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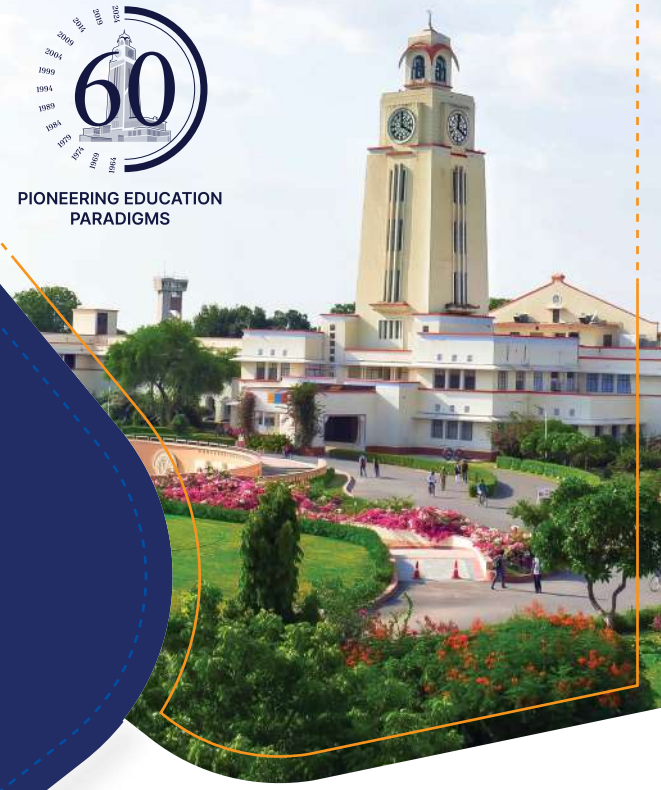

International Conference on

Greener Technologies in Mechanical Engineering (ICGTME-2025)

3-4 February 2025

Abstract Proceedings

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INTERNATIONAL CONFERENCE ON GREENER TECHNOLOGIES IN MECHANICAL ENGINEERING (ICGTME-2025) 3-4 February 2025

Book of Abstracts
Conference Proceeding

Venue: DEPARTMENT OF MECHANICAL ENGINEERING, BITS PILANI, PILANI CAMPUS.

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ABOUT THE CONFERENCE

BITS Pilani, an institution of eminence, is celebrating its 60th year of establishment and has been at the forefront of education, research and entrepreneurship globally. To commemorate BITS Pilani's diamond jubilee, the Mechanical Engineering Department at BITS Pilani is organizing an international conference with the core theme of "Greening minds for a greener future". This conference aims to explore and foster innovative solutions that promote eco-friendly practices and technologies for a greener future. In this context, the convergence of thermal, design, manufacturing and industrial system engineering offers a powerful platform to drive sustainability. This conference will explore the role of mechanical engineering in driving sustainability and achieving the UN's Sustainable Development Goals (SDGs). This conference targets the following areas with respect to the focused SDGs.

ABOUT PRE-CONFERENCE WORKSHOP

The Pre-Conference Workshop is designed to offer participants practical, hands-on training in cutting-edge technologies and methodologies across diverse research areas. The workshop focuses on key topics such as solar PV-assisted fluidized bed dryers, emphasizing energy-efficient drying processes, and cooling of EV batteries, addressing thermal management challenges in electric vehicles. Participants will gain insights into friction and wear measurement techniques critical for material durability, sustainable automation strategies for eco-friendly industrial processes, and microwave heating technology for innovative thermal applications. Additionally, the workshop covers battery testing and characterization, ensuring reliable energy storage systems, and sustainability assessment, equipping attendees with tools to evaluate environmental and economic impacts. This comprehensive training aims to bridge theoretical knowledge and practical application, fostering innovation in sustainable technologies.

ABOUT BITS Pilani

Birla Institute of Technology and Science, BITS Pilani, is an all-India Institute for higher education. Founded with strong technical collaboration with MIT (USA) under the Ford Foundation Grant, BITS Pilani has evolved into India's leading institute of higher education, distinguished by its illustrious legacy, modern campuses, and exceptional placement records. The institute's commitment to excellence, adherence to merit, transparency, innovation, and enterprise has been the hallmark of its journey. BITS Pilani has got campuses in Dubai, Hyderabad, Goa and Mumbai in addition to Pilani. These expansions have solidified BITS Pilani's reputation as a premier educational institution. The past six decades have been exceptional for BITS Pilani, marked by groundbreaking achievements in research, teaching, and fostering entrepreneurship. Some of the milestones and key achievements include:

- Institute of Eminence
- BITS BioCyTiH Foundation
- BITS-Technology Enabling Centres (TEC)
- Center for Research Excellence in Semiconductor Technologies (CREST)
- Center for Research Excellence in National Security (CRENS)
- BITS GATI (Gender Advancement for Transforming Institutions)
- SATHI Project Awardi

ABOUT MECHANICAL ENGINEERING DEPARTMENT

The Mechanical Engineering Department at BITS Pilani is spread across its four campuses of Pilani, Dubai, Goa and Hyderabad. It offers undergraduate, postgraduate, and Ph.D. programs and focuses on theoretical learning and hands-on experience. Established as early as 1946, the department is known for research in fields like Design, Manufacturing, Thermo-fluids, Engineering Management, etc. Our students explore specialized areas such as Robotics, Mechatronics, Energy Management, 3D Printing, Battery Technology etc. and are trained in software tools like AutoCAD, CATIA, COMSOL Multiphysics, MATLAB, Fusion 360 etc. Faculty members are deeply involved in cutting-edge research, addressing both fundamental and applied problems, with strong links to industry. We aim to produce skilled graduates ready for impactful careers in industry, academia, and research. With a focus on critical thinking, innovation, and problem-solving, we contribute to technological advancements while addressing real-world challenges through innovative pedagogy.

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Vice-Chancellor's MESSAGE

It is with immense pride and great honor that I extend a warm welcome to all participants of the International Conference on Greener Technologies in Mechanical Engineering (ICGTME-2025). Organized by the Department of Mechanical Engineering at BITS Pilani, this conference is a significant milestone in our institution's illustrious journey, marking six decades of academic excellence and relentless pursuit of innovation. As we celebrate our Diamond Jubilee, ICGTME 2025 stands as a testament to our unwavering commitment to advancing sustainable engineering solutions that align with global environmental imperatives.

The theme of this year's conference, "Greening Minds for a Greener Future," underscores the urgent need to address critical challenges such as climate change, resource depletion, and sustainable manufacturing. In an era where sustainability has become a global priority, this conference serves as a vital platform for fostering interdisciplinary collaboration, facilitating knowledge exchange, and driving meaningful progress. Through pioneering research, insightful case studies, and policy-driven discussions, ICGTME-2025 will explore transformative advancements in renewable energy, circular economy frameworks, eco-centric design, and innovative thermal management solutions. These deliberations are instrumental in harmonizing technological progress with environmental stewardship, furthering our collective mission to achieve the United Nations' Sustainable Development Goals (SDGs).

ICGTME-2025 brings together a distinguished community of scholars, researchers, industry leaders, and policymakers, creating an intellectual crucible for groundbreaking ideas and forward thinking solutions. I am confident that the insights and innovations emerging from this conference will address some of the most pressing challenges of our time and contribute meaningfully to the betterment of society.

I extend my heartfelt wishes for a highly successful and impactful conference. May ICGTME-2025 inspire new frontiers of sustainable engineering and empower future generations to lead with vision, responsibility, and purpose.

Warm regards,

Ramgopal Rao

Prof. V. Ramgopal Rao

CONFERENCE CHAIR MESSAGE

I am honored to warmly welcome each of you to the International Conference on Greener Technologies in Mechanical Engineering (ICGTME-2025), organized by the Mechanical Engineering Department at BITS Pilani to commemorate the institution's diamond jubilee. This event stands as a remarkable testament to scholarly excellence and collective determination to advance eco-friendly practices.

The conference theme, "Greening Minds for a Greener Future," aptly captures the spirit of collaboration among researchers and industry experts. It advocates for shaping solutions that go beyond incremental improvements. The theme greener future perfectly resembles with the sustainability goal of "meeting the needs of the present without compromising the need of the future". The synchronization of interdisciplinary fields such as thermal, design optimization, industrial system innovation and sustainable materials aids in attaining the same goal of greener future and sustainability. By aligning with one or more United Nation's Sustainable Development Goals (SDGs) the interconnection of disciplines is embarking in an era of sustainable future promoting responsible consumption of resources, emissions reduction and lower carbon footprints.

This volume of the conference proceedings has accumulated vibrant views on best practices of research emerged from discussions, case studies, presentations and insightful dialogues. The readers will be able to grasp the essence of the theme with pioneering works related to the field of waste valorization, waste to energy as well as waste to wealth frameworks, circular economy principles, design for environment, and innovations in manufacturing. The works adhering to the objectives of sustainability and fostering long term ecological balance.

It is through this ongoing synergy between academia, industry, and governance that transformative practices can take root, spurring the next generation of engineers, innovators, and leaders to strive relentlessly for a cleaner and more equitable world. The research presented here not only chronicles the thought-provoking dialogue of the conference but also inspires further breakthroughs that will guide us in safeguarding our planet while promoting inclusive development for future generations.

I sincerely thank our keynote speakers, sponsors, organizing committee members, student volunteers, and, most importantly, our participants for their valuable contributions and for being part of this journey.

Prof. Srikanta Routroy
Conference Chair (ICGTME-2025)

Inaugural Talk: Prof. Pradip Dutta

Title: Sorption based Thermal and Gas Storage Systems

ABSTRACT:
The basic operating principle of thermochemical energy storage (TCES) technology consists of an endothermic reaction in which surplus heat is added to separate the sorbent and the sorbate (desorption or charging process) and an exothermic reaction during which heat is released while two components are combined (sorption or discharging process). Among TCES technologies, thermochemical sorption storage systems (or sorption thermal batteries) have recently gained popularity as a viable alternative to conventional heat pumps for space heating and domestic hot water production. The sorption thermal batteries are suitable when low-grade thermal energy in the form of waste heat or non-concentrating solar thermal energy is available; they are thus ideal examples of clean energy.
In any TCES system, designing the reactor is a critical exercise as desorption, adsorption and heat exchange with the HTF all occur in this component. The reactor design should effectively address issues such as effective bed thermal resistance for adequate heat input (or removal) rate, bed permeability for adequate mass transport rate of gas/vapour (as determined by macrostructure and packing fraction, and reaction kinetics which depends on the bed pressure and temperature. All these phenomena are coupled, and this makes the reactor design extremely challenging. In this work, a systematic scaling analysis is presented first, addressing the issues of competing phenomena such as reaction kinetics, vapour flow and heat transport. Transport equations of mass, momentum and heat coupled with reaction kinetics are solved using a CFD model. Corresponding experimental studies are also performed, and the results are compared. A parametric study is performed to show the efficacy of the water vapour transport through the bed for varying heat exchanging domains with different aspect ratios, particle sizes and operating conditions. Results show that water vapour's heat and mass transport within the bed strongly affect the reaction kinetics occurring in fixed bed reactors. This research work provides a framework for designing the thermochemical energy storage system and optimizing the operating parameters. The dynamics of the entire system as functions of various operating parameters are presented, and the multifunctional features of the thermal battery system are demonstrated with respect to various heating and cooling applications.

Bio-sketch:

Pradip Dutta is currently Professor in the Centre for Energy Research and in the Department of Mechanical Engineering at the Indian Institute of Science, Bangalore. Currently, Prof. Dutta's research group focuses on thermal energy storage, advanced cooling technologies, and on technologies related to phase change and adsorption. Prof. Dutta received his undergraduate degree from IIT Kharagpur, Master's from IIT Madras and Ph.D. from Columbia University, New York, all in Mechanical Engineering. He has been elected Fellow of ASME, ASTFE and Fellow of all the four National Academies of India in Science and Engineering. He has received Distinguished Alumnus Awards from both IIT Kharagpur and IIT Madras, J. C. Bose National Fellowship, and Outstanding Teacher Award from the Indian National Academy of Engineering. He is a former President of the Indian Society of Heat and Mass Transfer.

Plenary Lecture: Prof. Moghtada Mobedi

Title: Thermal Energy Storage and PCM Heat Exchangers

Abstract:
The energy demand increases continuously due to the global population growth and rapid technology development. Fossil fuels not only cannot compensate the required energy demand but also causes serious environmental problems such as global warming. This forces researchers to develop technologies for utilization of the renewable energy sources. However, most of renewable energy sources are intermittent, and therefore the energy storage becomes the key issue for the utilization of renewable energy sources. Among many methods for energy storage, thermal energy storage has attracted attentions of researchers due to simple working principle and wide application area. In this talk, a detailed classification of thermal energy storage as sensible, latent, thermochemical and hybrid methods as well as their advantages and disadvantages are discussed with examples. Among them, special attention is paid to solid-liquid thermal storage due to its practical advantages. The needed device for the use of solid/liquid thermal storage is a PCM heat exchanger. The design of PCM heat exchangers is completely different than traditional heat exchangers and many additional parameters must be taken into account, which are explained in this talk in details. Furthermore, classification of PCM heat exchanger is carried out by reviewing more than 100 studies in this field. The classification of PCM heat exchanger is an important issue since it allows to know the advantages and disadvantage of each type and therefore to predict the application areas of each group. It helps to have a systemically comparison between the heat exchanger types which is an important issue for their improving. Finally, the gap research area still required to be studied are explained.

Bio-sketch:

Moghtada Mobedi is a professor in Mechanical Engineering Department of Shizuoka University in Hamamatsu City in Japan. He is also a member of Graduate School of Integrated Science and Technology and Graduate School of Science and Technology of the same university. His research area is “heat and mass transfer” in general, and specifically on heat and mass transfer in porous media, thermal energy storage, heat transfer enhancement and heat transfer in satellites. Many of his projects were awarded by funding in Turkiye and in Japan. He received funding for his researches from “State Planning of Turkey”, “Scientific and Technological Research Council of Turkey”, “Izmir Institute of Technology”, and after moving to Japan his projects were awarded by “Suzuki Foundation”, two projects by “Japan Society for the Promotion of Science”. The total number of his master and PhD students is more than 60 and they work in different fields in industry around the world. The results of these scientific activities are; over 180 papers published in international and national journals as well as in the proceedings of international conferences. He edited two books, which were published by CRC, Taylor and Francis group (2022), and MDPI publications (2024). He also wrote a textbook on heat transfer for graduate students and it was published by Springer Verlag, Singapore in 2023. He also wrote 8 book chapters on his research topics in different prestigious edited books. He was the conference chair of “Fundamental of heat and mass transfer in porous media: Fundamental and application” in Xian, China 2024 and also, he was the guest editor of 5 special issues on thermal energy storage and heat and mass transfer in porous media in different prestigious journals.

Plenary Lecture: Prof. Apurbba Kumar Sharma

Title: Microwaves in Material Processing: A Green Approach

Abstract:
Rapid success of humans while moving in the ladder of 'civilization' came at the cost of at least two aspects – depletion of natural ambience and resources. However, the world could wait no further, but to look for solutions; of course, without any compromise in quality and costs. Consequently, it becomes a challenge for all to adopt green approaches in their own paradigm. Globally, production sectors alone are responsible for one–fifth of carbon emissions and consume 54% of the world's energy sources. Such situations call for a transition to both carbon-neutral operations within the boundaries of the organisation, as well as carbon-neutral value chains. It is thus apt to adopt increasingly resource-efficient approaches in material processing. Usage of microwaves as a source of energy in material processing in select applications has shown encouraging potential in terms of energy and time saving. In the recent time, microwaves are being explored in material processing, for both heating and non-heating applications. However, there are many challenges – including safety and scaling. Exploiting its capabilities in the energy intensive applications like casting, joining, machining, heat treatment etc. shall contribute significantly to reduction in carbon emissions, while gaining a big processing time advantage. Research also shows that better or comparable product/output quality is achievable without straining the resources further. The current study highlights few such promising developments, although at the laboratory scale, involving some popular manufacturing processes.

Bio-sketch:

Dr. Apurbba Kumar Sharma is a Full Professor in the Department of Mechanical and Industrial Engineering and currently the Head of the Department of Design at IIT Roorkee, India. He led the academics at IIT Roorkee as the Dean of Academic Affairs (DoAA) during April 2021 to March 2024. He was responsible for overhauling the UG as well as PG curricula in IIT Roorkee aligning with the NEP 2020 as the Chairman of the Curriculum Review Committees during the period. He was the coordinator of 'नवोन्मेष' Design Innovation Center at IIT Roorkee during August 2018 to March 2021. Earlier, he was holding the positions of Associate Dean, Academic Studies and Chairman, Institute Academic Performance Evaluation Committee in this Institute during July 2013 to April, 2017. He has obtained his Bachelor degree from Dibrugarh University, Assam. He has subsequently obtained his Master and PhD degrees from IIT Madras, Chennai. Research interests of Dr Sharma include:

1. Advance Manufacturing Methods, Hybrid Processes
2. Microwave Material Processing (Microwave Drilling, Microwave Casting, Microwave joining, Microwave Cladding)
3. Surface Engineering

Dr. Sharma has filed ELEVEN **Indian Patents**; TEN of them have already been **Granted**. He has published more than **145 research papers** in International Journals and published more than 150 research papers in International and National Conferences. Dr. Sharma is a reviewer of several reputed international journals. He has also served the International Journal of Advanced Manufacturing Technology as its **Guest Editor** (2008). Dr. Sharma contributed one Chapter "Electrochemical Discharge Machining" **on Invitation in the Handbook** Titled: 'Design for Advance Manufacturing – Technologies and Processes' published by McGraw-Hill Education.

He has also contributed several chapters in books published by Springer, John Wiley & Sons, Inc. and Taylor and Francis Group.

Dr. Apurbba Kumar Sharma achieved **First Rank** among the Indian researchers with **9.40** Citations per paper and **65th Rank** in Top 100 Authors of IITs based on Number of Articles as reported on 'Indian Citation Index 2016', Published by Confederation of Indian Industries (CII). He has developed a Full Web-based Video Course on "**Advanced Manufacturing Processes**" under the NPTEL Programme of the Government of India. He has also developed a course as the Principal Developer on "Principles of Industrial Engineering" for undergraduate students under the Pilot Phase of the National Mission Project on Pedagogic Development, Sponsored by the Ministry of Human Resources Development (MHRD), Govt. of India. Dr. Sharma has advised/supervised **TWENTY** PhD programs and FOUR others are in-progress. He has also supervised Fifty-Five Master's Dissertations and Forty Bachelor's Dissertations. He was working as **a DAAD (Germany) Fellow** in the Institute of Pulsed Power and Microwave Technique (IHM), Karlsruhe Institute of Technology (KIT), Germany. He has completed five funded research projects; three other projects funded by MHRD and DST, Government of India are in progress. He has also completed a few consultancies. Dr. Sharma has coordinated one program on "**Nurturing Future Leadership Programme** (**NFLP**)" under the MMTT Programme of the Ministry of Education, Govt. of India. Dr. Sharma is associated with several professional bodies which include- Fellow of the Institution of Engineers (India), Member of American Society of Mechanical Engineers, USA, Member of Society of Manufacturing Engineers (SME), USA, Member of Global Science and Technology Forum (GSTF), Singapore, Member of Materials Research Society of India, Member of the Indian Institute of Industrial Engineers and a member of ISTE, New Delhi. Dr. Sharma was instrumental in formulating and implementing the new Program Structures for UG and PG Programs in the year 2013 at IIT Roorkee as Associate Dean (Academic Studies). He is also a member of Board of Studies of other universities. Dr. Sharma is a member of the Editorial Board of the *ISME Journal of Manufacturing Sciences* published by the Indian Society of Mechanical Engineers, India.

Plenary Lecture: Prof. Sunny Zafar

Title: Innovations in Sustainable Composites: Recycling Methods and Performance Optimization.

Abstract:
This talk will present latest innovations in sustainable composite materials, emphasizing cutting-edge recycling methods and improvements in material performance. It reviews research on techniques for recovering and repurposing composite waste to minimize environmental impact. Furthermore, the enhanced mechanical and thermal properties of recycled composites demonstrate their potential for expanded industrial applications. By refining recycling processes and optimizing material characteristics, these advancements pave the way for sustainable composite material cycles, supporting circular economy principles and contributing to a lower carbon footprint in both production and end-of-life stages.

