left(\frac{8000}{0.5T}\right) \quad (1)$$

$$\varepsilon_{0.5} = 1.144\times10^{-3} * d_0^{\,0.28} * \dot{\varepsilon}^{\,0.17}\exp\left(\frac{6400}{T}\right) \quad (2)$$

$$X_{dyn} = 1-\exp\left[-0.693*\left(\frac{\varepsilon-\varepsilon_C}{\varepsilon_{0.5}}\right)^2\right] \quad (3)$$

$$d_{dyn} = 22600 * Z^{-0.27} \quad (4)$$

$$d_{avg} = d_0 * (1-X_{drex}) + d_{rex} * X_{drex} \quad (5)$$

SIMULATION PROCEDURE

Combined with empirical models, FEM code DEFORM 3D can be used to simulate the free forging process for the specimen size 10mm dia 15mm long up to 60% reduction in height. Simulation was carried out at 1100 ^{O}C. The velocity of the upper die was 5mm/sec. The friction coefficient between billet and dies was 0.3. Substituting the parameters for simulation in Deform 3D and implementing the all the empirical equations in the user-defined subroutine, forging process and microstructural evolution can be simulated.

ACHIEVEMENTS

The FE simulation results of cross-section of the billet after the first stretching are shown in Fig. 1. From the figure, it can be seen that the dynamic recrystallized volume fractions in most areas are greater than those in the corresponding areas and the maximum volume fraction in the central area in Fig. 2 reaches 1.0, which means that a complete dynamic recrystallization occurs. Furthermore, the dynamic recrystallization appears in the areas contacting with dies to some extent and the recrystallized volume fraction of these areas reaches 0.3. The reason is that the deformation in the first stretching process is greater than that in the first upsetting process. It can be concluded that the stretching recrystallization process is effective to increase the effective strain of the billet. Compared with Fig. 3, the average grain size decreases significantly in Fig. 4 after the first stretching process, and the maximum and the minimum values are 24.2 and 11.8 μm, respectively. This means the grain size becomes uniform and refined after stretching process. Fig.5 shows the FE simulation results of cross-section of the billet of the final forging piece. It can be seen from Fig.5 that the dynamic recrystallized volume fractions in most areas of the final forging reach 1 after a series of processing steps including upsetting (three times), stretching (twice), rounding, flattening. The average gain size of the final forging decreases to about 10 μm from original grain size 90 μm. It is proved that all the forging steps, especially stretching and upsetting, is effective to refine the microstructure of the billet and make the grain size uniform.

Fig.6 shows the relationship between effective strain and the average grain sizes of given two points, that is, P1, which is in the center of the billet, and P2, which is in the top of the billet during the whole deformation course. It can be seen that the effective strain of the two points rises significantly till 12.2 with the increase of the forging steps (Fig. 5), whereas the average grain sizes of the two points reduce to 10 μm from original 90 μm sharply as the forging steps increase. In the beginning, due to low temperature and small effective strain that will lead to inadequate recrystallization, the average grain size of point P2 decreases slowly. However, it decreases quickly with continuation of forging processes, because of larger effective strain that will lead to a complete dynamic recrystallization. The average grain sizes of points P1 and P2 are equivalent at last.

Recrystallized volume fraction and grain size are the main characteristic parameters, which can be used to describe the behaviour of microstructure evolution. It shows the FE simulation results of the cross section of the billet after the compression.

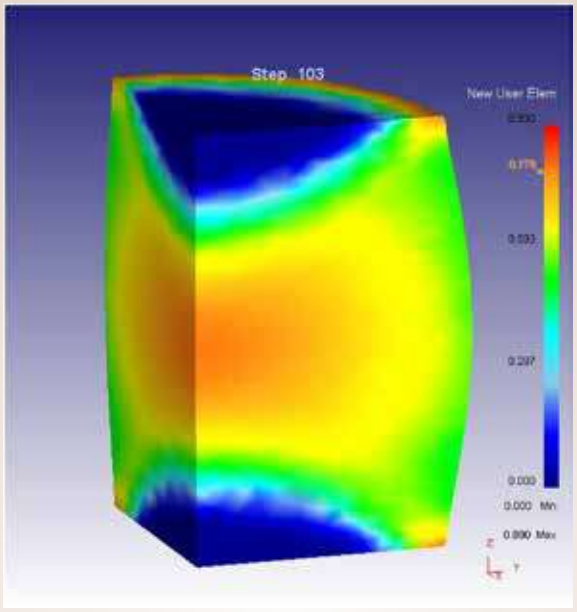

Fig 3. Dynamic recrystallized volume Fraction contours obtained from compression simulation

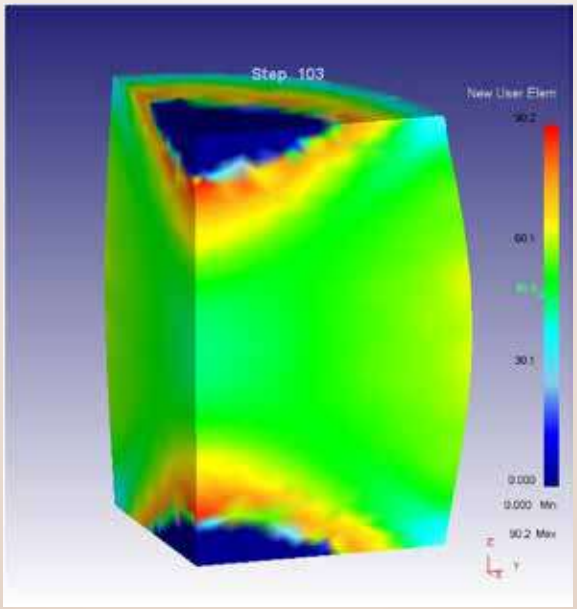

Fig 4. Dynamic recrystallized grain size contours obtained from compression simulation

It can be seen that the recrystallised volume fraction in the centre is greater that of edge of cross section. In the areas contacting with the dies, the recrystallised volume fraction is small. This phenomenon indicates that the dynamic recrystallization in the central area, in which the strain, strain rate and temperature exceed the critical value, will occur easily. On the contrary, the dynamic recrystallization in the area contacting with dies, due to lower strain and temperature, will not take place. It can be concluded that recrystallization behaviour is sensitive to temperature and strain. It shows the dynamic recrystallized grain size distribution.

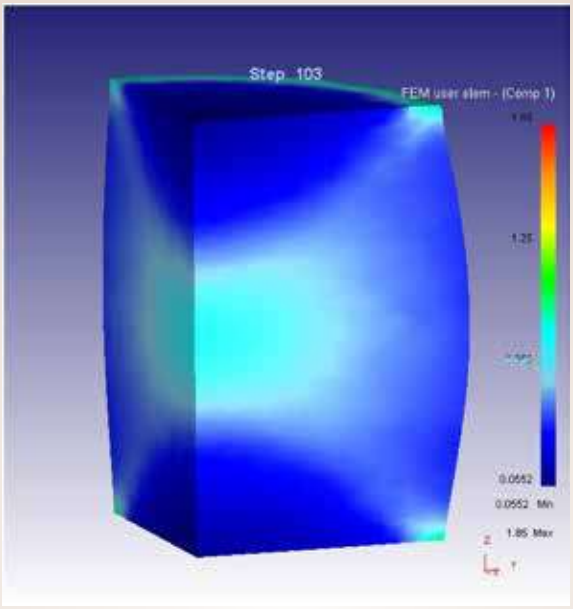

Fig 5. Effective strain distribution contours obtained from compression simulation

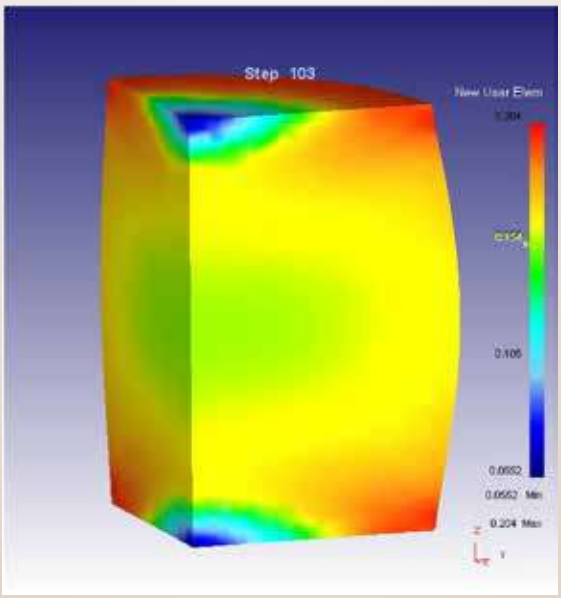

Fig 6. Retained strain distribution contours obtained from compression simulation