Bio-sketch:

Sunny Zafar is an Associate Professor in the School of Mechanical and Materials Engineering (SMME) at the Indian Institute of Technology Mandi, a position he has held since August 2016. He completed his B.Tech. in Mechanical Engineering with distinction from Punjab Technical University in 2011, followed by an M.Tech. from the Indian Institute of Technology Roorkee in 2013. He earned his Ph.D. in Mechanical Engineering from the Indian Institute of Technology Roorkee in August 2016. Dr. Zafar has made significant contributions to academia, authoring over 85 original peer-reviewed journal articles in esteemed international publications and holding three patents. He has also successfully mentored four research students during his tenure. His current research interests include Advanced Manufacturing Processes for Polymer Composites and Sustainable Biocomposites, Recycling of Polymer Composites, Surface Engineering, and Experimental Tribology. Dr. Zafar is actively developing innovative methodologies such as the Microwave Assisted Compression Molding (MACM) process and Vacuum Assisted Resin Infusion Microwave Curing (VARIMC) process for polymer composites. Additionally, he is engaged in Microwave Assisted Chemical Recycling (MACR) for thermoset composites and advancing microwave-based machining processes for fiber-reinforced polymer composites.

Plenary Lecture: Prof. Dr.-Ing. Stephan Kabelac

Title: Fuel cell driven aircrafts for green aviation

Abstract:
The transition of aircraft technology towards climate friendly green aviation is only at its beginning, there is still a long way to go. On one side there is an inevitable need of air transportation, there is no other reasonable chance to connect and link people across continents. Ships are only a partial solution, they are also not on a sufficient sustainability level yet. The existing airplane technology based on jet propulsion has evolved to a very high level of maturity, but unfortunately this existing technology is harmful to environment and thus it must be replaced within the next 20 years. Two technologies are under strong debate on this behalf. Much of the existing technology standard could be kept when special liquid fuels replace the climate harmful kerosene, a hydrocarbon having this awful high energy density. These new fuels, Sustainable Aviation Fuels SAFs, must be synthesized from green hydrogen, thus they are rare and expensive. The other way of transformation heads towards the full electric plane with an electric driven propeller propulsion approach. The electric energy needed for this propulsion concept is furnished either by battery of by a fuel cell system. A fuel cell being the main energy conversion device calls for a disruptive adaption in airplane design. As only chemical energy storage offers a sufficient high mass specific energy envelope the energy conversion should be electro chemical, as this results in higher conversion efficiencies as TCE combustion or heat power cycles. The integration of fuel cells into airplane structures is demanding. PEM fuel cells offer a high volumetric power density, but they suffer from additional heat exchangers needed for the thermal management of the fuel cell system. These huge heat exchangers increase weight and drag. High temperature oxide fuel cells (SOFC) offer positive heat integration, but they have still a low mass and volumetric power density. Both fuel cell types will probably see liquid hydrogen as a fuel, as this carrier of chemical energy seems to be the best compromise compared against ammoniac or methanol, for example.The talk will introduce both the state of art on behalf of PEM-fuel cell concepts within airplanes as well as the SOFC-concept for a new airplane concept. The focus for the PEM-concept will be on the thermal management topic, especially the heat exchanger design, while the SOFC high temperature approach will be discussed on behalf of thermodynamic heat integration cycles. Short and medium range planes are favoured in the discussion.

Bio-sketch:
Prof. Dr.-Ing. Stephan Kabelac, born in Bremen, Germany (1958), is a distinguished scholar in Technical Thermodynamics. He earned his Mechanical Engineering degree (1983) and PhD (summa cum laude, 1987) from Leibniz University Hannover, where he also completed his Habilitation in Radiation Thermodynamics (1991). He worked at Bayer AG (1992-1994) before becoming a professor at Leibniz University Hannover (1994-2002, 2011-present) and Helmut-Schmidt University, Hamburg (2001-2011).
His key roles include Dean of Studies (2016-2020), member of ISFH's Scientific Committee, DKV executive board, and Hamburg's Academy of Sciences. He served on the German Research Foundation's evaluation committee (2004-2012) and as Editor-in-Chief of Engineering Research (1996-2023).
His research spans high-temperature fuel cells, evaporation, condensation, radiation heat transfer, and vapor compression cycles, establishing him as a leader in thermodynamics. Prof. Kabelac has contributed significantly to academic, industrial, and interdisciplinary advancements.

Plenary Lecture: Prof. Perumal Nithiarasu

Title: Digital twins of thermal systems

Abstract:
Recent strides in artificial intelligence (AI) have brought about transformative changes across various engineering domains, particularly manufacturing and healthcare [1]. This impact extends to thermal sciences, where machine and deep learning integration is becoming increasingly prevalent [2]. This lecture aims to provide an insightful overview of the current state of the art in AI applications within thermal engineering, focusing on the emerging realm of digital twins. Digital twinning, defined as a virtual platform where a physical entity and its digital counterpart continually influence each other until achieving a desired outcome, presents distinct challenges. In thermal sciences, where measurements are often sparse and prone to noise, the first significant challenge lies in integrating this sparse data into physics-based models to reconstruct a comprehensive solution [4]. The lecture will address this challenge's intricacies, emphasising the need for accurate reconstruction models. Even if such models are feasible, they often are not cost-effective and real-time solution reconstruction is a challenge. For digital twins to effectively control physical entities, especially in extreme thermal environments, nearly real-time transient solution reconstruction becomes imperative [5].

1. N.K. Chakshu and P. Nithiarasu, An AI based digital-twin for prioritising pneumonia patient treatment, *IMECHE Journal – Part H*, 236,1662-1674, 2022.
2. W. Bielajewa, M. Tindall and P. Nithiarasu, Comparative study of transformer- and LSTM-based machine learning methods for transient thermal field reconstruction, *Computational Thermal Sciences: An International Journal*, (2024).
3. A Di Meglio, N. Massarotti and P. Nithiarasu, A physics-driven and machine learning-based digital twinning approach to transient thermal systems, *International Journal of Numerical Methods for Heat & Fluid Flow*, (2024).
4. H.T.Jahromi, N.K.Chakshu, I. Sazonov, L. Evans, H. Thomas and P. Nithiarasu, Data-driven inverse modelling through neural network (deep learning) and computational heat transfer, *Computer Methods in Applied Mechanics in Engineering*, 369, 113217, 2020.
5. W. Bielajewa, M. Tindall and P. Nithiarasu, A novel, finite-element based framework for sparse data solution reconstruction and multiple choices, (submitted, 2024).

Bio-sketch:

Perumal Nithiarasu (PN) is a Computational Engineering Professor and the Associate Dean for Research, Impact, and Innovation at the Faculty of Science and Engineering, Swansea University. With a career spanning nearly three decades, PN has made significant contributions to computational fluid dynamics, biomedical engineering, and heat transfer. PN's expertise in computational heat transfer is currently focused on the interface between physics-based models and machine learning. PN has a prolific publication record, with over 300 articles and two books to his credit. PN's contributions have been recognised with prestigious awards, including the Zienkiewicz Silver Medal from ICE London in 2002, the ECCOMAS Young Investigator Award in 2004, and the esteemed EPSRC Advanced Fellowship in 2006. He holds the position of Founding Editor-in-Chief of the *International Journal for Numerical Methods in Biomedical Engineering,* published by Wiley-Blackwell. PN was elected a Fellow of the Learned Society of Wales in 2018.

Plenary Lecture: Prof. Sara Rainieri

Title: Optimal Design of Enhanced Heat Exchangers for the Sustainable Food Industry

Abstract:
One significant challenge continually encountered by manufacturers of heat exchangers is the imperative for a design approach grounded in technological innovation aimed at producing devices that are not only more thermally efficient, but also feature reduced pressure drop, volume, manufacturing and operational costs, and high-quality surface finishing to mitigate fouling phenomena. A strategy that has been successfully explored in literature to achieve this goal consists in the use of emerging additive manufacturing technologies, that enable to produce surfaces with an optimized morphology. This challenge requires a multidisciplinary approach that couples the advantages of numerical approaches to experimental advanced measurement and data processing procedures, mostly based on highly resolved infrared thermographic systems. The possibility of obtaining detailed information about the heat transfer capability of enhanced surfaces can be suitably achieved by using numerical tools in the optimization problem that adopts experimental data as a necessary either input or validation elements. The present contribution aims to showcase applications of two complementary approaches—numerical and experimental—regarding passive heat transfer enhancement solutions implemented in heat exchangers. Particular focus is given to the food industry, which faces significant challenges in improving the energy efficiency of related equipment.

Bio-sketch:

Prof. Sara Rainieri, Born in Fidenza, Parma, Italy (1969), graduated summa cum laude in Physics at the University of Parma, PhD in Applied Physics (1997), post-doc fellowship at the University of Parma (1997-1998) and at the University of Bologna (1999), University Researcher (1999), Associate Professor (2002) and Full Professor (2015) in Applied Physics at the Department of Engineering and Architecture of the University of Parma. Honorable mention for the Ph.D. thesis within the EUROTHERM Young Scientist Prize and Awards 2000.
Pro-Rector for Education and Student Affairs at the University of Parma, Italy (2017-2023). President of the Italian Union of Thermal Fluid Dynamics (2023-2025). President of the Italian Association of Applied Physics (2023-2025). Best Associate Editor (2022) for the ASME Journal of Heat Transfer. National coordinator of the project PRIN2022 "MOOD4HEX - MOrphology Optimized Design for Heat EXchangers", founded by the Italian Ministry within the National Recovery and Resilience Plan. The research activity is focused mainly on these main following topics: techniques for the heat transfer enhancement in forced convection, with specific reference to challenges in the food industry, solution techniques of inverse heat transfer problems, with both theoretical and experimental approaches, innovative data processing and parameter estimation procedures based on infrared thermographic mapping, optimization approaches of energy performance in integrated systems.

Plenary Lecture: Prof. Viswas V. Wadekar

Title: Some Fascinating Aspects of Experimental Research and Modelling for Industrial Heat Exchange

Abstract:
This presentation describes examples of experimental and analytical research undertaken to support modelling of industrial heat exchangers, used primarily in chemical process plants. As a backdrop to the examples of research discussed here, geometric complexities of multistream heat exchangers are described. For example, how multiple streams, sometimes as many as up 20 streams, are introduced in the exchanger and how they are arranged internally in the exchanger to maximise the amount heat transferred and minimise the transverse variation of metal temperature. Such complexities directly impact on the exchanger modelling because the axial profiles for temperature, pressure and vapour quality need to be calculated for multiple streams rather than just one hot and one cold stream. The examples of research presented here deal with research of practical relevance carried out in support of design and simulation software for heat exchangers. The examples range from the partially additive nature of enhancements, arising from two-phase flow and special geometric features, to improving the performance correlations for plate heat exchangers with highly viscous fluids. The fascinating area of relating the local measured pressure gradients to the prevailing two-phase heat transfer characteristics in a boiling channel is also reported. It is observed that in the near dry-out region the two-phase pressure gradients are significantly lower than those just before the near dryout region. These low-pressure gradients cannot be predicted correctly by the homogeneous flow model; a modified homogeneous flow model, which takes into account thermal non-equilibrium effects, is required for this purpose. In another example the use of enhancement technology for augmenting single and two-phase flow heat transfer is discussed. It is demonstrated that special boiling surfaces, designed to enhance boiling heat transfer can provide nearly an order of magnitude enhancement in boiling heat transfer but the use of incorrect enhancement device for boiling would result in a marginal enhancement, thus, illustrating the concept of the right enhancement devices for right applications. Finally, it is concluded that commercial research driven by the need to validate and enhance design and simulation software can be just as stimulating and interesting as academic research. Furthermore, even if much of the research is not published in the open literature, it too contributes to greater understanding of thermal-hydraulic phenomena in the context of industrial heat exchange.

Bio-sketch:

Dr. Vishwas V. Wadekar is a Consultant based in the UK with extensive experience in heat transfer and thermal systems. Previously, he worked at the PS2E Institute, Paris-Saclay Research Centre, focusing on industrial heat recovery, and served as Technology Director for HTFS Research at AspenTech Ltd, UK. Dr. Wadekar has authored numerous technical papers on compact heat exchangers, multiphase flow, heat and mass transfer, and boiling.
He has lectured internationally as an invited speaker and contributed to several scientific organizing committees. As co-chairman of the Enhanced and Compact Heat Exchanger Conference for many years, he also delivered training courses globally on advanced heat exchanger technologies. A visiting faculty member at various universities, he is a member of the UK National Committee for Heat Transfer and served as Associate Editor for Heat Transfer Engineering.

Plenary Lecture: Dr. Vivek Kumar

Bio-sketch:

Vivek Kumar, Principal Application Engineer & Sustainability Leader joined Ansys after he graduated from IIT Kanpur. He has over 18 years of experience in Computational Fluid Dynamics (CFD). Vivek specializes in multiphase flow simulations, particularly in Volume of Fluid (VOF) - Discrete Phase Model (DPM) coupling for applications such as sprays and film dynamics with numerous conference and journal publications in gas turbine and aviation conferences. Over the last four years, he has been focused on sustainability solutions, leading a team of Ansys experts across Asia providing simulation-based solutions to Ansys customers for green energy. His team has contributed extensively to the advancement of simulation methodologies for energy and sustainability-related applications. He focuses on developing advanced modeling techniques to support industrial sustainability efforts and drive innovation in energy transition technologies. Vivek has played a key role in leveraging CFD for clean energy solutions, including hydrogen production, storage, and transport.

Track:

Renewable Energy

Performance Analysis of a Conventional Double-Slope Solar Still for Solar Distillation: Experimental Findings

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ABSTRACT

An experimental study has been performed on a conventional double-slope solar still which enhances water desalination performance significantly because of more exposure to the sun in comparison to single slope solar still. It has a basin of size 1000 cm x 600 cm with an absorber plate coated with black paint. It has double-slope glass covers for full exposure to the sun and also for condensation. Glass wool has been used as insulation to minimize the loss of heat and enhance thermal efficiency of the unit. The experiments have been conducted with two different water depths, 1 cm and 3 cm. While the shallower depth of 1 cm yielded a significantly higher output, reaching up to 510 ml per day, the 3 cm depth produced a slightly lower yield of 480 ml per day. Therefore, it is evident that the shallower depth performed much better in terms of thermal efficiency and rate of evaporation. These results suggest that optimization of the water depth in double-slope solar stills has good potential to improve distillation performance. Enhancement with use of reflective surface and new materials will probably improve its performance further. This study will sum up useful knowledge on the enhancement of solar distillation technologies as renewable alternatives in remote areas suffering from scarcity of water.

Key Words: Double Slope Solar Still, Solar Distillation, Water Purification, Thermal Performance, Renewable Energy.

Hybrid Solar Thermal and Organic Rankine Cycle Integration for Efficient Green Hydrogen Production

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ABSTRACT

This study explores the integration of a parabolic trough collector (PTC) with an Organic Rankine Cycle (ORC) using four refrigerants—Toluene, MDM, n-Pentane, and Cyclohexane—to generate electricity for powering a proton exchange membrane (PEM) electrolyzer, aimed at efficient green hydrogen production. The ORC performance was evaluated in terms of thermal and exergetic efficiency, electricity generation, and pump work, while the PEM electrolyzer's performance was analyzed based on hydrogen production rate and current density. Toluene emerged as the most efficient refrigerant, achieving the highest electricity generation (100 kW), thermal efficiency (0.33), exergetic efficiency (0.75), and hydrogen production rate (1.8 kg/h) at a turbine pressure ratio (PR) of 0.9. MDM demonstrated reliable and consistent performance with moderate electricity generation (70 kW), thermal efficiency (0.22), and hydrogen production (1.25 kg/h), alongside the lowest pump work (<1 kW). n-Pentane and Cyclohexane showed moderate performance, suitable for applications with less demanding efficiency requirements. The results underscore the potential of integrating solar thermal and ORC technologies for scalable and sustainable hydrogen production, with Toluene being the most effective refrigerant for optimizing overall system efficiency.

Key Words: Solar energy; organic Rankine cycle; Biomass; Green hydrogen; Economy and environment.

CFD-based analysis of coated solar PV panels for concentrated solar power applications in diverse Indian climates

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ABSTRACT

This study analyzes the performance of various solar photovoltaic (PV) panels for concentrated solar power applications using computational fluid dynamics (CFD) simulations. The simulations consider PV panels with various coatings, each having distinct radiation properties, to evaluate their impact on system performance parameters such as silicon layer temperature, solar panel efficiency, and power output. A parametric investigation was conducted to assess the effects of solar irradiation, wind velocity, and ambient temperature on system performance parameters. In addition, a multivariable regression model was developed in MATLAB, which can predict the system performance parameters based on a set of input conditions. Five locations across India - one each from the north, south, central, west, and east regions - were selected for detailed analysis. Historical weather data for these locations, including daily variations in irradiation, wind velocity, and ambient temperature, were collected for four representative months of the year. PV system performance predictions were generated for each location, and the results were thoroughly analyzed to assess regional variations in system performance. The effectiveness of the various coatings on solar PV performance at these locations was also studied in detail. Based on these findings, a comprehensive solar PV performance sheet was prepared, providing insights into the feasibility and efficiency of the proposed PV system installations across the selected locations.

Key Words: Numerical investigation; Radiatively enhanced coating; Photovoltaic panels; Concentrated solar power.

Green Hydrogen: The Future of Clean Transport in India

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ABSTRACT

Green hydrogen is becoming the most transformational energy solution for the future, providing a possible means to decarbonize India's transportation sector and wean off the dependency on fossil fuels. The paper is on the adoption and implementation of green hydrogen technologies in various transportation domains across India. Some of the prominent case studies include Indian Oil Corporation launching hydrogen fuel cell buses, Kerala having a strategic roadmap for deploying hydrogen-powered buses, and Indian Railways innovatively retrofitting diesel multiple units with hydrogen fuel cells. The Indian Army's collaboration with IOCL for hydrogen fuel cell technology also highlights the feasibility of sustainable mobility in challenging terrains and climatic conditions. India has also been a leader in this field, as it demonstrated green hydrogen mobility advancements to Bhutan, thereby showing commitment to regional collaboration in sustainable energy solutions. Despite such great progress, infrastructure development, production costs, and scalability remain the most critical barriers. Through a thorough literature review of the existing projects and proposals the paper intends to analyse the operational efficiency, performance reliability, and environmental impact to provide a framework for scaling green hydrogen initiatives. The adoption of green hydrogen is also an important milestone toward the decarbonization goals of India but quite importantly, it is a giant step ahead in making the country one of the world's leading destinations for innovation in green energy. For the benefit of policymakers and stakeholders in the industry and researchers, the findings are expected to bring actionable insights for shifting into a cleaner and more sustainable future of transportation.

Key Words: Green Hydrogen, Sustainable Transportation, Decarbonization, Hydrogen Fuel Cell, India

Solid Oxide Fuel Cell Combined with Gas Turbine for Tomorrow's Aviation

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ABSTRACT

In the pursuit of urgently needed sustainable aviation, alternative propulsion concepts based on electrical systems are becoming increasingly important. One option for delivering electrical energy to power such propulsion systems is through fuel cells. Fuel cells can convert the chemical energy provided by a fuel directly into electricity to a large extent, without requiring heat as an intermediate form of energy. Unlike traditional combustion engines, fuel cells are thus not limited by the Carnot efficiency. The remaining chemical energy is converted into heat due to irreversibilities during the electrochemical conversion. This heat is generated at a very high temperature level (1000 K) and can therefore be used in a Joule cycle, achieving high efficiencies. Fuel cells are categorized by their electrolytes and, from a thermodynamic perspective, can be classified as either low- or high-temperature fuel cells. The high-temperature solid oxide fuel cell (SOFC), in particular, shows promise for integration into aircraft engines, as its high exergetic waste heat remains within the system and is carried by excess air used to cool the SOFC. This excess heat can then be utilized in a downstream turbine. The SOFC-GT concept, therefore, combines the strengths of both systems: highly efficient generation of electrical power by the fuel cell and delivery of mechanical power by the gas turbine. Additionally, by using pure hydrogen as the chemical energy source, no carbon-containing emissions are produced, and the non-CO_2-related impact on the climate can be significantly reduced. This makes the SOFC-GT concept not only highly efficient but also exceptionally suitable for sustainable aviation.