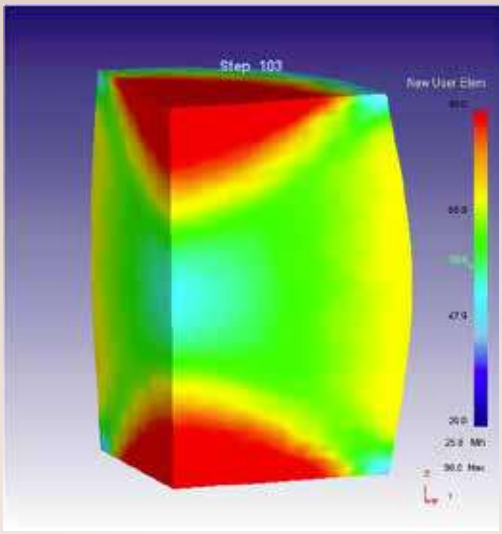

Fig 7. Average grain size distribution contours obtained from compression

SUMMARY

In this present investigation from FEM analysis and the observation of volume fraction recrystallized and dynamically deformation grain at different deformation stages, the drx of medium carbon micro-alloyed steel are studied. The following observations were followed from the drx constitutive analysis and microstructure evolutions.

The constitutive equations for dynamic, static and metadynamic recrystallization and grain growth behaviour will be obtained from literatures for Cr-Mn low carbon steels (S45C) and Vanadium Micro-Alloyed (VMA) medium carbon steels, (Which are extensively used by car manufacturing industry). From the simulation results, the recrystallized volume fraction in the center is greater that of edge of cross section. In the areas contacting with the dies, the recrystallized volume fraction is small. This phenomenon indicates that the dynamic recrystallization in the central area, in which the strain, strain rate and temperature exceed the critical value, will occur easily. On the contrary, the dynamic recrystallization in the area contacting with dies, due to lower strain and temperature, will not take place. It can be concluded that recrystallization behaviour is sensitive to temperature and strain.

"Technology innovation is starting to explode and having open-source material out there really helps this explosion. You get students and researchers involved and you get people coming through and building start ups based on open source products."

Tim Berners-Lee

Intelligent Automobile Brake Health Monitoring using Images of Brake Disc

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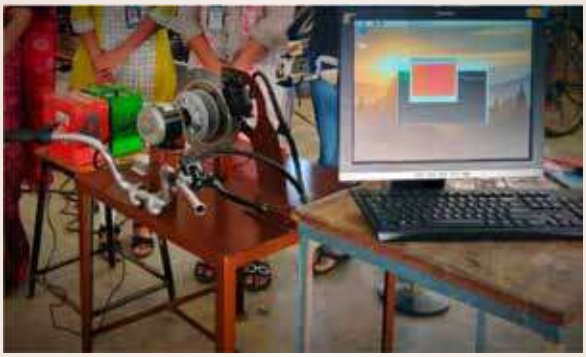
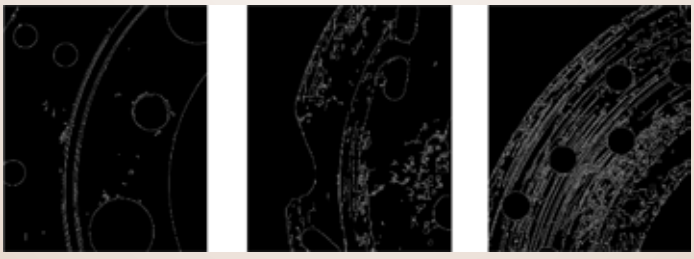


Fabricated model of 2 wheeler brake interfaced with camera (Lepton module) and Raspberry pi



Edges detected from three different disc images

OBJECTIVE

The aim of the proposed project is to develop an intelligent system which can monitor the condition of brake system using images of brake disc in an automobile using machine learning. The proposed system should work

in real time, monitoring the condition of vital components of the brake system and provide the information regarding the health of the brake to its user. Major objectives are the following:

1. Establish an experimental set-up of hydraulic brake components of an automobile which can be used as a simulation of the real scenario.
2. Generate test cases on the experimental set up to recreate all possible conditions that a braking system can be put to when in operation.
3. Diagnose the wear and tear by processing the images of brake disc. Suitable on-board sensors such as camera which can accurately capture the condition of disc, brake pad etc. must be identified.
4. Use machine learning for design of the health maintenance system using data captured from sensors, diagnose the health of braking system, and display it to the user.
5. Embed the sensors and processing unit in the automobile and prove the robustness and efficiency of the proposed system for use in real conditions.