Key Words: Solid Oxide Fuel Cell, SOFC-GT, Fuel Cells, Electrification in aviation

Centralized Energy Balance Controller with Mutual Coordination of Neighboring Prosumer Microgrids

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ABSTRACT

The Peer-to-Peer Prosumer Microgrid (P2P PMG) represents a novel strategy aimed at enabling energy prosumers to attain necessary energy while allowing the sale of surplus production. However, due to the intrinsically fluctuating nature of power generation, each prosumer must uphold a steady energy equilibrium through the energy exchange agreements made among the parties involved, as inconsistencies in energy allocation may lead to power losses and economic inefficiencies. To enhance stability, a collaborative framework that coordinates the efforts of two or more prosumers will provide more excellent reliability than isolated actions. Thus, this research presents an Energy Management System (EMS) that integrates two isolated Neighbourhood Prosumer Microgrids (NPMG), promoting a cooperative approach to attain energy equilibrium and optimize economic advantages. The proposed methodology features a Centralised Energy Balance Controller (CEBC) based on fuzzy logic to facilitate energy sharing among prosumers and collectively manage surplus resources. This is demonstrated in different case studies through MATLAB simulations.

Key Words: Energy Management System, Coordinated Energy Management System, Prosumer Microgrid, P2P Energy Exchange.

AI and ML based road detection for optimizing power source selection for a HEV

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ABSTRACT

Efficient power source management is the key to improving the performance and sustainability of hybrid electric vehicles (HEVs). This work introduces an AI-driven framework that uses machine learning (ML) to make dynamic choices between the power sources, namely the battery or internal combustion (IC) engine, based on road conditions. A Convolutional Neural Network (CNN) will process real-time visual data from vehicle-mounted cameras classifying surfaces such as asphalt, snow, and mud. Hardware implementation is done, integrating the CNN model with a Raspberry Pi, sensors, and an embedded control system to make real-time energy management possible. High classification accuracy and reduced emissions with better energy utilization paved the way for smarter hybrid vehicle technologies.

Key Words: IC engines, Motors, Hybrid vehicle, Regenerative braking, AI&ML techniques, Image processing.

AI-Based Regenerative Braking Assist for an EV

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ABSTRACT

Regenerative braking has emerged as an effective way for the automotive industry to improve fuel efficiency and reduce emissions. The system works by harnessing the energy generated while slowing down a vehicle and using it to recharge its batteries. To optimize regenerative braking efficiency, it is essential to consider both the speed management process and braking conditions. However, using high regenerative braking on surfaces with low coefficient of friction, such as ice, snow, and mud, could lead to accidents as vehicles become uncontrollable. To prevent accidents, it is crucial to identify the surface that the vehicle is travelling on to provide an advantage in terms of braking conditions. Moreover, rough terrains can cause the performance of Anti-lock Brake Systems (ABS) to deteriorate, making it challenging to control the steering and braking of the vehicle. Therefore, it is necessary to identify the surface type and adjust the braking strategy accordingly to prevent accidents. By carefully considering and monitoring road conditions, using regenerative braking systems in vehicles can significantly improve energy efficiency and reduce emissions while ensuring the vehicle's and its occupants' safety.

Key Words: Regenerative braking energy, Image processing, vehicle dynamics, road surface.

Design and development of regeneration energy management system for an EV

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ABSTRACT

The proposed work presents an investigation of advanced techniques for three major areas of electric vehicles, such as BMS, RE, and EM. Development of an algorithm for electric vehicles to calculate the tractive force and power required for vehicle motion. Then, implement the intelligent energy management algorithm that optimizes recuperation energy efficiently during braking and deceleration to enhance the vehicle's overall efficiency. Integration of the energy management system seamlessly into the existing vehicle algorithm to simulate control and performance monitoring. Validate and optimize the proposed energy management system through simulations to demonstrate its effectiveness in enhancing EV performance. As the methodology is further developed, it will be incorporated into the lab car.

Key Words: Energy Management system (EMS), Regenerative Braking (RE) and Batter Management System (BMS) Average Energy Consumption, Range, SIMULINK, Lab car.

Performance Analysis and Optimization of Lead-Free Flexible Perovskite Solar Cells

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ABSTRACT

Perovskite solar cells (PSCs) are third-generation solar cell technology that is highly sought after due to their high efficiencies, low cost, ease of manufacturing, and the possibility of fabrication on flexible substrates. However, the rapid advancement in perovskite solar cell efficiency encounters major challenges due to stability concerns and health risks from lead-based materials, strengthening need for alternate lead-free perovskite materials. In this research, we investigate the optimization of the power conversion efficiency (PCE) of a lead-free flexible perovskite solar cell (FPSC) using SCAPS-1D simulation software. The optimization focuses on various parameters for the absorber layer. The optimized performance parameters were obtained as follows: J_{sc} = 28.64 mA/cm2, V_{oc} = 1.22 V, FF = 89.61%, and PCE = 31.23%.

Key Words: SCAPS-1D, flexible, FPSCs, $MASnBr_3$, PCE

Biomass-based cathode materials for zinc-ion hybrid super capacitors

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ABSTRACT

Renewable energy sources like batteries and supercapacitors are being explored for powering high energy devices like smartwatches and electric cars. Still, commercial aqueous batteries are not widely adopted due to poor energy densities. Lithium-ion batteries are being modified for electrochemical storage, utilising abundant global biomass wastes to reduce energy loss compared to non-renewable sources. Banana peel biomass-derived carbon cathode materials perform brilliantly in zinc-ion hybrid supercapacitors, making them a promising material for future investigation. Our published research investigates the comparative performance of a zinc-ion hybrid supercapacitor based on the chemical treatment of biochar with phosphoric acid (H3PO4) activators. Energy storage performance is being studied using hybrid supercapacitors, which combine high power and energy electrodes. Zinc-based metal ion supercapacitors provide improved performance, safety, and environmental friendliness. Biomass-based cathode materials are being investigated to solve ecological problems. Biochar that experienced chemical activation treatment has significantly increased porosity, surface area, and surface functional group. The ZIHSC device, based on activated banana peels cathode material, achieves maximum energy density (120 Wh Kg-1 at 0.1 A g-1) and specific capacitance (228 F g-1) at 1 mV s−1 current density. Furthermore, our study advances our understanding of biochar-based cathodes by offering insight into how different activation procedures affect porosity and surface properties. Our published work emphasizes the usefulness of biomass-derived biochar as an energy storage material, particularly in ZIHSCs. The remarkable electrochemical performance highlights the importance of controlled chemical activation in increasing biochar properties for better supercapacitor applications.

Key Words: Banana Peels, Energy Storage, Hybrid Device/Super-capacitors

Secure Architecture for Blockchain-Based P2P Energy Trading in Clustered Microgrids

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ABSTRACT

The evolution of renewable energy-based energy systems has introduced decentralized models of power generation and consumption, requiring innovative solutions for their energy management. This paper presents a novel framework for secure and efficient peer-to-peer (P2P) energy trading within clustered energy systems. Emphasizing efficient segmentation of the landscape through thorough survey and distribution-focused clustering, classification into patron, beneficiary, and autonomous clusters improves cluster handling as well as the addition of new clusters. By leveraging blockchain technology and node clustering, the proposed system enhances energy distribution, ensures transaction security, and improves operational efficiency. Ease of implementation and access by consumers were key components taken into consideration while designing the system. Key components of the system include a client-server architecture, isolated private key handling, and clustering for dynamic load balancing.

Key Words: P2P Energy Trading, Energy Marketplace, Light Blockchain Technology, Clustering in Microgrids, Renewable Energy Management.

Phase Change Material for Managing Solar Intermittency in Solar-Powered Cold Storage

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ABSTRACT

Small-scale solar-powered cold storage systems provide sustainable, decentralized cooling, helping farmers preserve their produce. This benefits the farmers economically while also ensuring steady supply of fresh vegetables. However, a significant limitation of solar cold storage systems is their dependency on intermittent solar energy. This poses a challenge for cold storage systems which are required to operate continuously to maintain optimal storage temperatures. This study investigates the efficacy of incorporating phase change materials (PCMs), namely n-tetradecane, to sustain cooling during off-sunshine hours when the solar-powered refrigeration system is not active. Numerical simulations utilizing computational fluid dynamics (CFD) were employed to analyse the thermal distribution of produce filled crates and PCM in a 2 MT apple cold storage facility. Three operational scenarios were examined: (a) Conventional cold storage, (b) Solar cold storage without PCM, and (c) Solar cold storage with PCM. The simulation reveals that once the PCM solidifies and the refrigeration system was stopped and cooling fans were used solely to circulate air within the storage, the PCM system can maintain optimal conditions for approximately 50.63 hours, saving a total compressor energy of 40.92 MJ. These findings demonstrate that thermal energy storage with PCM is a viable solution to mitigate the challenges of solar intermittency, enhancing the reliability and sustainability of solar-powered cold storage systems.

Key Words: Cold storages, Computational Fluid Dynamics (CFD), Thermal energy storage, Phase change materials, Sustainable technologies.

A Comprehensive Review of Bio-Ethanol Production from the By-Products of Waste Biomass for Greener Technology

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ABSTRACT

The global demand for ethanol is continuously rising due to rapid industrialization and population growth. The sugarcane and maize as feedstocks are insufficient to meet the escalating need for bio-ethanol production. Agro-waste and other lignocellulosic materials have emerged as promising alternatives due to their abundance, cost-effectiveness, and renewability. This review explores the advanced technologies employed to convert agro waste biomasses into bio-ethanol, highlighting the advantages of utilizing these resources in sustainable energy production. However, handling and transportation of lignocellulosic feedstocks pose significant challenges, necessitating the development of effective pre-treatment techniques. Pre-treatment is a critical step for efficient delignification, which enhances enzymatic saccharification and increases the yield of fermentable sugars. Optimized pre treatment strategies can significantly boost the conversion of glucose and xylose into bio ethanol, thereby improving the overall cost-effectiveness and scalability of the process. Furthermore, this study examines the fermentation processes, properties, and potential applications of bio-ethanol derived from agro-waste by-products. The integration of advanced enzymatic technologies and innovative fermentation methods has paved the way for a more sustainable and efficient bio-ethanol production process. In conclusion, leveraging agro-waste as a primary feedstock for bio-ethanol production not only supports global energy demands but also reduces greenhouse gas emissions and minimise dependence on fossil fuels with sustainable development. Future research should focus on optimizing pre-treatment methods, improving fermentation efficiencies, a n d exploring diversified applications of bioethanol to maximize its potential as a renewable energy source.

Key words: Agro-waste; Pretreatment; Bio-ethanol; Lignocellulosic biomass; Waste-to-energy utilization

Automated Temperature Controlled Solar Pannel for Sustainable Power Output of SPV System

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ABSTRACT

This Maintaining the optimal temperature of solar panels is crucial for achieving maximum efficiency. This project introduces an innovative temperature control system that utilizes a small water tank attached to the back of a solar panel. By leveraging Peltier elements for heating and cooling, water is circulated through the tank to regulate the panel's temperature. The system is monitored and controlled using a DHT11 sensor to maintain the optimal temperature of 27°C, ensuring better efficiency and longevity of the panel. This approach enhances energy output by minimizing thermal losses, making solar panels more effective and sustainable.

Key Words: Peliter Element, Ambient Temperature, Module Temperature, Optimum Power Output

Enhancing Thermal Energy Storage: CFD Analysis of RT-35 PCM Melting Dynamics with Fe3O4 Nanocomposites

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ABSTRACT

This paper presents a Computational Fluid Dynamics (CFD) investigation into the melting behaviour of RT-35, a phase change material (PCM) for thermal energy storage, with a focus on enhancing the process using Fe3O4-PCM nanocomposites. Employing ANSYS Fluent software, a comprehensive simulation is conducted to model the melting dynamics within a rectangular PCM domain. The study observes the evolution of liquid fraction contours over a total simulation time of 5000 seconds, offering insights into the shape and progression of the melting interface with respect to time. By analysing these contours, the paper elucidates the intricate motion and deformation of the melting front throughout the process. Furthermore, the simulation is extended to investigate the influence of Fe3O4 Magnetic Nanoparticles on the melting behaviour of the PCM. The incorporation of Fe3O4 nanocomposite particles is found to enhance the melting process significantly. The paper discusses how the presence of these nanoparticles alters the thermal conductivity and latent heat characteristics of the PCM, consequently accelerating the melting rate and improving overall energy storage efficiency. This research provides valuable insights into the thermal behaviour of PCM melting processes and underscores the potential of nanocomposite materials in enhancing thermal energy storage systems. The findings contribute to the optimization of PCM-based energy storage technologies for diverse applications, including renewable energy integration and thermal management in various industries.

Key Words: Thermal Energy Storage, Phase Change Materials, Fe3O4 magnetic nanoparticles, Computational Fluid Dynamics, Melting, Liquid fraction.

Design and Analysis of Vertical Axis Wind Turbine for Power Generation

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ABSTRACT

In recent years, the depletion of traditional fuel sources for power generation has become a growing concern, making it imperative to explore sustainable and renewable energy alternatives. Renewable energy sources, such as wind, offer a promising solution to mitigate the depletion of conventional fuels while also addressing the environmental pollution caused by their use. One of the significant advantages of the Savonius-type wind turbine is its potential application in small-scale and decentralized power generation. Unlike large-scale wind farms, these turbines can be used in diverse locations, such as alongside highways, where they can be integrated into road infrastructure to power streetlights, signs, and other highway utilities. Additionally, they have the potential to function as portable power generation systems for residential use, providing a reliable energy source in remote or off-grid locations. This article highlights on the design and analysis of power generation using a Savonius-type wind turbine. Specifically, the study investigates a 3-blade, 4-blade and 5-blade configurations of the Savonius wind turbine, with simulations conducted using Ansys software to model its performance. It has been observed that the most efficient system of blades among the 3-blade, 4-blade and 5 blade turbine is a 3-blade turbine system which is cost effective and causes less turbulence than a 4 blade and 5-blade turbine system. The power generated by the 3-blade turbine is then calculated using MATLAB software, and the system is further validated through hardware implementation. The study depicts the versatility of Savonius turbines, demonstrating their ability to serve various energy needs while contributing to the global transition toward sustainable and clean energy solutions. The prototype turbine is made light enough so as to reduce the amount of inertial drag in the rotation of turbine. Through this research, the practical implementation of Savonius turbines offer new opportunities for enhancing energy accessibility and reduce dependence on conventional power sources.

Key Words: Wind Turbine, Ansys Simulation, Power Generation, Wobbling, MATLAB

A Novel Design of Hybrid Solar Wave Energy Converter for Sustainable Offshore Power Generation

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ABSTRACT

The present study addresses the development of a wave energy converter device integrated with solar photovoltaic panels to generate electricity from a single system. Over the last few decades, several research teams and coastal engineers have mainly focused on modeling, developing, and deploying various wave energy converter devices for harnessing ocean energy. However, both solar and wave energy come with their own deficiencies. Combining solar and wave energies is a promising approach towards sustainable energy generation by engaging two abundant natural resources while minimizing environmental impacts such as air or water pollution, including biodiversity support. To explore the maximum efficiency of the hybrid system, four solar photovoltaic panels are installed on the top of the device with suitable angle adjustment and solar tracking system, and the device is equipped with an oscillating water column wave (OWC) energy converter, which makes the device equally sophisticated and adaptable for installation in a different offshore location (see FIGURE 2 and FIGURE 3). A power control system is necessary to achieve a constant output from the hybrid system, stabilizing the voltage from each source before merging. Solar PV systems utilize an MPPT converter to adjust their output based on sunlight intensity. At the same time, the OWC device optimizes power generation depending on the inner chamber pressure and airflow through the turbine by holding the air column at specific points in the wave cycle using Latching control. Suitable battery storage is added to the system to store excess energy and balance the output of the hybrid solar-wave system as per user requirements. Depending on various wave conditions, the hydrodynamic performance and power output of the OWC device are studied here using a numerical approach. The energy generated by four 300-watt standard solar photovoltaic cells with 15% - 20% efficiency and assuming 5 hours of full sunlight daily, approximately 900 - 1200 kWh per annum. With 10 % - 15% efficiency, the OWC device can generate approximately 1200 -1500 kWh of energy per annum depending on various wave conditions, which makes the hybrid system adaptable for sustainable energy generation.

Key Words: Renewable energy integration, Wave energy converter, Wave energy, Solar energy, OWC system.

Innovations in Waste-To-Energy Technologies: Harnessing The Power of Waste for Sustainable Energy Solutions

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ABSTRACT

Red mud, an industrial waste is produced during bauxite refining via Bayer process. The basic constituents of red mud are Fe2O3, Al2O3, SiO2, Na2O etc. Red mud production is around 180MTPA and annual expected growth ~6%. The common red mud disposal is dumping it in tailing ponds which raises serious concern of adverse effect on soil/ground water due to its high pH value. Also, fugitive dust of red mud in air may cause permanent damage of human respiratory system. To alleviate these challenges, this is an effort to use large scale red mud to harness green energy through hydroelectric cell (HEC). HEC is fabricated using uniquely processed, oxygen deficient, nano porous red mud with two dissimilar electrodes attached. Working principle of HEC is based on spontaneous dissociation of H2O into OH− and H3O+ collected at anode (Zn)and an inert cathode (Ag). The process involves chemisorption and physisorption phenomenon for dissociation of water molecules which leads to the hopping of H+ ions into nano pores; thus, generating an electric potential. The electrode potential leads to the dissociation of physisorbed water molecules; thus, maintaining current in the cell. The HEC developed using red mud produced an output of 7 mA with maximum offload output power of 6.86 mW. An empirical model was used and it is ascertained that an estimated 0.33 million ton of industrial waste redmud may be utilized to generate 100 MW power. The generation of green energy using red mud HEC represents a significant advancement in sustainable energy technologies.

Key words: Hydroelectric cell, Nanoporous, Red mud, Non-photocatalytic activity, Green energy

Second Law Based Analysis of Heat Transfer Circuit for Transporting Solar Heat from the Collector to the Steam Generator of a Parabolic Trough Collector Based Solar Thermal Power Plant using Different Heat Transfer Fluids

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ABSTRACT

In this paper, an exergy analysis of the Parabolic Trough Collector of type LS-2 is carried out. Three different heat transfer fluids namely, Therminol VP-1, Dowtherm A and Solar Salt have been examined for the analysis. At first, a brief introduction on the importance of solar thermal power plants and details of various heat transfer fluids used, is presented. A theoretical model for exergy analysis of parabolic trough collector is presented, followed by evaluation of exergy gain, exergy destruction rate and exergy efficiency of the solar collector for three different heat transfer fluids using MATLAB. Solar Salt was found to give the best results for exergy gain and exergy efficiency and showed least exergy destruction rate, at a constant mass flow rate of 0.5 kg/s and varying fluid inlet temperature. It was observed that exergy destruction rates for all the three cases decreased with increase in temperature. Therminol VP-1 and Dowtherm A with similar thermophysical properties showed almost similar results in all the cases, which could suggest both of these heat transfer fluids to be equally suitable for this case.

Key Words: Solar Thermal Power Plants, Parabolic Trough Collector, Exergy, Heat Transfer Fluids, Exergy Gain, Exergy Efficiency, Exergy Destruction Rate.

Advancing Urban Transportation with Hydrogen-Compressed Natural Gas Blends: Environmental and Economic Insights

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ABSTRACT

Hydrogen-compressed natural gas (HCNG) blends offer a viable pathway to reduce greenhouse gas (GHG) emissions while optimizing the performance of internal combustion engines. By utilizing hydrogen's clean-burning properties, HCNG significantly reduces carbon dioxide (CO2) and carbon monoxide (CO) emissions, presenting a practical solution for greener transportation. This study focuses on retrofitting urban bus fleets to operate on HCNG, evaluating economic, technical, and environmental feasibility within the framework of existing infrastructure. Key technical considerations include engine modifications, fuel storage, and distribution systems. The analysis highlights the benefits of HCNG, such as reduced emissions and improved fuel efficiency, while addressing challenges like infrastructure adaptation and cost implications. The findings underscore the potential of HCNG as a transitional fuel, supporting the global shift toward sustainable urban mobility.