ACHIEVEMENTS

As part of the research project, utilizing the fund amount, we have been able to fabricate a test rig and procure a thermal camera and other necessary interfacing equipment. We could achieve the following:

- 2D Design models were prepared using AutoCAD software and Assembly of overall test rig was prepared using Solid Works.
- FLIR Thermal camera was connected to a Lepton Radiometric break out board and this was interfaced to Raspberry Pi.
- Software necessary for collecting the images using thermal camera was deployed in the Raspberry Pi board.
- The test rig was interfaced with FLIR Radiometric Lepton Dev Kit using Raspberry Pi. This enables us to collect pictures of disc while the disc is in motion and brake is applied.
- Old and new discs are collected and images of those discs were captured.
- Relevant image processing code is developed which includes,
    - o Color Image segmentation: To separate disc from the background
    - o Edge Detection: Using canny edge detector number of edges on the disc can be identified.
- The image processing code is deployed and run in Raspberry Pi.
- The approach proposed is proved by training a model using the images of old and new discs.

The Zappy Disinfectant Bot for Modern Healthcare System

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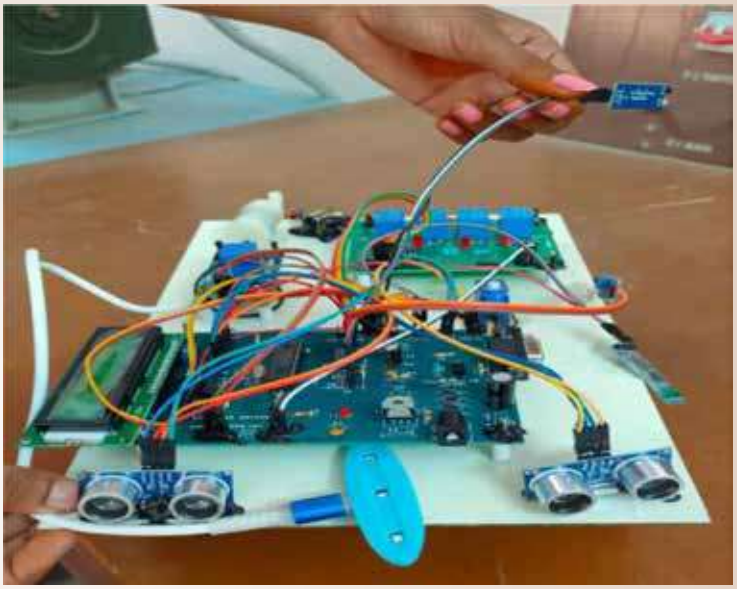
OBJECTIVE

- To minimize the human exposure to pathogen in cleaning the patients rooms during pandemic.
- To automate the task of sanitization in hospital without the use of health workers and staffs.
- To reduce the time taken for sanitization with the help of disinfectant robots.
- To identify the pathogen with the help of disinfectant robot in the quarantine room and sanitize it easily.



Zappy Disinfectant BOT

ACHIEVEMENTS

A cost efficient and effective disinfectant robot has been designed to limit the spread of bacteria and viruses, which goes along the given path and has the capacity to reach the inaccessible areas for effective disinfection. The disinfectant robot is equipped with (motion sensor) IR sensors which are mainly used to disinfect the places by not affecting the human or disturbing them. These IR sensors are mounted on the top of the robot to sense any movement (human/animal) so that it turns OFF the spray by itself. The robot is designed in such a way that it follows a pre-defined path provided by the user (the nurse or the caretaker). Disinfection process starts when the robot is turned ON. The proposed Disinfection Robot is designed to work in both automatic and manual mode depending upon type of path required to cover and sanitize with the capability of maximal possible coverage of floor surface and walls around, without any direct involvement of humans in cleaning process. Based on the results obtained from the developed system, the paper has been presented in Conferences during July 2022.