Key Words: HCNG, hydrogen, compressed natural gas, greenhouse gas emissions, sustainable transportation.

Thermal performance analysis of bio-based phase change material integrated cool roof composite for passive cooling in buildings

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ABSTRACT

Uncontrolled urbanization and population growth have resulted in urban heat island effect in metropolitan areas, necessitating innovative solutions for thermal comfort in buildings. Utilizing bio based PCM for thermal energy storage (TES) has been extensively studied from technical and scientific perspectives. The extensive literature review shows that only a limited experimental research has been carried out on using environmentally friendly PCM as an admixture in the building's roof. Therefore, it is felt essential to examine the unique features and applicability of the bio-based PCMs, to enhance energy efficiency and passive cooling potential without altering the strength of the buildings drastically. In the present study, Cetyl alcohol was successfully microencapsulated within melamine formaldehyde polymeric shell (MEPCM) and shape-stabilized using fly ash-based pebbles as the supporting matrix (SSPCM). The thermal performance of the as-prepared slabs made using these MEPCM, SSPCM, and control slab (the one without PCM) was carried out by the hot box method as per ASTM C 1363. Based on these investigations, MEPCM and SSPCM cool roof slabs were observed to be promising choices for building passive cooling applications.

Key Words: Roof cooling composite, Bio-based PCM, Microencapsulated PCM, Shape-stabilized PCM, Passive cooling of buildings.

Computational Approach to Dust Management In Solar Power Plant

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ABSTRACT

Dust accretion on solar modules which is oft-times considered as an understated issue significantly impacts (i) output efficiency of module (ii) anti-reflective coating due to recurrent cleaning sessions. Accordingly, the computational paradigm that can determine accurate cleaning time is requisite. In this paper, the elements affecting dust concentration on solar Photo Voltaic (PV) module surface are analysed and discussed. Based on the mathematical analysis, a method of calculating the dust mass of PV modules due to dust deposition on its surface is put forward. According to changes of daily dust concentration, weather and irradiance, the output power reduction of PV modules is calculated, which lays a foundation for the formulation of the cleaning strategy. The classification based predictive, scalable model is developed that not only forecast the performance ratio but contemplates dust deposition parameters to figure out accurate cleaning time. The real time data from ACME Solar power plant database of PAVAGADA AC-50MW and DC- 67.46MW with latitude-14.260099°N/longitude-77.471534°E of site are taken in account to create the prediction model.

Key Words: Solar power, Dust accumulation, Photo voltaic, Cleaning, Prediction Model

Experimental Analysis of Heat Transfer in Transitional Flow through Circular Channels

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ABSTRACT

An experimental research investigated the thermohydraulic performance of transitional flow water in a circular evenly heated channel with inlet obstruction at the entrance. Reynolds numbers ranged from 500 to 7000. The channel is evenly heated by 0.5 and 1 kWm-2. Variable parameters included three height (h) and width ratios (w). New Nusselt number and friction factor correlations are presented. For an evenly heated plain channel, the essential Reynolds number for transition start is 2525 and for transition termination is 3125 The flap restriction at the test section inlet was likewise observed to start and finish the laminar-turbulent transition early. At a heat flux of 0.5 kWm-2, the transition occurs at Re = 1696 and finishes at Re = 3125, while at 1 kWm-2, it begins at Re = 1659 and ends at Re = 3362. At 1 kWm-2 heat flow, a height ratio of 0.75 and width ratio of 0.25 had the largest Nusselt number increase.

Key Words: Heat transfer, fluid flow, transition flow, enhancement, heat exchanger

Numerical Simulation Analysis of Variable Air-Flow Rate for Enhanced Cooling in Triangular PV/T Array

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ABSTRACT

Photovoltaic Thermal (PV/T) system is used to generate electrical and thermal energy simultaneously. However, certain amount of the solar energy radiation is converted into electrical energy and remaining amount generate thermal energy in the form of heat. It increases the temperature of the PV cell which result in reduction of the efficiency of the PV cell. Therefore, a cooling system is required to extract the heat by means of forced airflow through an extraction system attached to the bottom of the PV panel. The aim of the present study is to analyses the effect of airflow rate variation on the cooling of the PV array. An array of seven photovoltaic panel with triangular heat extraction system has been considered for the simulation analysis with variable air flow rate from 1.5 m/s to 3.5 m/s. The simulation of PV panel has been performed in steady state thermal tool and fluid domain is resolved in CFX tool under ANSYS 18.2 as coupling method. The results are presented in form of the visualization of temperature distribution throughout the length of the array. The results revealed that increasing the air flow rate significantly enhanced the cooling of the PV array and reduces the temperature of the PV cell simultaneously.

Key Words: Fluid Solid Interaction (FSI) Model, ANSYS, PV/T Array, Numerical Simulation, Coupling Method, Heat Transfer

A Review of Domestic Solar Concentrators for Energy Generation in Central India Belt

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ABSTRACT

This paper reviews solar concentrators, emphasizing their potential in fulfilling domestic energy requirements in central India. It explores the principles, designs, materials, and fabrication processes of different concentrator technologies. The paper highlights the efficiency improvements of solar concentrators over traditional flat-panel systems by focusing sunlight onto smaller areas, which enhances energy density and power output. It also discusses the challenges related to cost, installation complexity, and maintenance, particularly in domestic uses in India. Various technological advancements in materials and tracking systems have made solar concentrators more viable for residential use, especially for heating, cooling, and electricity generation using Parabolic Dish, Parabolic Troughs, Fresnel Reflectors, and Solar Power Towers. Among the discussed technologies, parabolic dish reflectors are particularly promising for household applications due to their cost-effectiveness and moderate ease of installation. Future research directions are recommended, including design optimization and materials innovation, to enhance the feasibility and adoption of solar concentrators in domestic settings.

Key Words: Renewable Energy, Solar, Photovoltaic cells, Concentrated Solar Power, Domestic Energy Generation, Central India

Rheological Evaluation Of Castor Nano-Enhanced Bio-Lubricants

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ABSTRACT

The growing emphasis on sustainability has accelerated the demand for eco-efficient lubricants, fostering advancements in high-performance bio-lubricants for automotive and industrial applications. This study presents properties evaluation of such bio-lubricants obtained by adding nano additives to transesterified castor oil with Cerium Oxide(CCO) series in the given concentrations: 0.1%, 0.3%, 0.6%, 0.9%, and 1.2%. The experiments were performed using the standards outlined in ASTM D4172, considering TRIBO tester under an applied load of 10 N and a test duration of 1 hour at 40°C/100°C. From the rheological analysis, it also follows that the addition of nano-additives significantly increases the stability of viscosity when comparison with standard transmission lubricating oils. The tribological tests showed that the lubricant with 0.3% nano-additive had the lowest COF, 0.05; FT, 0.2 Nm; WSD, 0.35 mm compared with other nano-enhanced lubricants and base oil. Shear stress. CT_CCO6 at 100°C has stable viscosity from 12 to 16 mPa·s within a wide range of shear rates from 12.3 to 600 s^{-1}, while under similar conditions, the viscosity of base oil was in the range of 10–14 mPa·s These findings confirm that the 0.3% nano-additive bio-lubricant exudes better rheological and tribological characteristics, inviting wide applications in industries where consistent lubrication with improved wear protection under high-temperature and high-shear conditions are required. It is observed that the presence of nano-additives improves the shear-thinning characteristics and structural recoverability of the bio-lubricants, and hence, these sustainable bio-lubricants are being considered as potential candidates for conventional lubricants by coupling green benefits with high-performance features.

Key words: Bio-lubricant, Transesterification, Nano-additives, Rheology, Tribology, Cerium Oxide(CeO2)

Assessment of Dairy Scum Biodiesel Mixed with Oxygenated Additives as An Alternate Fuel in Diesel Engines at Enhanced Compression Ratio

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ABSTRACT

The excessively high consumption of fossil fuels due to rapid development of the transportation sector and faster industrialization have led to the threat of depletion of fossil fuel sources across the world in near future. The ever increasing demand in energy, scarcity of fossil fuels causing escalated fuel price and hazardous environmental degradation have intensified the search for an alternate resource of fossil fuels in order to sustain the economic development and industrial growth. The biofuel produced from waste dairy scum can be a solution to the rapid rate of depletion and hazardous emissions of the fossil fuels. This can reduce the heavy waste disposal cost and simultaneously cater the demand of fuel for the fast growing world. However, the biofuels exhibit poor engine characteristics from thermal performance and emission of nitrogen oxides point of view. The poor characteristics can be improved by addition of suitable additives and proper monitoring of combustion parameters. The present work aims to achieve improved performance and emission characteristics of an automotive engine working with dairy scum biodiesel by adding ethylence glycol diacetate as an oxygenated additive and varying the compression ratio. The oxygenated additive has been added 3% by volume with the dairy scum biodiesel containing 40% of scum oil methyl ester for use as fuel in a variable compression ratio diesel engine at compression ratios of 16, 17 and 18. By increasing compression ratio from 16 to 18, the BTE increases by 5.8% while the BSFC decreases by around 7.2%. From the standpoint of emission, the HC emissions reduce by 22% and CO emissions reduce by 23% while the NOx emissions increase marginally by 2.5% as CR increases from 16 to 18. However, the exhibited results indicate slightly lower brake thermal efficiency of 1% and increased brake specific fuel consumption of 2.8% for the additive doped biodiesel compared to pure diesel at nominal compression ratio. Corresponding to same combustion parameters, the hydrocarbon and carbon monoxide emissions were observed to be reduced by 26 and 22% respectively with 8.5% hike in nitrogen oxide emissions. Thus, the ethylene glycol diacetate can be suitably used for characteristic improvement of an automotive engine. Simultaneously, increased compression ratio can be adopted for compression ignition engines to achieve enhanced performance and emission characteristics. Hence, the petroleum diesel can be replaced by dairy scum biodiesel with suitable quantity of oxygenated additives at enhanced compression ratio of a variable compression ratio diesel engine.

Key words: Biodiesel; oxygenated additive; performance; emission; combustion.

Risk Mitigation in Deep Localization Strategy: A Structural Equation Modeling Analysis from the Indian Solar Sector Perspective

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ABSTRACT

Effective risk mitigation in supply chains(SC) relies on complex relationships between suppliers, manufacturers, and governance structures. The Indian Solar PV sector has been facing significant challenges, including major demand fulfillment through imports, lack of availability of raw materials, limited technological know-how, regulatory uncertainties, inadequate infrastructure, and inefficiencies in collaboration between supplier and manufacturer. The government of India's effort to promote localization has observable gaps that hinder the success of developing a self-reliant solar PV ecosystem. These challenges undermine the resilience, agility, and sustainability of the SC, highlighting the need for a deeper localization strategy. The deep localization strategy/program fosters a strong collaboration and helps to overcome these challenges. The research investigates how collaboration between suppliers and manufacturers, coupled with deep localization (i.e., positioning suppliers and manufacturers in close proximity and their transactions and relationships) enhances supply chain performance and resilience. A questionnaire survey was conducted to collect the responses and the proposed hypothesized framework is validated using structural equation modeling (SEM). This research contributes to advancing theoretical and practical understanding of the Indian Solar PV supply chain by offering a validated model for improving resilience and attaining sustainability in dynamic market environments.

Key Words: Solar PV supply chain, Risk Management, Structural Equation Modelling, Sustainability, Deep Localization.

Government Initiatives for Renewable Energy to Combat Climate Change and to Promote SDGs in India

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ABSTRACT

The rapid economic growth in India has increased the massive energy demand making the country third largest energy consumer and carbon emitter globally. As a country preparing for five-trillion dollar economy, the greatest challenge is the sustainable access to clean electricity to its population by 2030. This study has been carried out to investigate the energy scenario and the key initiatives by the government for promoting Renewable Energy (RE) and the measures to combat the climate change and its impact in the country. The study also explores the efforts and activities of the Indian government for the achievement of SDGs focusing on Goal 7 and Goal 13. For energy security and environmental sustainability, the government plans to increase the share of RE and committed achieving the carbon neutrality through a multiple intervention. India aims to install 337 GW of RE capacity by 2027, and 500 GW of installed power capacity from non-fossil fuel sources by 2030 whereas current capacity is 200 GW. The country has updated its Nationally Determined Contributions (NDCs) to meet its target of Net Zero emissions by 2070. India is now actively developing long-term strategies for both mitigating and adapting to climate change. It has actively involved in international climate negotiations by multilateral and bilateral communication. India still needs to improve the overall performance for achieving SDGs as the global rank is 109 out of 167 countries in overall performance with the score 64.0 which less than regional average of 66.5. Regarding the Goal 7 it is moderately improving with significant challenges while for Goal 13 (Climate Action), challenges remains and still in declining status, however, SDG India Index prepared by NITI Aayog reported highest increase in score for Goal 13 between 2020-21 and 2023-24. For monitoring and tracking the progress of SDG implementation in the country, NITI Aayog conceived the SDG India Index in 2018. As per the report, the composite score for national level for whole country improved from 66 in 2020-21 to 71 in 2023-24. Many efforts are underway as there are dozens of programs to achieve the SDGs. A balance of energy policy, financial resources, and investments is needed to address both development needs and climate change challenges. Central government can focus for policies enhancement and the state and union territories along with the local government can play significant role for the implementation.

Key words: Energy security, SDG 7, SDG 13, Sustainable, Policy.

Track:

Eco-centric design Innovations

2d Materials-Based Multiparameter Sensors for Greener Technologies

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ABSTRACT

Advancing energy management and environmental monitoring necessitates innovative multiparameter sensors. This study highlights the potential of a single graphene-based device to simultaneously detect two analytes, and, in real time. The device tracks shifts in resonance frequencies of two distinct vibrational modes with contrasting mode shapes, enabling independent estimation of both analyte concentrations. The proposed method demonstrates high accuracy, with percentage errors in the estimation of and consistently remaining within 5%. This simultaneous dual-analyte detection capability significantly improves sensing efficiency, reducing the need for multiple devices and streamlining monitoring processes. The approach highlights the exceptional sensitivity, robustness, and versatility of 2D materials like graphene. These findings open pathways to designing compact, cost-effective sensors that can address complex challenges in energy systems and environmental protection. The integration of graphene into sensing technology underscores its potential to revolutionize multiparameter monitoring applications.

Key Words: 2D Materials, Graphene, Nanoelectromechanical Systems (NEMS).

Greening Minds for A Greener Future: Harnessing Eco-Technological Advertising Through Emotions

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ABSTRACT

Combining science-driven innovations with emotional power and shared environmental values educates and inspires change for a greener future. The integrated technologies will be essential in balancing development demands and preserving our planet's resources. "Greening Minds for a Greener Future" emphasises the role of technology in creating environmentally responsible solutions and merging it with rational and emotional appeals to engage diverse audiences, driving the adoption of eco-friendly innovations. From advertising, an emotional aspect helps to bridge the gap between rational knowledge and the behavioural changes required for long-term sustainability. The advertisers use an innovative storytelling tool to inspire individuals to adopt green technologies and internalise their role in shaping a sustainable world. The approach taps into a potential for a growing desire to reshape industries and transform societal attitudes. The study shows a paradigm shift regarding emotional engagement at the forefront of green innovative campaigns and positioning with different technologies as a symbol of hope and progress. The research will employ a literature review to assess and provide actionable insights for marketers, environmental advocates, and policymakers seeking to promote greener futures by examining consumer behavior and emotional engagement.

Key Words: Sustainable future, Eco-Technology, Green Innovation, Emotions.

Controlled Microwave Curing of Waste Diaper and Flyash-Based Polycrete Composite

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ABSTRACT

Microwave energy (2.45 GHz) was used to accelerate the curing in a three-step controlled manner for the polycrete fabricated using fly ash and a binder made with Super Absorbent Polymer (SAP) present in waste diapers, cast into 5 cm × 5 cm × 5 cm blocks. Firstly, the blocks were heated to a temperature of 80°C along with the mold (initial heating phase). During the second cycle, the blocks were cured with the mold; in the third cycle, the blocks were cured without the mold. A temperature range of 80–100°C was maintained in both the second and third cycles. Microwave curing decreased the curing time by 400% and reduced the water absorption while increasing the density of the cast specimens. Fast curing also increased the compressive strength up to 10 MPa, making the product suitable for non-load-bearing applications. The effect of microwave curing was observed on four different compositions by varying the binder concentration (6N, 8N, 10N, and 12N). Compositions with a 12N binder concentration showed higher compressive strength, dry weight, and wet weight density results. After compression strength testing, FESEM and EDS analysis performed on each specimen revealed the intricate cross-bond microstructure of SAP and fly ash. The SAP expands upon absorbing the alkaline binder solution, embedding the fly ash particles within its gel network and promoting hydration reactions. This results in the formation of calcium silicate hydrate (C-S-H) and aluminosilicate gels, which enhance the bonding between SAP and fly ash particles, contributing to a denser and stronger microstructure, as confirmed by XRD results. The microwave curing of the specimens was also simulated using COMSOL Multiphysics software to analyze the microwave heating phenomenon in polycrete. The simulation revealed the heating patterns of the polycrete blocks, which aligned well with the experimental results.

Key Words: Microwave curing, Super absorbent Polymer (SAP), Mechanical properties, characterization

Optimizing Bio-inspired Conical Geometries for Efficient Fog Water Collection Across Varied Wettabilities

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ABSTRACT

Collecting water from ambient fog has emerged as a viable and sustainable source of clean, drinkable water, particularly in humid and arid environments. Various living organisms have evolved passive microstructures on their surfaces that facilitate the nucleation, gathering, and transport of fog droplets from the surrounding air. Although conical geometry is optimal for collecting water from atmospheric fog and condensation, a reliable framework is necessary to evaluate and quantify the water collection efficiency (WCE), η_{wc} of conical shapes with varying wettabilities. This study assesses the WCE of bio-inspired conical structures with tip angles (2α) ranging from 5° to 45°, featuring four distinct wettabilities—hydrophilic (HPL), mildly hydrophobic (MHPB), highly hydrophobic (HHPB), and superhydrophobic (SHPB). The concept of onset time is utilized to thoroughly investigate the mechanism of fog condensation and water collection across different scenarios. It has been established that smaller cone angles, such as 5° and 10° demonstrate greater η_{wc} (%) due to stronger Laplace pressure force, compared to those with larger angles, for a particular wettability. The purpose of the study is to improve the condensation and transport rates to optimize the passive fog water collection system. It has been found that the superhydrophobic surface exhibits a shorter onset time. Collecting water from fog with a single conical surface may yield a small amount of water. Nonetheless, the present research establishes a foundation for developing an effective fog collector utilizing arrays of conical structures.

Key Words: Fog harvesting, Conical geometry, Laplace pressure force, Wettability, Water collection efficiency, onset time of water collection.

An Eco-Luxury on Wheels: A Supercar Redefining Clean Energy

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ABSTRACT

Electric vehicles (EVs) help protect the environment by reducing air and noise pollution. They offer lower running costs since there is no need for petrol or diesel, resulting in significant fuel savings. EVs also have lower maintenance costs, tax and financial benefits, enhanced performance, zero tailpipe emissions, and are easy to drive and quiet. Additionally, they provide the convenience of home charging, with no fuel required and no emissions produced. We are developing an electric car model in our workshop, styled as a Lamborghini replica. This is the first electric supercar of its kind that also incorporates a solar panel system, allowing it to recharge using sunlight. The solar panels are integrated into the car's design, with parts of the panel fitted on the bonnet and roof of the car. This innovative and indigenous setup allows the car to operate on both electric and solar power, ensuring it is free from air pollution. This super car combines luxury with eco-friendliness, being one of the best electric models available. Electric cars provide numerous advantages over internal combustion engine (ICE) vehicles, including a significant reduction in local air pollution. Since they produce no exhaust emissions, they avoid releasing harmful pollutants such as volatile organic compounds, hydrocarbons, carbon monoxide, ozone, lead, and nitrogen oxides.

Key words: Electric Vehicle, Solar Cell, Green & Clean Energy

Molecular Dynamics Study for the Adhesion Property of a Metallic Surface with Polymer Coating

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ABSTRACT

Polymers have become an integral part of our daily lives, contributing significantly to product quality through their use in composites and coatings. One noteworthy application is their potential to enhance the corrosion resistance of metal surfaces. However, not all polymers are effective in such applications due to challenges in achieving strong adhesion between polymers and metal substrates. This study evaluates the effectiveness of polymer coatings by analysing their interaction properties with metallic surfaces. Specifically, molecular dynamics (MD) simulations were employed to investigate the adhesion behavior of polymer coatings on ferrous oxide substrates. The study further examines the influence of temperature variations, ranging from 248 K to 373 K, on the polymer coatings' structural integrity and adhesion performance. Interaction energy at the polymer substrate interface was calculated to predict the coating's behavior under the given temperature conditions. These insights provide a deeper understanding of polymer-metal interactions and aid in the design of advanced polymer coatings for improved corrosion resistance.

Key Words: Molecular Dynamics Simulation, Adhesion, Polymer Coatings, Metal Protection.

Development of an Opto-µ-Fluidic Sensor for Pesticide Residue: Sustainable and Eco-centric Innovation

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ABSTRACT

Screening of Pesticide residues in fruits and vegetables is a crucial step to prevent non-intentional pesticide poisoning. However, rapid, point of care detection in resource limited settings of pesticide residues remains a challenge. Here, we developed a 3D printed colorimetric device for detection of Organophosphorus pesticide residues. The 3D printed Device employs biodegradable materials like Polydimethylsiloxane (PDMS) for microfluidic chip and polylactic acid (PLA) for device fabrication. Using passive mixing elements such as Split and Recombine and Spiral micromixers enhanced mixing with low sample volume was achieved. The device also houses an integrated transimpedance amplifier and a signal conditioning circuit. Validation of the device was done using dimethoate pesticide with Limit of Detection (LoD) of 0.63 mg/L. Thus, the developed device could be used for detection of organophosphorus pesticide residues for food safety applications.

Key Words: microfluidics, pesticide detection, colorimetry

Investigation of Rotary Kiln Tyres Using Numerical and Simulation Techniques

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ABSTRACT

This paper focuses on the study of Rotary kiln tyres, which is a critical component of the Rotary Kiln used for the process industry. Rotary kiln size varies from 3.4 m to 6 m in diameter with length varying from 40 to 85 m. The rotary kiln is supported by tyres or riding rings and total number of supports or riding rings depends on length of rotary kiln. Kiln tyres or riding rings rest directly on two support rollers with shafts mounted at a 30-degree angle. Turning loads, including mechanical component weights and material weight, get transferred to kiln tyres, which directly support the rotary kiln. Inside the kiln, the temperature varies from 800 degrees. To 1400 deg. However, due to the refractory lining of insulating bricks and material coating, outside kiln shell temperature varies from 200 to 450 deg. Computational analysis of rotary kiln tyres is carried out in this study using finite element techniques as well as numerical techniques. When tyre is rotating, forces from mechanical and thermal loads are transferred from tyres to support rollers and then to foundations. The investigation includes the study of stresses developed in kiln tyres, contact stresses or Hertzian stresses developed when kiln tyres are in contact with supporting rollers & thermal stresses in kiln tyres. A comparative study is done between Hertzian pressure calculated through the numerical method with results of simulation carried out using Finite element analysis software ANSYS. The investigation also includes an analytical study of reaction forces on tyre, tyre bending stress, circumferential stress distribution, and thermal stress in tyres which develop when loads are transferred from kiln shell to tyres. Due to changes in loads and operational parameters, changes occur in kiln tyres with due course of time. These changes are again analyzed which would help industry experts to make necessary corrections/replacements in existing kiln components before catastrophic failure takes place.

Key Words: Hertzian stress or contact stress, tyre bending stress, Hertzian pressure, circumferential stress distribution, thermal stress.

An Integrated Approach to Product Design: Bridging Lean, Sustainable, and Smart Manufacturing

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ABSTRACT

Product design decisions have a profound and lasting impact on the product life cycle, influencing production cost, quality, and performance. It is significantly more efficient to optimize designs upfront than to implement costly fixes during manufacturing. Inefficient design practices often lead to increased scrap and rework, resulting in a decline in organizational profitability. A common issue arises from the separation of design and manufacturing processes, both physically and intellectually, which limits opportunities for synergy. Integrating design with manufacturing processes can enhance efficiency by minimizing resource consumption and waste. However, the coexistence of diverse manufacturing paradigms—such as lean manufacturing, sustainable manufacturing, and smart manufacturing—poses challenges for designers to harmonize these approaches effectively, given their isolated development. This paper explores a unified framework for integrating these paradigms into product design, aiming to address these challenges and improve overall manufacturing efficiency.

Key Words: Integrated design, Lean design, Eco-design, Smart design

Site Selection for EV Charging Stations: Integrating MCDM and Machine Learning Approach

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ABSTRACT

The swift proliferation of Electric Vehicles (EVs) has underscored the pressing necessity for a resilient charging infrastructure. This research presents a comprehensive data-informed framework aimed at identifying appropriate zones for the establishment of EV charging stations. By integrating machine learning models alongside Multi-Criteria Decision-Making (MCDM) methodologies such as the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), the study systematically examines demographic, geographic, and infrastructural characteristics to forecast demand and prioritize potential sites. The dataset encompasses variables including population density, availability of infrastructure, and socio-economic indicators. Linear Regression emerged as the most effective model, attaining a Mean Squared Error (MSE) of 28.83 and a Root Mean Squared Error (RMSE) of 5.37. The framework identified Pin Code 400068 as the most viable zone, securing a TOPSIS score of 0.646994. By addressing infrastructural deficiencies, the study offers pragmatic insights for policymakers and urban planners. The findings make a substantial contribution to the advancement of sustainable urban mobility and the preservation of environmental integrity.

Key Words: Electric Vehicles (EVs), EV Charging Station Location, Machine Learning Models, Multi-Criteria Decision-Making (MCDM), Site Selection.

Track:

Sustainable Manufacturing Practices

Shock Wave Governed High Velocity Forming of Thin Sheet Metals-A Review

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ABSTRACT

Tailor-welded blanks (TWB) have numerous benefits over conventional blanks for manufacturing automobile sheet metal components, including more product design freedom, improved structural rigidity, and improved crash behavior. Tailor-welded blanks (TWB) usage also decreases manufacturing costs, vehicle weight (making them more environmentally friendly), and removes post-forming welding activities. However, one of the biggest issues with TWBs is their low formability in conventional sheet metal forming techniques. Shock tube forming, which uses shockwaves to deform a blank, is one of the possible means for improving TWB's formability. A pneumatically operated device is a shock tube, in which high-pressure driver segment and a low-pressure driven section are divided by a plastic or metallic diaphragm. The diaphragm ruptures when the pressure differential reaches a certain level, and a shockwave is produced when gas is released suddenly. The sheet at the end of the tube gets struck by the high-velocity shockwave as it travels down it. Most of the work on analyzing the formability aspects of monolithic sheets under biaxial tension has been performed using a shock tube forming process. However, literature on the formability prediction of TWBs using the shock tube forming process is scarce. The current review paper presents the high strain rate forming aspects of unwelded blanks for defense applications and also the formability of welded blanks using the shock wave forming process. Also, the potential advantages and future scope of using shock wave forming have been outlined.

Key Words: Tailor Welded Blanks, Shock Wave Forming, Welding Process, Conventional Forming, Finite Element Analysis.

Kerf Taper Minimization in AJM: A Novel Approach with Local Seashore Sand

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ABSTRACT

Abrasive Jet Machining (AJM) is crucial for precision machining of hard materials, but controlling kerf taper, a significant deviation in machined profiles, remains challenging. Traditional optimizations of air pressure, nozzle diameter, stand-off distance (SoD), and abrasive flow rate (AFR) yield limited improvements. This study introduces a novel method to minimize kerf taper by dynamically reducing SoD during machining and optimizing impingement time. Additionally, the use of locally sourced seashore sand from Goa as a sustainable abrasive offers a cost-effective alternative to conventional materials.

The experiments followed Taguchi's L27 orthogonal array to evaluate the effects of air pressure (5.515, 6.5, and 8 bar), nozzle diameter (2, 2.5, and 3 mm), SoD (2, 3, and 4 mm), and AFR (46.8, 283.8, and 470 g/min) on kerf taper and material removal rate (MRR). A second phase incorporated a dynamic SoD reduction strategy, dividing impingement time into segments (540, 600, and 660 seconds), enhancing jet focus and stability for improved precision. This innovative approach reduced kerf taper significantly from 33.4° to 8.25° while maintaining MRR performance comparable to conventional abrasives. Goa's seashore sand proved effective and sustainable, with SoD and nozzle diameter identified as the most critical parameters for achieving taper control.

This study highlights the potential of dynamic SoD adjustments and optimized impingement time in improving kerf taper control for AJM. It offers a scalable and environmentally friendly solution for high-precision machining, particularly for industries seeking cost-effective manufacturing techniques. Future research can explore broader material and geometry applications using this methodology.

Key words: Abrasive Jet Machining, Kerf Taper, Stand-off Distance, Impingement Time Optimization, Taguchi Method, Seashore Sand, Material Removal Rate.

Casting Quality Improvement using AutoCAST Simulation

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ABSTRACT

Quality is the important aspect of a foundry to manufacture acceptable casting in a cost effective manner. Improving quality offers many financial benefits to the foundry. For the high quality, necessity of process control has been discussed in this work. By using casting simulation, an optimum gating system can be designed to improve the quality of the casting. This paper presents work on analysis of a real world industrial casting for quality improvement and defect elimination. A commercially available software AutoCast has been employed for this purpose. Simulation technique has been used to predict the shrinkage porosity defects in the casting and its effects on casting quality and rejection. The modifications suggested in this paper resulted in 4.50% decrement in rejection at overall foundry level. Considerable improvement in quality has been realized.

Key Words: Computer simulation, Gating design, Defect elimination, Quality.

Simulation of Carbon Emissions Dynamics in the Machining Process Using Hybrid Petri Nets and Dynamic Parameter Variations

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ABSTRACT

The carbon emissions in the machining process are an important concern for environmental sustainability. This research helps present a novel simulation approach that utilizes Hybrid Petri Nets (HPNs) to model and analyze the dynamics of carbon emissions in machine tools. The dynamic parameter variations such as cutting speed, feed rate, depth of cut, and flowmeter rate are being integrated into the Petri Net model to observe the impact on carbon emissions over time. This model helps employ the random variations in the machining parameters to simulate the realistic operational conditions and then uses a simple emission calculation formula to quantify the emissions. The simulation results reveal how the different parameter combinations influence the emission levels. This provides valuable insights into the machining process's efficiency and environmental impact. This offers a dynamic perspective on carbon emission management and helps contribute to the development of more sustainable machining practices. These findings show the importance of parameter optimization in the reduction of carbon emissions.

Key Words: Hybrid Petri Nets, Carbon emissions, Machine tools

Wavelet Transform-Enhanced CNN Architecture for Energy-Efficient Bearing Fault Diagnosis: A Sustainable Approach to Industrial Maintenance

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ABSTRACT

With the increasing emphasis on sustainable manufacturing, energy-efficient fault diagnosis systems have become crucial for industrial maintenance. This paper presents an innovative approach combining Wavelet Transform (WT) and Convolutional Neural Network (CNN) for bearing fault diagnosis, offering both high accuracy and reduced computational overhead. The proposed methodology employs discrete wavelet transform to decompose vibration signals into multiple sub-bands, effectively capturing both time and frequency domain characteristics of bearing faults. The designed CNN architecture consists of three convolutional layers with ReLU activation, followed by max-pooling layers and two fully connected layers, optimized for efficient feature learning while maintaining minimal energy consumption. The model's effectiveness was validated using experimental dataset containing various bearing fault conditions including inner race, outer race, and rolling element defects under different load conditions. Results demonstrate a classification accuracy of [98%], with a significant reduction in computational complexity compared to traditional deep learning approaches. This research contributes to sustainable manufacturing by providing a framework for energy-efficient fault diagnosis that balances diagnostic accuracy with computational resource utilization, ultimately reducing the carbon footprint of industrial maintenance operations.

Key Words: Convolutional Neural Network, Wavelet Transform, Fault Diagnosis, Rolling Element Bearing, Industrial Maintenance.

Behaviour of Additively Manufactured Stainless Steels to Cavitation and Slurry Erosion: A Review

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ABSTRACT

Additive manufacturing is one of the latest techniques of manufacturing that is getting more and more popular these days. There are various classifications of this manufacturing process like Solid based Additive manufacturing, Liquid based Additive manufacturing and powder-based techniques also known as a PBF and so on. All sorts of material whether ceramics, metals or plastics, are being manufactured using Additive manufacturing these days, because Additive manufacturing techniques have certain advantages such as good mechanical properties of material made, low material wastage, tooling free process, more control over the procedure, ease of making complicated shapes, flexibility and adaptability in design, possibility of using complex materials and so on. Like every other process there are some drawbacks of Additive manufacturing as well like, presence of porosity in made parts, limitation of size, high cost of equipment, lower production rates, need of post processing in certain materials, requirement of skilled labor and so on. With all these factors in view, a lot of research is being seen in the field and scientists are working to make the process more industry friendly. Present work is an effort to explore yet another aspect of Additively manufactured stainless steels. Here we try to analyse their behaviour when subjected to Cavitation and slurry erosion. Why and how these materials lead to failure under such conditions? and whether their performance is any better than or even comparable to their conventionally manufactured counterparts? Are some questions that we try to explore in this work with the help of previously written articles.

Key Words: Additive manufacturing, Cavitation Erosion, Slurry Erosion, Stainless Steel

Lean Six Sigma and Industry 4.0 Integration for Sustainable Manufacturing: Ranking Enablers and Barriers Using Best Worst Method

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ABSTRACT

The integration of Lean Six Sigma tools with advanced technologies from Industry 4.0 can support the achievement of sustainable manufacturing goal by utilizing waste reduction principles and optimized decision-making. In this study, we identified the key enablers and barriers of implementation of integrated Lean-Six Sigma and Industry 4.0 and ranked them using Best Worst method. The barriers and enablers identified using systematic literature review and ranked with the support of experts using the Best Worst Method. The findings of this study highlight that leadership commitment, organizational culture, technological readiness and skilled workforce for the successful integration. Cost implications and resistance to change will be the major challenges that industries need to be addressed for the effective outcome. This study supports the industries to prepare their adoption of Industry 4.0 technologies along with Lean Six Sigma methodologies for meeting the sustainable manufacturing requirements in most efficient way.

Key Words: Lean Six Sigma, Industry 4.0, Sustainable Manufacturing, Best Worst Method

Optimizing Battery Pack Joining for Electric Vehicles: Challenges and Ml-Driven Solutions

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ABSTRACT

Electrification of vehicles is the latest significant trend in the automotive industry, driven by the need to reduce vehicle emissions while increasing efficiency, reducing running costs. This is achieved either by integrating electric power with the combustion engine in hybrid vehicles or by relying solely on battery power. Both methods use large battery packs which are made by joining multiple cells together in series/parallel configurations as per the vehicle's requirements. The assemblies are made by welding cells to bus bars, which link the power distribution points in a battery pack. Apart from being strong and resistant to wear, the welded joint should also have desirable electric properties to maximize energy efficiency. The welded joints' properties are influenced by multiple parameters such as the weld speed, power input, pressure, etc. Research on the numerical relationship between these parameters is limited, relying mostly on experimental data to get an approximate value of ideal parameters. To address this limitation, supervised learning-based predictive analysis can be a promising approach. Advanced methods like convolutional neural networks and ensemble learning can predict the effects of parameters on joint performance. These results can be validated by assessing metrics like Mean Absolute Error, Root Mean Square Error and R2 score upon comparison with experimental data. However, the limited training data is not enough to meet standards of production lines with strict quality standards. To mitigate this issue, alternate approaches like two branch network architectures can be employed. Such approaches not only compensate for limited training data, but also aid in accurately identifying the optimal operating parameters for the welding process.

Key Words: Electric Vehicles, Battery Manufacturing, Battery Joints, Parameter Optimization, Machine Learning

Multi-Physics Simulation and Experimental Investigation of Nickel Powder-Based Microwave Cast

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ABSTRACT

This paper presents an experimental and simulation-based study on the in-situ cast of nickel powder (135 × 30 × 2 mm³) in a domestic microwave oven. COMSOL Multi-physics tool-based numerical simulations are carried out to visualize the microwave heating effects during the ongoing casting and heating process. Based on simulation results, the optimal location of the casting setup is determined within the applicator cavity. The exposure time to microwave cast the nickel specimen is predicted as 2280 s through simulation. As per simulation results, maximum electric field strength (4.46 × 104 (V/m)) and resistive heating losses (4.9×109 W/m3) are observed around the mold cavity in the susceptor domain. Heat transfer through conduction is found to be most pronounced at the bottom of the mold cavity. The experimental exposure time is subsequently optimized to 1980 s, closely matching the predicted value. The microwave-cast specimen is characterized through microstructural analysis, phase formation studies, and microhardness indentation testing. Furthermore, the Specific Damping Capacity (SDC) and structural loss coefficient of the cast specimen are also determined experimentally using a logarithmic decrement approach.

Key Words: Microwave casting, Nickel, COMSOL Multi-physics, Specific Damping Capacity (SDC).

Investigation of MHD Convection in the ECDM Process for Microchannel Fabrication

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ABSTRACT

Microchannels are needed in the space, medical, and electronic packaging industries. Microchannel fabrication is mainly carried out on glass and PFMA materials. Most of the work on conventional ECDM has already been done by researchers who elaborate on the effect of controllable parameters on the material removal rate and width overcut. Control of the hydrodynamic regime is important for deep microchannel fabrication. The hydrodynamic regime controls the gas film characteristics and bubble formation phenomena, which is important for deep microchannel fabrication. Gas film thickness and discharge frequency are important parameters that the various voltage, concentration, and duty cycles cannot control. This paper applies MHD convection to regulate the gas film characteristics and bubble formation phenomena. Experiments were conducted on the fabricated setup of the MAECDM process. Permanent magnets were attached to the conventional ECDM process to induce the MHD convection INECDM process. MHD convection is caused by the association of a magnetic field with an electric field. The results show improvements in MRR and WOC when MHD convection is applied in the ECDM process. Metaheuristic algorithms were implemented to find the optimal set of input parameters. Results obtained by various metaheuristic algorithms were also compared.

Key words: ECDM, MHD, Optimization, Lorentz, WOC, MRR

Effect of Montmorillonite Nano-Clay on the Mechanical and Thermal Properties of PLA-Based 3D-Printed Honeycomb Structures

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ABSTRACT

Additive manufacturing, commonly known as 3D printing technology, has revolutionized the creation of complex architectures, including bioinspired structures. These structures are often topologically optimized, balancing lightweight design, high strength, and toughness properties characteristic of many biological materials. The 3D manufacture of complex multifunctional material systems with adjustable optical, chemical, and mechanical characteristics is made possible by 3D photo polymerization-based techniques. The present work explores the effects of montmorillonite nano-clay (MMT) reinforcement on Polylactic acid's mechanical and thermal properties, commonly known as PLA-based 3D-printed honeycomb structures with varying concentrations of MMT. Including M1 (pure PLA resin), M2 (PLA resin with 1% MMT), M3 (PLA resin with 3% MMT), and M4 (PLA resin with 5 % MMT). Dispersion techniques using magnetic stirring were used to disperse nanoparticles. A Prusa SL1S stereo lithography apparatus (SLA) was used to print honeycomb panels. Printed specimens were subjected to tensile, bending, and compression tests. Scanning electron microscopy, energy dispersive spectroscopy, X-ray diffraction, thermal gravimetric analysis, and Fourier transform infrared spectroscopy were used for the characterization study. A correlation was developed between these performance parameters and the weight percentage of the nanoparticles. The SEM and EDX analysis revealed remarkable properties, such as a surface structure devoid of fractures, pores, and cavities and substantial carbon stretching in almost all samples obtained by FTIR. TGA results showed that under heating conditions, how samples had essentially the same characteristics and showed essential signs of crystallization in XRD analysis.