PUBLICATION

Dr V Jamuna, M Asha and K Priyanka has presented a paper titled “The Zappy Disinfectant BOT for Modern Healthcare System” in the AICTE sponsored Fourth International Conference on Emerging Trends in Science, Engineering & Technology, (ICETSET 2022) held on 7th and 8th July 2022 and efforts are made to publish the work in reputed journal.

Vibration Damping and Thermal Analysis of Various Cross-sectional Beams Printed using Additive Manufacturing

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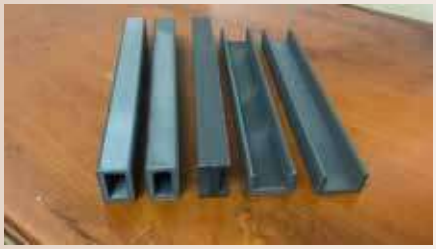


3D printed beams of various Cross sections

Flexural testing of 3D printed Beam

OBJECTIVE

In today's contemporary society fuelling up the production process without wastage of materials has become a necessity on an economic basis. One solution for this problem is Additive manufacturing, which has been adopted by a range of corporations and companies to optimize their production process. The technology of the additive manufacturing (AM) process has significantly kindled the interest of researchers and industrial players from various areas. 3D printing, also known as Additive manufacturing, is a method of creating a three-dimensional object layer-by-layer using a computer created design. 3D printing is an additive process whereby layers of material are built up to create a 3D part. This is the opposite of subtractive manufacturing processes, where a final design is cut from a larger block of material. Types of additive manufacturing include binder jetting, material jetting, powder bed fusion, vat photopolymerization, direct energy deposition, material extrusion, sheet lamination. Also, in recent years, fibers made from carbon have become increasingly popular instructural industries such as aerospace and automotive industries. Fiber-reinforced polymer composites have been employed in the early development of AM technology, and they have further potential application in various types of product design. Moreover, the research and development of these materials are extensively progressing as the materials are varied and have unique characteristics. The main aim of this work is:

- To evaluate the bending strength of the I, C and Box cross sectional beam under 3-Point bending method.
- To evaluate the frequencies and damping ratio of the various cross-sectional beam by modal analysis.
- To find out the thermal decomposition of the beams by thermo-gravimetric analysis.

ACHIEVEMENTS

Among additive manufacturing (AM) techniques, the filament-based technique involves what is referred to as fused deposition modelling (FDM). FDM materials are currently limited to a selected number of polymers. The development of innovative materials for FDM is gaining an increasing interest in various fields, with different perspectives which range from processing green filaments with wooden constituents to the use of composites or high-performance polymers .With AM, arbitrarily complex geometries, such as intricate internal features, lattice structures, and honeycomb structures, can be produced directly from a 3D CAD model . Some other capabilities include reduced material waste, part consolidation, and the ability to produce parts directly without the need for expensive part-specific tooling. The investigation of different materials for FDM filaments should extend the application of FDM techniques to unexplored fields in which the design freedom for complex shapes is an advantage, thermal and acoustic insulation and scaffolds for regenerative medicines that require personalized solutions together with more suitable materials.

The samples of varying cross-section (Channel, Box & I) were modelled in solid works software and converted into STL format. Slicing and tessellation of the STL data was done and then the input parameters like infill density, infill shape, layer height and orientation of printing is set in slicing software. These data from the STL file are transferred to the 3D printing machine and printing was done in the printer. The samples are printed in 0,45 and 900 orientations. These printed parts are then tested for the flexural properties and vibration damping properties as per ASTM standard. The thermal stability of the specimens was tested using thermogravimetric analyser.

Flexural strength and modulus of I-cross-section is 63.2734% higher than channel cross-section and this is due to better L/D ratio that the I section possess. From frequency response function plot for various cross sections following are observed:

- Among the beams tested, box beam performed with minimum amplitude at the first and successive natural frequencies. It indicates the effective damping behaviour of box-shaped beam with respect to other shapes preferred under cantilever condition. This is because that the attainment of low amplitude level between two vibration spectrums possesses the best damping performance structure.
- The centroid and shear center of box and I sections are coincident due to two symmetry axes, whereas for the channel section, they are located apart and obeying one symmetry axis. This variation in the position of the centroid and shear center over the shapes caused modified shear flow and shear stress level due to bending.
- The variation in vibration response confirms the influence of beam shape over dynamic stability.
- Thermogravimetric analysis shows that minimal weight loss of 1.85% till 400°C and hence this filament can be used for applications exposed to temperature less than 400°C.