Key Words: 3D SLA printing; Nanocomposite; TGA; XRD; FE-SEM

Comparative Life Cycle Assessment in Drilling of Inconel 718 Superalloy Under Dry & Cryogenic Conditions

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ABSTRACT

This study conducts a comparative Life Cycle Assessment (LCA) of drilling operations on IN-718, a high-performance super-alloy, under dry and cryogenic-assisted conditions. The assessment utilizes OpenLCA 2.2.0 software and embraces a cradle-to-gate approach, covering stages from raw material extraction to manufacturing. Drilling experiments employed a 6mm TiAlN-coated carbide twist drill bit, with cryogenic cooling expedited by liquid nitrogen (LN2). The environmental sustainability of the machining processes was assessed using the ReCiPe 2016 v1.03 Midpoint (H) methodology. Key LCA phases, including goal and scope definition, Life-Cycle Inventory (LCI), Life-Cycle Impact Assessment (LCIA), and Life-Cycle Interpretation (LCIn), were thoroughly scrutinized. Tool life is extended by 87.5% for drilling of IN-718 under cryogenic environment when compared to dry environment but after evaluation of 18 life cycle impact categories, 30-52% higher impacts were generated for LN2 machining conditions due to cutting fluid consumption in comparison with dry machining. Though, dry machining emerged as a eco-friendly alternative as compared to LN2 assisted machining. But till today the dry machining of Inconel 718 is not a viable solution for industry as it leads to reduced tool life, increase in tool wear, worse chip evacuation, poor surface quality and subsequent deterioration in fatigue life of the final product during its life cycle.

Key Words: IN-718, Life Cycle Assessment, LN2, Cryogenic Cooling, Life-Cycle Interpretation (LCIn).

Extensive Analysis of Carpet Waste Generation, and their Management for Light Weight Engineering Application

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ABSTRACT

In the twenty-first century, waste has become a significant issue for industries and manufacturing areas. The management of different kinds of waste, such as gaseous, liquid, and solid, is essential for environmental aspects. The various approaches developed for waste management are employed in the manufacturing sector and institutions. Waste from the manufacturing and use of carpets is substantial in amount and non-biodegradable in nature. In this regard, various techniques are employed to reuse carpet waste products. The environmental conditions and harmful ecological impacts are caused by waste generation. Recycling and appropriate reuse of wasted materials can help to manage waste. The "waste to wealth" theory could benefit individuals and the manufacturing sectors. Waste from the textile and carpet industries is a concern due to their large volumes (40000 tons) and includes high decomposition costs. Additional involvement from educational institutions, manufacturing, and research organizations is highly required as materials made from waste carpet polymers are still in the transition stages. This paper aims to examine carpet waste generation and management thoroughly. The constraints of traditional manufacturing processes were overcome using the resin transfer molding method (RTM) in a vacuum environment. Tensile, flexural, compression, and impact strength analyses are performed to explore the feasibility of the developed sample from discarded carpet waste for a sustainable manufacturing approach. It is found that the tensile, flexural, compression, and impact strength of the carpet waste polymer composite material is 9.70 MPa, 7.55 MPa, 80.60 MPa, and 6.15 kJ/m2. In addition, it improves 41.958%, 45.565%, 30.76%, and 30.76%, including 0.25 wt.% of carbon nanomaterial over the carpet waste/epoxy composite. This technique could be helpful for the carpet and textile industrial sector by recycling discarded materials.

Key Words: Waste, Carpet, Polymer, Tensile, Flexural, Composites

Synthesis and Characterization of Magnesium Ferrite Nanoparticles

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ABSTRACT

Magnesium ferrite nanoparticles were synthesized by chemical co-precipitation method. Morphological and structural properties of MgFe2O4 nanoparticles were determined by scanning electron microscopy (SEM) and X-ray diffraction (XRD) where single cubic phase formation of magnesium ferrite nanoparticles was confirmed. The size of nanoparticles was calculated by Scherrer formula using X-ray diffraction (XRD) peaks. The average size of nanoparticles was found to be 30.95 nm and there was some uniform and non-uniform strain found in magnesium ferrite. Magnesium ferrite has a cubic structure of normal spinel-type which is a soft magnetic n-type semi-conducting material, having a number of applications in sensors operating in hazardous environment, adsorption, magnetic technologies, etc.

Key Words: MgFe2O4, XRD, SEM and Spinel Structure.

Robot-Based Assembly for Sustainability and Its Economic Impact

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ABSTRACT

Robotic assembly has emerged significantly for sustainable manufacturing. Robots can perform highly precision tasks by minimizing material waste during manufacturing processes. This capability helps industries to reduce waste, conserve energy, and optimize resource utilization more efficiently. Robots are integrated with advanced sensors and energy-efficient technologies that optimize their movements and reduce energy consumption by reducing the overall carbon footprint of manufacturing operations. It also supports lean manufacturing by streamlining processes, reducing excess production and inventory, and saving energy and raw materials. In addition, robots play a vital role in recycling and waste management. It can sort recyclable materials with great accuracy, which helps recover valuable resources for reuse. Robots also align with the circular economy by assisting in disassembling and recycling old products, reducing the need to extract new raw materials. Economically, robots minimize labor costs and enhance productivity by working faster and more accurately than humans. While automation might replace some manual jobs, it creates opportunities for skilled roles in robot programming and maintenance to adapt the changing industry needs. Despite their benefits, robots require significant initial investment and regular maintenance. These costs can pose challenges for smaller businesses. However, the long-term savings in energy, labor, and material expenses make robot-based assembly a worthwhile investment for sustainable manufacturing. Moreover, integrating artificial intelligence (AI) with robotics is expected to amplify these advantages, further enhancing efficiency and sustainability in manufacturing processes.

Key Words: Robot, Automation, Economic Impact, Circular economy, Sustainable Manufacturing

Integrating Smart Techniques, Technologies and Circular Economy Principles for Sustainable Manufacturing Ecosystems

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ABSTRACT

The increasing focus on sustainability in manufacturing has underscored the need for efficient resource utilization, minimized carbon footprints, and adoption of circular economy principles. This paper explores how sustainable materials and manufacturing practices, guided by the different frameworks (6R, Life Cycle Assessment (LCA), Circular Economy Model, Lean Manufacturing practices, etc.) can help achieve these goals. By integrating smart manufacturing technologies and optimizing processes, businesses can improve operational efficiency, reduce waste, and lower energy consumption, which together contribute to a reduced environmental impact. This research highlights the impact of advanced manufacturing techniques like precision manufacturing, additive processes, and real-time data analytics in reducing material waste while maintaining high product quality. Additionally, it underscores the importance of incorporating sustainability principles into product, process and system design to facilitate recycling and remanufacturing. Ultimately, the study demonstrates that selecting sustainable materials and adopting smart manufacturing approaches can lead to a more efficient, circular, and environmentally responsible manufacturing ecosystem, benefiting both society and industry in the long term.

Key Words: Sustainability, operational efficiency, smart manufacturing

Risk Assessment Of Pearl Millet Supply Chain Using Fuzzy Bayesian Network

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ABSTRACT

Food security is a global problem of growing complexity due to rapid climate change and population growth. One way to mitigate it is the adoption of pearl millet, a climate-resilient crop found in arid and semi-arid regions. This study identifies, analyzes, and models risks in the pearl millet supply chain in India, focusing on their individual impacts and interconnections to provide actionable insights. A multi-layer perceptron neural network (MLP-NN) is developed and trained to classify 27 identified risks into fuzzy sets of low, medium and high impact, on the basis of survey data. Simultaneously, a DEMATEL analysis is carried out to highlight the causal relationships between these risks; this formed the basis for constructing the Bayesian Network. The MLP-NN achieved an accuracy of 75% while the DEMATEL analysis revealed 14 cause drivers and 13 effect drivers. The Bayesian Network, more aptly termed a Fuzzy Bayesian Network, developed with the help of the DEMATEL analysis was linked to the fuzzy probabilities provided by the MLP-NN and subjected to simulation using the Fuzzy Inference System (FIS). The simulation studied the impact of risks on supply chain resilience and its ripple effects. This study represents a novel integration of MLP-NN-based classification and DEMATEL analysis within a Fuzzy Bayesian framework for risk assessment of agriculture produces such as pearl millet. It is the first of its kind to comprehensively assess pearl millet supply chain risks using a combined MLP-NN, DEMATEL, and Fuzzy Bayesian Network approach. These findings can support decision-makers navigate complexities and ensure economic and ecological sustainability in food systems.

Key Words: Agricultural supply chain, Fuzzy Bayesian Network, DEMATEL, Multi-layer Perceptron, Fuzzy Inference

Effect Of Heating Rate on the Microstructure of Aa 5083

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ABSTRACT

Microwave hybrid heating of bulk metal materials is a newly emerging technology. It offers uniform heating and enhanced material properties. The present study investigates the microstructure and mechanical properties of the AA 5083 aluminum alloy, cast with three different heating rates {10°/min, 15°/min, and 20°/min). AA 5083 aluminum alloy is widely used for its superior corrosion resistance and mechanical strength. Microwave casting was performed in an argon atmosphere using a 2.45 GHz microwave furnace. After mirror polish, the samples were analyzed using optical microscopy (OM), scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), XRD, and Vickers hardness to evaluate grain structure, phase distribution, and mechanical properties. Results showed that a high heating rate (20°C/min) causes rapid nucleation leading the cast alloy to exhibits a finer grain structure with higher yield strength, which is ideal for strength-critical applications. On the other hand, a slow heating rate, 10°C/min, leads to coarser grains and reduced yield strength, suitable for ductility-focused applications. Microwave hybrid heating can be a sustainable method to harness aluminum alloy properties.

Key Words: Microwave curing, Super absorbent Polymer (SAP), Mechanical properties, characterization

Tensile, Flexural, and Machinability Investigation of Polymer Nanocomposites Reinforced with Caron Nano Materials

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ABSTRACT

The present paper focuses on the manufacturing of carbon nano-onion-modified polymer nanocomposites. The hand layup technique (HLT) is used to fabricate the proposed polymeric sample. The impact of nanomaterials was evaluated by mechanical testing, including tensile and flexural tests, compared with pristine epoxy composite materials. It is found that pristine epoxy has a tensile and flexural strength of 11.942 MPa and 64.268 MPa, respectively. The loading of carbon nano-onion (*C*) 1.5 wt.% increased the tensile strength by 81.027% and flexural strength by 59.337% over pristine epoxy composite. The Box Behnken Design (BBD) of experiments is used to execute drilling operations of the proposed composite material and investigate the machinability aspects (cutting force and surface roughness). The impact of drilling factors, namely cutting speed (*S*), feed rate (*f*), and weight % of (*C*), was studied to find the best conditions for *Cf* and *Sr*. The drilling results show that adding the nanomaterial improves the drill hole surface quality. Also, the *Cf* and *Sr* were examined to explore the impact of drilling factors, including *S* and *f*. It was found that the *S* of 1500 rpm and *f* of 50 mm/min was the optimum for reducing cutting force and achieving favorable machinability functions. The results of tensile, flexural, and machinability tests demonstrate the practicality of the developed polymer nanocomposites for structural and other high-performance applications.

Key Words: CNO, Polymer, Drilling, Composite, RSM, Cutting force

Sustainable Solutions for Bulk Processing: Evaluating the Moldability of Recycled Plastics in Rotational Molding

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ABSTRACT

Plastics, known for their lightweight, versatility, and durability, have revolutionized numerous industries, from automobiles and computers to medical advancements like heart valve replacements. However, their widespread use has led to significant environmental challenges. Discarded plastics can persist for centuries, clogging landfills, overburdening waste-handling systems, and threatening marine life, wildlife, and future generations.

This study investigates the potential of thermoplastic waste in bulk polymer processing using Rotational Molding (RM). A review of the literature highlights that recycling plastics via RM offers environmental benefits and economic opportunities. By keeping "still-useful" materials out of landfills, this approach not only protects the environment but also fosters innovation in developing new products from recycled plastics.

The study explores the RM process for recycling plastics in bulk to create large-scale products. It presents findings on the necessary material characterization tests—such as Melt Flow Index, dry flow, bulk density, and particle size distribution—to establish correlations between virgin and recycled material grades. Considering the outdoor applications of RM products under continuous stress, critical properties like Environmental Stress Cracking Resistance (ESCR) and Creep are examined. Additionally, preliminary findings comparing these properties for virgin and recycled grades of LLDPE are discussed.

Key Words: Rotational Molding, Recycling of Plastics, Melt Flow Index, Material characterisation.

The Impact of Multiple Chemical Processing on the Physical Characteristics, Mechanical, Thermal, and Structural Capabilities of Calotropis Gigantea Bast Fiber

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ABSTRACT

This research focuses on the chemical surface modifications of Calotropis gigantea (CG) bast fiber to achieve appropriate qualities as reinforcements in polymeric composites. This study also looked at how chemical alteration affects numerous qualities such as physical, mechanical, thermal, and morphological properties. For this reason, the extracted fibers were chemically treated with sodium hydroxide, potassium permanganate, sodium chlorite, and benzoyl chloride. Following surface modification, density, mechanical properties, thermal gravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR), and surface morphology were carefully examined. The tensile strength and Young's modulus of alkali-treated CG fiber were determined to be 210.39 MPa and 1.77 GPa, respectively. The crystallinity index was increased by 25.37% when compared to untreated CG fiber. Overall, the study concludes that alkali-treated Calotropis gigantea fiber is a suitable reinforcement material for polymer matrix composites intended for light load-bearing applications. Based on the positive and encouraging results, the research can be expanded to create alkali-treated Calotropis gigantea fiber-reinforced polymer composites and evaluate their static and dynamic mechanical properties. Finally, it was discovered that alkali-treated fiber improves the performance and characteristics of Calotropis gigantea stem fibers for application as a new reinforcement in composites.

Key Words: Calotropis gigantean; bast fibers; chemical treatment; thermal stability; mechanical properties

Prediction of Sustainability Parameter Co_2 Emission for Tools, Fixtures and Product Parts

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ABSTRACT

Sustainability has gained unprecedented momentum in recent years, and John Deere is committed to a bold goal of reducing CO2 emissions (Scope 1 and Scope 2) by 50%. However, measuring CO2 emissions, particularly within Scope 2, presents significant challenges, especially when it comes to predicting emissions during the design phase of tools, fixtures, and product components. Currently, there is no established methodology for estimating CO2 emissions at this critical stage of development.

During the design phase, tools, fixtures, and product parts are designed based on specific requirements, followed by the creation of manufacturing drawings. These components are then produced either by suppliers or in-house toolrooms. Throughout the manufacturing process, energy consumption and associated CO2 emissions vary significantly depending on the operations involved in it.

Our study aims to bridge this gap by providing a predictive framework for estimating CO2 emissions early in the design process. This study offers insights into the potential energy consumption and CO2 emissions during the manufacturing of fixtures, thereby equipping designers with essential sustainability parameters. By understanding these factors at the design stage, designers can implement corrective actions proactively, fostering a more sustainable approach to product development. This research not only enhances awareness of sustainability issues but also contributes to achieving John Deere's ambitious emissions reduction targets.

Key Words: Sustainability, CO2 Emission, Scope 1 and Scope 2, Prediction.

Exploring the Microstructure and Corrosion Resistance of HAP/Tio_2 Coatings on Ti-6Al-4V: A Comprehensive Experimental Study

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ABSTRACT

The Ti-6Al-4V alloy is commonly used in artificial hip and knee joints due to its strong biocompatibility and specific strength, but it faces challenges with corrosion resistance over time. This study aimed to enhance the alloy's resistance to corrosion and biocompatibility by applying a composite coating of hydroxyapatite (HAP) and Titanium dioxide (TiO2) using plasma arc spray technology. The coatings were examined for morphology and microstructure through SEM and XRD analysis. In-vitro corrosion test was performed by immersing the samples in simulated body fluid (Ringer solution) at body temperature for 24 hours, resulting in high corrosion resistance of coated specimens as compared to uncoated Ti-6Al-4V alloy .This indicates high compatibility of the material, crucial for bone implants. The hydroxyapatite in the coating promotes osteointegration and when combined with TiO2, enhances the material's performance for medical purposes. The composite coating demonstrated superior biochemical stability in corrosive environments in comparison to pure hydroxyapatite, making it a promising choice for bone implant applications.

Keywords: Ti-6Al-4V,corrosion resistance, HAP,TiO2,coatings

Effect of Charge Geometry on Microwave-Based Hybrid Heating of Bulk Metals: 3d Multiphysics Simulation and Experimentation

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ABSTRACT

In the present study, finite element models of two different load geometries with edges and smooth surfaces (Cube and Cylinder) have been developed to study the effect of shape on electric field distribution and heating uniformity during the microwave heating process. Multi-physics simulations have been carried out with specific processing conditions on the distribution of electric field inside the cavities at 2.45 GHz for Al-Mg-Si alloy as charge. The electric field variations and temperature uniformity have been analysed with two different charge geometries. The result indicates that cylinder geometry has higher temperature absorption efficiency and uniformity than cube geometry.

Key Words: Microwave heating, Load geometry, Multiphysics simulation, Thermal profile

The Influence of Chemical Treatment and Fiber Loading on the Characteristics of Bauhinia Vahlii Bast Fibers/Acrylonitrile Butadiene Styrene Composites for Automobile Body Parts

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ABSTRACT

Now a days, automobile industries are focusing more on producing lightweight materials for vehicle body sections. Because of their lightweight and environmentally benign character, natural fibers have been the subject of extensive research. In the current study, composites were made by reinforcing treated Bauhinia vahlii bast fiber (BV) fibers with Acrylonitrile butadiene styrene (ABS) thermoplastic polymer to make light-weight automotive parts. Several parameters, including static and dynamic mechanical properties, thermal, and morphological properties, were investigated. To improve compatibility with the ABS matrix, fiber surfaces were treated with various chemicals. Mechanical qualities improved as treated BV fiber loading increased until it reached its optimum (23 wt%), after which they declined. The maximum mechanical values obtained at optimum fiber loading were 68.94 MPa tensile strength, 7.02 GPa young's modulus, 95.27 MPa flexural strength, and 33.25 kJ/m2 impact strength. These qualities are far superior to those achieved with other treated composites. SEM examination revealed improved fiber-matrix bonding. The TGA results revealed that the composite was thermally stable when compared to other manufactured composites. Again, DMA revealed that the treated fiber composite had good dynamic mechanical characteristics. According to the current study, BV/ABS composites have a lot of potential in industrial lightweight engineering and outdoor applications, such as building panels and automotive elements like dashboards and door panels.

Key Words: Acrylonitrile butadiene styrene, Bauhinia vahlii, chemical treatment, fiber loading, fiber- matrix bonding, mechanical properties, regression curve

Ecological Impact Analysis of a Hyperloop Model

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ABSTRACT

The Hyperloop promises a very efficient mode of transport, enabled by vacuum tube technology combined with electromagnetic levitation of the vehicle to propel at high speeds with efficiency. This paper examines its viability through a "well-to-wheel" LCA analysis of the environmental impacts of implementing the Hyperloop transport system. From the extraction of raw materials to waste management, we researched all the life cycle stages in its evaluation using OpenLCA. Key materials in the construction phase include Aluminium 6061 T6 for Track, Chromium Steel for tube, CFRP for pods, and Steel Reinforced Concrete for support pillars. High-impact manufacturing processes, such as PAN-to-CFRP conversion and aluminium smelting, are analysed for their embodied energy and greenhouse gas (GHG) emissions. Operationally, the Hyperloop achieves near-zero emissions through renewable energy integration, with solar panels generating up to 285 MW at peak capacity. The hyperloop system is 50% less carbon-intensive than short-haul aviation. Recycling strategies to make this include CFRP pyrolysis and aluminium recovery, as well as reducing lifecycle waste by over 80%. Comparative LCA reveals that operational and end-of-life phases significantly offset these impacts while initial manufacturing is resource-intensive. A comparison was made with other means of transport, including planes, trains, and automobiles, to quantify the Hyperloop's ecological impacts on a relative scale. The findings show that even though the initial manufacturing is emission-intensive, the operational emissions are way below those from conventional transportation systems due to the many energy-intensive materials used. The Hyperloop has the potential to become a very sustainable and green transportation mode in conjunction with renewable energy and low-carbon materials for even short-haul routes.