The Institution of Engineers (India)

Recognized as Scientific & Industrial Research Organization by
Ministry of Science & Technology, Govt. of India

IEI R&D Grant-in-Aid Scheme

INSTRUCTIONS TO AVOID REJECTION OF PROJECT PROPOSALS DURING INITIAL SCRUTINY

(I) MUST FURNISH THE FOLLOWING GENERAL INFORMATION PRECISELY

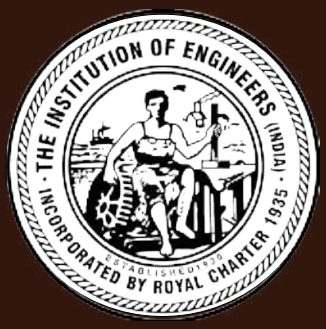
1. The project title should have clarity and must be relevant to the proposal.
2. Attach supporting documents for NBA / NAAC Accreditation or valid NIRF Rank for the Institutions.
3. Applications from Institutional Members [IMs] will be preferred.
4. Do not include names of more than two guides for a single project proposal .
5. Both the guides should be Corporate Members (AMIE/MIE/FIE- for UG Project Proposals and MIE/FIE- for PG & PhD Project Proposals). In case they are not, they must send the membership form with requisite fees along with project proposal.
6. Guide(s) should be from the same Institution as that of the Applicant(s).
7. A guide will not be allowed to carry out more than one project simultaneously.
8. Maximum number of students/applicants that can apply for a single UG Project Proposal must be limited to five. In case of PG & PhD only one student per project is allowed.
9. UG Applicants should be Student Members (SMIEs) of the Institution, whereas, PG & PhD students must be Corporate Member. In case they are not, they must send the membership form with requisite fees along with project proposal.
10. The 'Completion Date of Study' (Item D) should not be earlier than 'Project Completion Date' (Item H) or should not exceed the maximum duration prescribed for each category.
11. Inclusion of different category of applicants (UG/PG/PhD) in a single project proposal is not permitted.
12. Only full time students pursuing a course in engineering at UG/PG/PhD is eligible for funding. Faculty Members or those who are pursuing part-time course in engineering will not be considered as students.
13. PG applicant must enclose 'Enrolment Certificate' whereas PhD applicant must enclose 'Enrolment Certificate' as well as 'Registration Certificate' along with project proposal.
14. Project proposal will be considered for scrutiny only when the soft copy sent via email is followed with a hard copy of the proposal which must be signed and sealed by all concerned in required places.

(II) MUST ESTABLISH NOVELTY & FINANCIAL FEASIBILITY OF THE PROPOSAL

1. 'Review of R&D in the proposed area' (Item G) should be well documented and must establish novelty/uniqueness of the proposal.
2. Under item 'G', a list of 'References' should be provided for the earlier works carried out in the area.
3. The Applicant's Institute must extend its infrastructural facilities or provide partial funding for carrying out the project.
4. Proposals receiving Industry Support in cash/kind will be given preference.
5. It is expected that the proposal must provide complete information about items being procured. Procurement under non-permissible heads will not be considered for funding. In order to avail maximum grant 'Details of Financial Requirements' [Item-O] must be filled up with reference to upper ceiling of funding available under various Heads.

(III) INFORMATION SHEET & PAYEE DETAILS MUST BE COMPREHENSIVE

1. The 'Information Sheet' must be completely filled along with Membership Numbers for Guides, Students & Institute. Contact Numbers and E-mail of Guide(s) and Students must be furnished.
2. Payee Details should include all requisite details along with the GST number of the Institution.
3. Project proposal should be accompanied by hard copy of cancelled cheque. The cancelled cheque should be from the same account against which payee details have been provided and should bear the name of signatory authority.
4. Request of transfer of grant to account other than Principal/Director/Registrar/Dean (R&D) will be not entertained.



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