Key Words: Hyperloop, Life Cycle Assessment, Sustainability

Impact of Heat Treatment on the Deformation Behaviour of AA7075 Alloy Sheets

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ABSTRACT

Growing environmental concerns, increase of electric vehicles, and requirement of greener technologies have accelerated the adoption of lightweight aluminium alloys in the automotive and aerospace industry. AA7075 aluminium alloy is a heat treatable alloy, and is found to be a promising material that shows good strength to weight ratio when compared to traditional steel material. This study investigates the effect of three heat treatment conditions on the hardness and deformation behaviour of AA7075 sheets. The Vickers hardness of AA7075-T6 temper was the highest whereas the sample subjected to W-temper showed the lowest hardness. Deformation behaviour was assessed in terms of part depth and thickness distribution when deformed using a 20 mm and 50 mm punch. The highest limiting dome height (LDH) and relatively smooth thinning pattern was observed for W-tempered sample, when compared to T6 tempered and sample quenched after 250oC. The higher deformation behaviour of W-tempered sample is indicative of higher formability, which can help minimize material wastage in actual stamping and thus contribute to sustainability.

Keywords: AA7075 aluminium alloy, W-temper, Limiting Dome Height (LDH), Formability

Rapid Tooling in Sheet Metal Forming Processes-A Review

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ABSTRACT

Sheet metal forming refers to processes in which sheet materials are plastically deformed by application of tensile forces or a combination of tensile and compressive forces to produce a variety of simple and complex components in industries like automotive, locomotive, aircraft, agricultural, home appliances and food packaging. Unlike other manufacturing operations, most of the components produced from sheet forming processes are finished which do not require any secondary operations to be performed before their actual use. Most of the sheet metal forming processes are carried out on a hydraulic or a mechanical press with suitably designed conventional tooling system. Sheet metal forming based on conventional tooling have some common limitations such as material springback, wear and maintenance of the tool, complex tool design to achieve desired geometry, etc. Rapid tooling (RT), also known as additively manufactured (AM) tooling, is one of the potential tooling techniques that can be used to overcome the constraints of conventional tools. As a result, engineers devised strategies for introducing AM tools for the fabrication of sheet metal parts. The present study reviews forming aspects of sheet metal (unwelded and welded) using conventional and AM tools. Also, the potential advantages of using AM tools have been outlined.

Key Words: Sheet Metal Forming, Rapid Tooling, Conventional tooling, Friction Stir Welding, Finite Element Analysis.

Experimental Investigation and Process Optimization in Electrical Discharge Machining of Sustainable Beryllium-Free Copper Alloys

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ABSTRACT

Compared to copper alloys containing beryllium, beryllium-free alloys like copper-nickel-silicon-chromium (Cu-Ni-Si-Cr) can improve environmental sustainability through decreased toxicity and increased worker safety. These alloys can contribute to a more sustainable approach in various industries, such as die and mould making, focusing on energy efficiency, lower emissions, recyclability, and affordability. Non-contact manufacturing technology such as electrical discharge machining (EDM) can be efficiently used to machine materials possessing high hardness and strength, like Cu-Ni-Si-Cr alloys. Previous works on EDM mainly considered titanium alloys, Inconel and steel as workpiece materials, and research on EDM of Cu-Ni-Si-Cr alloys has seldom been reported. As EDM highly depends on workpiece material properties, this work presents a novel approach to understanding the effects of EDM parameters, such as TON, TOFF, electrode material, and polarity, on surface topography, electrode wear rate (EWR), and material removal rate (MRR). Three-dimensional surface topography analysis is selected for this study as it considers most of the surface points and gives more reliable results on surface topography than two-dimensional roughness parameters. Maximum height, Sz, is the selected three-dimensional topography parameter. Minitab software designs a four-factor multilevel full factorial design, and thirty-six experiments are conducted. TON and TOFF vary in three levels, and two types of electrode material are selected. Both positive and negative polarity are considered for the study. Developing empirical models using regression analysis correlates the relationship between output and input parameters. Significant input parameters affecting the surface topography, MRR and EWR are identified by conducting ANOVA (analysis of variance). Multi-objective optimisation of input parameters is performed to maximise MRR and minimise EWR and surface roughness. The study's findings show that electrode material and polarity are the factors most influencing MRR, EWR, and surface roughness. The effect of TOFF is the least.

Key Words: Be-free Cu alloys, Electrical discharge machining, Three-dimensional surface topography analysis, Multi-objective optimisation, Regression analysis.

Analysis and Development of Inclined Holes in Glass Fiber-Reinforced Plastics Using CO_2 Laser

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ABSTRACT

The next-generation material designed for lightweight engineering applications is glass fiber reinforced plastic (GFRP). This study examines the use of CO2 lasers with millisecond pulse durations for laser percussion drilling techniques to create inclined holes in GFRP. A inclined drill hole used to measure strain rate and thermal cracking in micro-robot hinges. In bone surgery, it is also utilized. The effect of input parameters such as laser current (C), pulse width (W), gas pressure (P), workpiece thickness (T), angle of incidence (I) on geometrical hole characteristics, such as hole circularity (HC) and hole taper (HT), has been analyzed parametrically for percussion using a CO2 gas laser. For every output response, second-order regression model is created using the Box-Behnken approach (BBD) and parametric analysis is carried out using response surface methodology (RSM) plots. For every output response, a second-order regression model is created using the BBD and parametric analysis carried out by RSM. It has been discovered that inclined drilling with a high laser current (200 A) and a high pulse width (2 ms) produces a hole with hole circularity (0.58) and hole taper. At high current (250 A), GFRP with a minimum thickness has high hole circularity (0.85) and low hole taper 3°. The Multi objective optimization (MOO) uses the desirability technique to construct a hole with hole circularity (0.8386) and hole taper (0.1621). The Scanning Electron Microscope (SEM) images show the hole generated at MOO input parameters has a higher surface integrity than the one parameter at time approach (OPAT).

Key words: GFRP, MOO, CO2 LASER, RSM.

Analysis of Mechanical Properties of EPDM Rubber Grommet Materials Using Mixer Design Strategy

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ABSTRACT

An EPDM rubber grommet is an integral part of automotive vehicles used for fixing and protecting the electrical cables passing through control panels to other locations of the vehicle body. The desired mechanical properties of the rubber grommet are very much essential in order to achieve the anticipated performance of the component as well as the automotive vehicle. In the present study, various mechanical properties such as tensile strength, elongation, hardness and ash content of EPDM rubber grommet materials are analyzed in order to achieve the anticipated performance of the component. The different EPDM rubber compound mixture is prepared considering the lower and upper limits of the ingredients composition using design of experiment (DOE) technique. After that, different rubber compound is made based on the various ingredients of rubber grommet materials. Finally, rubber grommet component is produced using compression molding process for various testing and measurement purposes. The effect of temperature, pressure and other process parameters on rubber grommet component during compression molding is not investigated in the present study. The existing material composition of the rubber compound will be studied followed by new additives in order to achieve the improved mechanical properties of the EPDM rubber grommet. The new rubber grommet will be more suitable in term of product performance to accustom with dynamic changes of automotive vehicle.

Key Words: Rubber Grommet, EPDM, Mechanical Properties

Review on Application of Molecular Dynamics Simulations for Nano-M/C of Metallic and Non-metallic Surfaces

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ABSTRACT

Nanomachining (Nano-M/C), the precise fabrication of nanoscale components, underpins advancements in electronics, biomedicine, and nanotechnology. Achieving optimal atomic-scale machining requires insights into material behavior, with Molecular Dynamics (MD) simulations emerging as a pivotal tool for studying phenomena such as material removal, surface integrity, and tool-substrate interactions. This review explores the application of MD simulations in the nano-M/C of metallic, non-metallic, and semiconductor surfaces, addressing recent progress, challenges, and methodologies. The findings identify current limitations, and advocates for incorporating machine learning to enhance predictive accuracy and efficiency. This aims to provide a concise yet systematic resource for researchers and practitioners, promoting innovation in precision manufacturing.

Key Words: Nanomachining, Molecular Dynamics, LAMMPS, Atomic-Scale Modeling, Material Removal Mechanism, Nano-finishing.

Additively Manufactured Tooling in Sheet Metal Forming Processes-A Review

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ABSTRACT

Sheet metal forming refers to processes in which sheet materials are plastically deformed by using tensile force, compressive force, or the combination of the two to manufacture various components in industries like automotive, aircraft, agriculture, and household appliances. Unlike other manufacturing operations, the majority of parts made using sheet forming processes are finished and do not require any secondary operations before use. Most of the processes are carried out on a hydraulic or mechanical press with a suitably designed conventional tooling system. Sheet metal forming based on conventional tooling has some common limitations, such as material springback, wear and maintenance of the tool, complex tool design to achieve desired geometry, etc. Rapid tooling (RT), also known as additively manufactured (AM) tooling, is one of the potential tooling techniques that can be used to overcome the limitations of using conventional tooling. As a result, engineers devised strategies for introducing AM tools for the manufacture of sheet metal parts. Rapid tooling (RT) fosters sustainability and environmental responsibility by requiring less material and energy than traditional tooling. Moreover, the RT process produces fewer emissions than traditional fabrication methods. The current review paper presents the forming aspects of unwelded and welded blanks using conventional tools as well as forming aspects of unwelded blanks using AM tools. Also, the potential advantages of using AM tools have been outlined.

Key Words: Sheet Metal Forming, Additively Manufactured Tooling, Conventional Tooling, Friction Stir Welding, Finite Element Analysis.

Fractography study of Hastelloy X Joints through Microwave Hybrid Heating (MHH)

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ABSTRACT

Enhancing the life of high performing components nickel-based alloys through hybrid microwave welding has generated significant interest in recent years. However, the detailed study on the impact of this welding process on Hastelloy X(HX) joining is not yet available. As HX alloy is widely used in challenging industrial applications involving elevated temperatures and corrosion, the present study aims to address this gap. The study examines the joints generated by hybrid microwave welding with Silicon Carbide susceptor and 1mm thick graphite separator and under a 1000W power setting of a domestic microwave as such conditions are found to generate superior best strength of the joint in comparison to the other choices like glass wool fiber as separator or coke as susceptor or a higher power setting. The joints were found to be of good quality visibly as well as in terms of strength of the joints as determined through a tensile test as per ASTM standards. Fractography study reveals the failure mechanism of specimen through mixed brittle ductile mode.

Key words: Hybrid microwave welding, Microwave hybrid heating, Hastelloy X, Nickel based alloys, Brittle fracture, Fractography.

Exploring the influence of Chromium and Titanium Oxides on Wear resistance on 17-4 PH SS in 3D-Printed vs. Cast Structures

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ABSTRACT

This study investigates the impact of titanium dioxide and chromium oxide coatings on 17-4 PH stainless steel components, comparing samples produced through additive manufacturing and traditional manufacturing methods. SEM analysis were performed to evaluate the impact of coating on the performance of 17-4 PH stainless steel components. Results showed that the hardness of parts produced via additive manufacturing was lower than those of their conventional counterparts. The use of titanium dioxide and chromium oxide coatings significantly improved these properties in both instances. The study also examined the microstructure and wear behavior of titanium dioxide and chromium oxide coatings on precipitation hardening martensitic stainless steel (17-4PH), which is widely used in the oil and gas industries. Scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) were used to analyze the microstructure and wear mechanisms. The wear resistance of 17-4 PH stainless steel underwent precipitation hardening for strength enhancement. The wear tests were performed using a pin-on-disc tribometer fitted with pins with different coatings. The wear resistance exhibited considerable variation attributed to the differing coatings on the pins. The study provides insights into optimizing stainless steel components for enhanced durability in harsh environments.

Key words: 17-4 PH stainless steel, additive manufacturing, coatings, wear resistance

Influence of nanoparticles on the mechanical properties of the fiber metal laminates

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ABSTRACT

The impact of montmorillonite (MMT) nano-clay on the flexural characteristics of Ti6Al4V titanium-based carbon fiber/epoxy laminates was examined in detail. Kalpak Universal testing machine equipped with a 20kN load cell, and a crosshead speed maintained at 2 mm/min was used to perform flexural tests in asper the ASTM D790. The test samples were cut with a span-to-depth ratio of 16:1 and measured 120 mm in length and 13 mm in width. Flexural stress-strain behaviour was impacted by the nanoparticles reinforcing the Ti6Al4V titanium-based carbon fiber/epoxy laminates. FMLs, without any nano-clay reinforcement, were considered the baseline for comparison of the flexural properties of other nano-clay-reinforced FMLs. When the weight percentage of nano-clay in the epoxy increased, there was a noticeable improvement in the flexural stiffness. Although there were some concerns, there was a noticeable increase in strength and stiffness among the nano-clay reinforced FMLs as the weight percentage of the nano-clay increased. When 1% of nano-clay was added to the epoxy, the flexural strength and stiffness decreased by 49.92% and 50.53%, respectively. The reduction of flexural strength and stiffness was largely due to the prevailing agglomeration phenomenon. It's interesting to note that when the weight percentage of nano-clay increased, the adhesion between titanium and the composite layer improved and the mechanical locking phenomenon began to work. This can be interpreted as an instantaneous increase in the flexural strength for 3% and 5% nano-clay reinforcement. With a drop of 44.37% for 7% nano-clay reinforcement, the flexural stiffness also increased for 3 and 7% nano clay reinforcement. For 5% nano-clay reinforcement, flexural strength increased, and flexural stiffness decreased. Flexural strength and stiffness are also impacted by the phenomenon of crack bridging. Field emission scanning electron microscopy was used for fragmentography to study the morphology of metal and fiber surface fractures in nano-clay-reinforced FMLs.

Key Words: Fibre metal laminate; Titanium alloy; Carbon fibre; Flexural strength; Flexural stiffness, FESEM

Track:

Industrial Engineering for the Green Economy

Supplier Selection in Construction Industry Based on Environmental Performance: A Life Cycle Assessment Approach

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ABSTRACT

Supplier selection has been of significant importance in supply chain management, particularly in relation to the sourcing process. In recent years, emphasis on supplier selection based on their sustainable practices has become increasingly important to meet the carbon emission goals. The construction sector is often considered the least sustainable among all the industries concerning its higher resource consumption and emissions. As a result, achieving sustainability in the construction supply chain becomes a significant challenge. One of the many solutions to reduce emissions and overall environmental impacts in the construction supply chain is the selection of green suppliers. This research investigates the selection of green suppliers based on the Life Cycle Assessment (LCA) approach. The environmental impacts of the suppliers are evaluated from the cradle-to-gate life cycle using SimaPro software. The emissions linked to supplier activities are accounted across midpoint impact categories and endpoint damage categories of the ReCiPe 2016 methodology. The research outcomes based on evaluated emissions will provide a framework for green supplier selection in the construction industry. Moreover, by prioritizing the focus on green supplier selection the overall emissions in the construction supply chain can be reduced, leading to a more sustainable and environment-friendly supply chain.

Key Words: Green Supplier Selection, Construction Supply Chain, Midpoint analysis, ReCiPe Methodology

Green Supply Chain Optimization Incorporating Aggregate Production Planning: A Multi-Objective Stochastic Model Solved with a Hybrid Metaheuristic Approach

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ABSTRACT

The studies in the field of supply chain research lay emphasis on minimizing greenhouse gas emissions in order to achieve compliance with the global sustainability initiatives. This research focuses on the critical need to factor in carbon costs with facility location, transportation mode analysis, and aggregate production planning (APP) decisions. APP involves operational decisions for a period of 3-18 months: decisions such as trade-offs regarding production rate and inventory, deciding optimal workforce size by actively hiring and firing workmen as needed). The paper develops a multi-objective stochastic programming model to minimize total costs, greenhouse gas emissions, lead times, and cost variability that would represent real world constraints of production, transportation, and storage activities. The applicability of the model has been tested to suit the real-world scenarios by the help of a case study. Advanced hybrid metaheuristic approaches have been used in order to solve the model: a hybrid GA-PSO-SA model combining Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Simulated Annealing (SA) in an effort to find solutions which could leverage each method's strength. The results prove the effectivity of the proposed model in reducing operational cost, lead time, emissions and cost variability, providing further decision making insights towards better supply chain management sustainability.

Key Words: Supply Chain, Greenhouse gas emissions, Multi-Objective, Stochastic Programming, Genetic Algorithm, Particle Swarm Optimization, Simulated Annealing

Overview of Membrane Technology in Industrial Effluent Treatment

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ABSTRACT

The Industrial wastewater treatment plays a crucial role in improving water quality by reducing pollutants and enhancing the capacity to recycle and reuse water. This process is essential for various applications, including agriculture and horticulture. Membrane technology is widely used in water treatment to separate dissolved contaminants based on characteristics such as size and charge. Key membrane types, including microfiltration, ultrafiltration, nanofiltration, reverse osmosis, and electrodialysis, are integral to removing impurities in industrial applications. This study presents a global survey of membrane-based treatment plants, evaluating their effectiveness in industrial wastewater management and their compliance with local pollution control standards. The survey covers a range of industries, including petrochemicals, power generation, steel, paper, food processing, mining, and textiles. The results show that membrane treatment systems can process an average of 6 million cubic meters of wastewater per day. In regions such as Europe, North America, the Middle East, and Southeast Asia, the power generation industry has significantly reduced water withdrawal by improving water reuse and recycling, thanks to the successful application of membrane technologies. Given the increasing stringency of water quality standards set by pollution control boards, membrane technology is expected to play a key role in addressing water quality issues and facilitating water reuse. The global membrane market is projected to grow at a rate of approximately 8.7% over the next decade. The study also highlights challenges such as membrane fouling and scaling, which impact the economic feasibility of membrane systems, and explores alternative cleaning methods to mitigate these issues.

Key Words: membrane technology, industrial wastewater treatment, water reuse, pollution control, membrane fouling, water quality

Investigation of the effect of time-dependent covariates on Maintainability Analysis

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ABSTRACT

Modern industries are being compelled to adopt green policies due to the degradation of the global environment, a shift that aligns with the principles of a green economy. An increasing frequency of repairs and maintenance in industrial plants is contributing to adverse environmental impacts. In this context, maintainability plays a key role in extending system availability and minimizing the frequency of maintenance intervention. Conventional techniques for assessing maintainability often focus primarily on repair time as a key determinant factor. The consideration of only the "time to repair" variable can indeed be restrictive because there are often other factors, or covariates, that can influence the time to repair of a system. Ignoring these covariates can lead to incomplete or inaccurate quantification of maintainability. Therefore, a more refined model is essential for precisely evaluating the influence of critical operational factors on maintainability in order to enhance the accuracy of maintainability predictions, particularly in industries where availability is of utmost importance. In the context of maintainability analysis, the Proportional Repair Model (PRM) is widely used. This model operates under the assumption that covariates, or factors that may influence maintainability, are time independent. The assumption that covariates are time-independent may not hold true in certain situations, and failing to account for time-dependent covariates can lead to biased estimates of maintainability. The aim of this paper is to explore the significance of time dependent covariates in modelling maintainability.

Key Words: Availability, Covariate, Degradation, Maintainability, Mean time to Repair

Innovative Approaches to Waste Reduction: Machine Learning Applications in Industrial Engineering

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ABSTRACT

The growing emphasis on sustainability and the need for efficient resource utilization have prompted the exploration of innovative approaches to waste reduction within industrial engineering. This paper investigates the application of machine learning techniques to identify, analyze, and mitigate waste across various industrial processes. By using large amounts of data, smart algorithms, and predictive modelling, machine learning can improve decision-making, make production processes more efficient, and help move towards a circular economy. Key areas of focus include waste classification, anomaly detection, and process optimization. Case studies from manufacturing and supply chains demonstrate that these machine learning applications can cut down on material waste, save energy, and reduce emissions. Overall, the research suggests that using machine learning can lead to better waste management and significant savings while benefiting the environment.

Key Words: Machine Learning, Industrial Engineering, Waste Reduction, Sustainability, Circular Economy

Sorghum as a Sustainable Food Choice: Understanding Consumption Patterns and Preferences

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ABSTRACT

Sorghum, an ancient and nutritionally rich grain, has long been recognized for its health benefits and environmental sustainability. However, its adoption, particularly among younger demographics in India, has been limited in favour of more familiar grains such as wheat and rice. The present study aims to explore the consumption patterns and preferences for sorghum-based products among college students, a growing segment of health-conscious consumers. A structured survey was conducted with 105 survey participants in Pilani, Rajasthan. Factors such as taste, price, availability, health perceptions, and social influence were added to the questionnaire to analyze the sorghum consumption preferences. Analysis of Variance (ANOVA) and regression analysis were employed to analyze the data. ANOVA revealed that health benefits, price, and availability had statistically significant effects on sorghum consumption, with p-values of 0.000 (health benefits), 0.036 (price), and 0.055 (availability), indicating that these factors strongly influence dietary choices. Regression analysis further quantified these relationships, showing health benefits were the most significant predictor of consumption, with a coefficient of 0.4665 ($p < 0.001$). Social influence and taste, however, were less significant, with coefficients of 0.058 ($p = 0.696$) and 0.1146 ($p = 0.218$) respectively. These findings highlight the need for targeted health marketing, affordable pricing strategies, and enhanced availability of sorghum-based products in different locations to increase consumption among younger population. The study provides valuable insights for stakeholders aiming to promote sorghum as a healthier, more sustainable dietary choice.

Key Words: Sustainable Agriculture, Sorghum-Based Products, Dietary Patterns

Carbon-Concious Supply Chain Design: A Multi-Objective Approach to Economic and Environmental Balance

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ABSTRACT

The increasing focus on environmental sustainability has transformed the priorities in supply chain management, leading to the need for including carbon cost considerations in the design of supply chain networks. This paper develops a multi-objective optimization model for balancing economic and environmental outcomes, that balances traditional operational costs with expenses related to carbon emissions across production, transportation, and storage activities. To prove the applicability of the developed model, a case study has been considered in order to assess the manner in which carbon cost impacts decisions such as locating a facility, transportation routes, and distributing an inventory. The model developed has been solved by using Integer Linear Programming (ILP). The results obtained suggest that by introducing carbon cost to any one of these decisions would lead to additional costs but it will significantly raise the environmental sustainability by keeping a very low carbon footprint. Therefore, this research benefits organizations in aligning the strategic supply chain with ongoing modifications to environmental regulations and increased pursuit of sustainability. Future research directions would include the extension of the model to accommodate dynamic demand scenarios.

Key Words: Environmental, Supply Chain, Multi-Objective, Carbon Cost

Numerical and Experimental Study on Transient Flow in Primary Air Fan

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ABSTRACT

In a Circulating Fluidized Bed (CFB) boiler, the discharge pressure from the primary air fans plays a very important role. Optimum pressure has to be maintained in the boiler wind box, to suspend or fluidize the fine coal particles for combustion, over the bottom bed. A low pressure will not generate adequate lift to fluidize the bed and a high pressure will make the coal particles escape the combustor without complete combustion. Therefore, the performance of the primary air fans in thermal power plants has a direct impact on boiler combustion behavior. Optimization of fan aerodynamic design is an important aspect, to improve performance and overall system efficiency. In this study, Computational Fluid Dynamics (CFD) analysis has been carried out to understand the transient flow behavior and its impact on the performance of a high-rotational speed radial fan. CFD methodology is extensively used to study performance at design and off-design points, capturing information on losses, pressure and flow streamlines. Static pressure data at important locations in the impeller zone are monitored to calculate the Blade Passing frequency and other dominant frequencies. The radial fan, coupled with a suitable motor, has also been tested in an experimental test track that is instrumented and established as per BS 848 standard. Nomograms have been obtained at different pressure and flow points during the tests. The quantitative CFD results are validated with the test data and the results are in good agreement (within 5%). This design optimization exercise helps in identifying the best operating point for the primary air fan and attaining optimum efficiency while providing the required airflow to the CFB combustor. The developed methodology predicts fan performance with reduced computational efforts. It strengthens fan sizing practices, achieving a reduction in auxiliary power consumption and in turn improving the overall power plant efficiency.

Key Words: Energy efficiency, CFD, Radial fan, CFB boiler, flow optimization.

Identifying key factors for building an efficient supply chain of EV components in India using MCDM approach

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ABSTRACT

India has set a target to achieve net zero emissions by 2070 and it has taken initiatives to progress towards low carbon development across the key sectors that include manufacturing, transport and energy amongst others. The transportation sector contributes over 15% carbon emission on account of petrol and diesel combustion. Towards decarbonization, electric vehicles (EVs) are considered as a formidable substitute for conventional fuel powered vehicles that use internal combustion engines (ICE). The Indian government have launched subsidies and tax incentive schemes on EVs to generate momentum in faster EV adoption for the consumers. The automotive manufacturers and tier 1 suppliers have started focusing on EV manufacturing. The transition to EVs is being pursued by the automotive ecosystem participants seriously, yet in India the supply chain for EV powertrain components is still in the nascent stages of development. Hence, the transition to EVs from conventional ICE vehicles will significantly impact the supply chain in the automotive industry. The Indian automotive industry is growing with the developments in EV technologies. An EV power architecture consists of energy source in the form of EV battery, electric motor, power electronics, battery management system, thermal management system and the drivetrain. The sensors are integral to EV power architecture, and they are critical to performance of EVs. There are various supply chain concerns which needs to be addressed to enable the domestic manufacturing of EV sensors. Also, this will demand the solving of various factors and challenges in building an efficient supply chain. This paper involves in identifying these key concerns in the EV sensors in India and ranks them using MCDM approach of an Analytical Network Process model. The obtained results can be used to prioritize the factors and solve them for establishing an efficient supply chain for EV sensors in India.

Key Words: EV supply chain, EV component, EV sensor supply chain, MCDM, ANP Model

Evaluating Demand Forecasting Algorithms for the Indian Automobile Sector: A Comparative Study of LSTM And DES Amidst Macroeconomic Influences

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ABSTRACT

The Indian automotive industry is growing with the increased purchasing power among the consumer segment and the shift from needs to luxury. Higher purchasing power boosts the manufacturing economy with technological innovation, cost-consciousness and sustainability efforts. However, factors such as government policy implementations, GDP growth, annual inflation, fuel price fluctuation, subjected interest rates and foreign investments should be observed that affect sales. This study analyses the impact of different macroeconomic factors in the Indian automotive industry by addressing economic sustainability to guide the sales of automobiles to numerous consumer segments. The paper provides insight into selecting an advanced multivariate demand forecasting approach based on collected secondary evidence such as past sales and macroeconomic data from credible sources. The selection of a fitting algorithm will reduce the environmental impact by optimizing the product flow in the supply chains. The results compare the predictive accuracy of double exponential smoothing (DES) and long short-term memory (LSTM) networks. The study highlights the strengths and limitations of each algorithm in forecasting demand under varying economic conditions. The DES performs well in steady and linear environments but struggles to adapt to abrupt economic or consumer behaviour changes. However, the LSTM is more accurate in dynamic scenarios as it captures complex, non-linear dependencies and gives more accuracy in dynamic scenarios. The findings underscore the importance of understanding the buying behaviour in changing scenarios to plan for optimal inventory and production planning as business decisions.

Key Words: LSTM, Double Exponential Smoothing, Macroeconomic factors, Seasonality, Level, Trend, Economic sustainability

Green And Lean Industrial Engineering Practices: A Pathway to Sustainable and Efficient Manufacturing

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ABSTRACT

Green and Lean industrial practices offer a synergistic approach to sustainable and efficient manufacturing. Lean manufacturing emphasizes eliminating waste and optimizing resources, while green manufacturing focuses on minimizing environmental impact. Integrating these principles can address both economic and ecological challenges. This paper provides a comprehensive roadmap for implementing Green and Lean practices, detailing strategies for waste reduction, energy efficiency, and sustainable process improvement. Through case studies of industry leaders like Toyota and General Electric, the paper highlights measurable benefits such as reduced greenhouse gas emissions, improved resource utilization, and cost savings. Challenges in implementation, including resistance to change and supply chain complexities, are addressed with practical solutions. The proposed roadmap serves as a guide for manufacturers aiming to achieve operational excellence while contributing to global sustainability goals. The manufacturing sector is facing unprecedented challenges in terms of environmental sustainability and economic efficiency. Green and lean industrial practices have emerged as a promising solution to address these challenges. This research paper provides a comprehensive review of green and lean industrial practices, their benefits, and implementation strategies. A roadmap to sustainable and efficient manufacturing is proposed, highlighting the key steps and milestones for industries

Key Words: green financing, sustainable development, climate change, green bond

Navigating the Green Economy: Challenges and Opportunities through Green Supply Chain Resilience and Green AI

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ABSTRACT

The transition to a green economy necessitates a paradigm shift in supply chain management and technological innovation. This study explores the challenges and opportunities arising from integrating Green Supply Chain Resilience (GSCR) and Green Artificial Intelligence (GAI) in the pursuit of a sustainable and environmentally conscious economy.This research paper explores the intersection of green supply chain resilience and the emerging role of green artificial intelligence (AI) as critical components in navigating this transformation. The first section addresses the challenges facing green supply chains, including resource scarcity, regulatory pressures, and the demand for transparency. It highlights how supply chains must adapt by incorporating sustainable materials, reducing carbon footprints, and enhancing their capacity to withstand environmental disruptions.The second section introduces the concept of green AI, examining its role in optimizing sustainability efforts within supply chains. From predictive analytics for efficient resource allocation to AI-driven environmental monitoring and waste reduction, green AI offers solutions to enhance operational efficiency while minimizing environmental impact. However, the ethical and energy-consumption concerns of AI technologies also pose challenges, necessitating careful governance and energy-efficient designs.The paper further discusses opportunities for integrating green supply chain resilience and green AI to create competitive advantages, improve environmental outcomes, and align with global sustainability goals. By fostering innovation, embracing circular economy models, and leveraging AI for sustainability insights, businesses can enhance their adaptive capacities in a green economy. Ultimately, the convergence of resilient green supply chains and green AI has the potential to drive both economic growth and environmental stewardship.

Key words: green economy, supply chain resilience, green AI, sustainability, environmental impact, circular economy, technological innovation.

Track: Sustainable Advances and Innovations in Thermal Engineering

Investigation of Temperature Distribution in Evaporator's Using Sustainable Refrigerants For Efficient Refrigeration System

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ABSTRACT

To maintain the food quality standards and to reduce the food wastage, it is important to have an effective refrigeration system. Since evaporator is an integral part of the system, to improve the refrigerative performance and reduce energy consumption, refrigeration systems must increase the efficiency of their evaporators. The key factors responsible for increasing the efficiency are evaporator design and the type of refrigerant used for heat exchange. In this paper, we analyse the performance of fin tube and circular finned tube evaporators by circulating three different refrigerants—propane (R290), ammonia (R717), and isobutane (R600a) using ANSYS, a computational fluid dynamics (CFD) tool. The temperature variations between the evaporators were examined for each refrigerant under similar operating conditions using a comparative analysis. Due to its thermodynamic qualities and ecology, propane, ammonia, and R600a were chosen to ensure a sustainable approach to design improvement. The results were compared based on the evaporator outlet temperature and the refrigeration capacity.

Keywords: Evaporator efficiency, Finned tube design, Circular finned tube, Propane (R290), Ammonia (R717), Isobutane (R600a), Thermal performance, Heat transfer.

Electro-Thermal Optimization of Thermoelectric Cooler Systems (TEC) for Thermal Management in Advanced Photonic Packaging Applications

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ABSTRACT

This paper presents a comprehensive Electro-Thermal analysis workflow for the Optimized X Packages and Optimized Y Packages, designed to investigate temperature distributions in the laser and photonic integrated circuit (PIC) components, with a focus on thermal management strategies. The Optimized X package is optimized for high-speed commercial data applications, while Optimized Y supports modular research flexibility. The study involves a detailed thermal and flow analysis of the integrated assembly, including the Optimized X / Optimized Y package, heat spreader, heatsink, adaptor board, and wire bond cover, all subjected to cooling via a high CFM fan (85.5 CFM) and thermoelectric cooler (TEC) systems.

The TEC was optimized to maintain a constant temperature of 50°C on the hot plate and above 20°C on the cold plate. In TEC geometry, the 'G' Factor is determined through various iterative methods. Using the TEC performance curve as a reference, the input parameters such as current (I) and heat flow (Qc) were varied to assess the temperatures of the hot and cold plates. At specific points corresponding to the 'G' Factor, the simulation results were compared with the performance curve to refine the TEC design. Iterative simulations were performed to optimize the TEC geometry by adjusting these input parameters, with results showing that both the Optimized X / Optimized Y packages successfully maintain their heat sources (laser and PIC) at controlled temperatures.

Under specific operating conditions, the temperature difference (ΔT) for cold plate in both packages ranged between 20°C and 30°C and hot plate temperatures stabilizing near 45°C—close to the targeted 50°C. The coefficient of performance (COP) of the TEC was found to be 1.3 for the Optimized X Package and 0.9 for the Optimized Y Package, suggesting significant thermal management efficiency. These results underscore the effectiveness of the integrated thermal management design in ensuring stable performance of the laser and PIC within both package systems. This work lays the groundwork for future enhancements in thermal optimization for advanced photonic packaging applications

Key Words: Electro-Thermal Analysis, Thermal Management, Conduction, Forced Convection.

Performance of Hydrodynamic Energy Extraction in Single and Tandem Configuration of Flapping Foils

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ABSTRACT

For improved flying and summing performance, schools of fish or flocks of birds frequently have wings and fins arranged in tandem. It is difficult to conduct emerging research on these topics supported by fluttering foil. The time of the foil-foil interaction that improves the hydrodynamic performance of a tandem configuration flapping foil at Reynolds number 1173 is the main topic of the current study. We investigate the tandem hydrofoil by substituting two new flapping trajectories (i) elliptical and (ii) fishtail flapping trajectories for the traditional flapping motion (vertical heave and pitch motion). Computational techniques are used to analyze the hydrodynamic efficiency, including the tandem hydrofoil's wake structure and propulsive efficiency. The flapping trajectories are also studied in conjunction with the impact of the Strouhal number (St) and inter-foil spacing. The goal of this study is to improve the biomimetic propulsion technology by increasing the hydrofoil's evoked thrust. The Strouhal number is varied between 0.2 and 0.5 using two distinct phase angles (counter-phase and in-phase) between the foils to conduct the research. It is determined that the reverse Karman vortex street is in charge of induced trust for a single flapping. The wake intensity (reverse Karman vortex street) is the highest of the three flapping trajectories in simple flapping, which leads to a greater push than the other two trajectories. Since the elicited thrust produces a tighter dipole than St's lower value, it increases with St.

Design and Analysis of a Standalone Type Micro-Combustion-Based Power Generator Using Fluid Mechanics and Heat Transfer Principles

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ABSTRACT

This work presents the design of a standalone microscale power generator combining a hydrostatic pressure-driven fuel (ethanol) delivery system and thermoelectric generator (TEG) modules. The system features a micro-combustor with a recirculating heat exchanger, where fuel flow is controlled using Bernoulli's equation to eliminate the need for active pumping, reducing auxiliary power requirements. Heat transfer and fluid mechanics principles are used to optimize component design and estimate power output based on the combustor's assumed wall temperature. The integration of heat recirculation enhances fuel-air preheating, improves combustion efficiency, and stabilizes the flame. Proposed methodologies focus on maximizing energy conversion efficiency and achieving compact, efficient, and autonomous operation. The results demonstrate the feasibility of this system for portable, off-grid applications. Beyond defence applications, such generators support rural electrification and critical devices in areas with limited or unreliable grid access, aligning with Sustainable Development Goal 7 (SDG7) and India's renewable energy ambitions.

Key Words: Portable power generator, Ethanol, Thermoelectric generator (TEG) , Renewable Energy

Transient Model of Compact Heat Exchanger for Bleed and Bleed-Less Air Cycle Aircraft Environment Control System Using Dymola

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ABSTRACT

Compact heat exchanger plays a very important role in aerospace applications such as controlling the environment inside the aircraft. The transient characteristics have a very significant role in the thermal performance of compact heat exchangers. In this paper, the dynamic model of the compact heat exchanger is developed using the commercial software Dymola. Initially, the steady state analysis is done using the MATLAB code to generate the characteristics map of the compact heat exchanger. The common information of the transient characteristics of the compact heat exchanger can be observed using the results of the dynamic model. The validity of the work is proven by comparing the static results obtained from the MATLAB code with those of Dymola. These models can help engineers design the compact heat exchanger when experimental data is unavailable initially. After the design is finished, the system's dynamical models can also be used to verify their control strategy.

Key Words: Compact Heat Exchanger, Transient Analysis, Dymola, Thermal Performance, MATLAB, Characteristics Maps.

Life Cycle Assessment of Hydrogen Production by Steam Methane Reforming and Coal Gasification Method

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ABSTRACT

This study presents a Life Cycle Assessment (LCA) to evaluate and compare the environmental impacts of two prominent hydrogen production technologies: Steam Methane Reforming (SMR) and Coal Gasification. Hydrogen is a clean energy carrier with diverse applications in energy, transportation, and industrial sectors. It plays an important role in worldwide efforts to reduce carbon emissions. However, the environmental impact of hydrogen production varies widely depending on the technology used, highlighting the need for systematic analysis. In this study, a cradle-to-gate approach has been adopted to quantify the emissions associated with the production of 1 kg of hydrogen. The analysis has been based on data from the ecoinvent v3.10 APOS Unit-Processes database and performed using OpenLCA software. Key assumptions included consistent feedstock quality and the exclusion of carbon capture technologies. The findings reveal that SMR emits 11.08 kg CO_2-equivalent per kg of hydrogen, which is considerably lower than the 20.85 kg CO_2-equivalent produced by Coal Gasification. These results offer valuable insights for improving hydrogen production methods. The outcomes of this research can guide policymakers and industry stakeholders in developing cleaner hydrogen technologies and advancing sustainable energy transitions.

Key words: Hydrogen Production, Life Cycle Assessment, Steam Methane Reforming, Coal Gasification, Climate Change assessment

Experimental Investigation and Economic Analysis of A Humidification-Dehumidification-Based Desalination System Across India

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ABSTRACT

In this work, two sensible heating setups, two humidification setups, a dehumidification setup with open-loop air circulation, and closed-loop water circulation in a two-stage humidification-dehumidification based desalination system were investigated experimentally. The HDH desalination system was operated in five different modes: dehumidification mode, humidification-dehumidification mode, single-stage mode, double-stage mode, and double-stage with water heating mode. These modes were tested using data on average annual temperature and relative humidity from 19 different cities across India, gathered from NASA Power from 2018 to 2022. Based on experimental data performance analysis, and economic analysis are carried out. The results of the analysis show the freshwater yield is maximum in double-stage with water heating mode compared to the other four modes, regardless of the city and years. The economic analysis results reveal that Kolkata and Agartala achieve the lowest CPL of 2.84 rupees per litre for dehumidification mode and Itanagar has the highest CPL of 9.47 rupees per litre for double-stage mode.

Key Words: Humidification-dehumidification based desalination system, NASA Power, economic analysis, freshwater yield.

Challenges in the Thermal Management of All-Electric Aircraft

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ABSTRACT

The European Union has set itself the goal of achieving climate neutrality by 2050 in response to growing evidence of the adverse effects of climate change. In accordance with this plan, the FLIGHTPATH 2050 outlines specific objectives for the aviation industry, which include a significant reduction in the emissions and noise pollution of future aircraft generations. The realisation of these goals is, among other factors, contingent upon the implementation of innovative technologies, such as the replacement of carbon-based fuels through the introduction of electric powertrains. These all-electric aircraft are intended primarily for the short-range market, given that their low power and energy densities render them incompatible with the power and energy requirements of long-range flights. The electric powertrain presents a significant challenge with regard to the dissipation of waste heat. The thermal management system is intended to address these challenges by cooling the distributed heat sources across the aircraft efficiently and reliably. Not only the number of heat sources but also their amount of heat rises due to the fact that the waste heat can no longer be dissipated via the hot exhaust gas of the engine. Conversely, the available heat sinks are very limited, consisting mainly of the cryogenic hydrogen and the ambient air. The ambient temperature is at its highest on ground level, resulting in a low prevailing temperature difference between the heat source and sink for the most demanding aircraft conditions. Shortly following take-off, the power requirement diminishes and the ambient temperature declines with altitude, so the thermal management is typically oversized for the majority of the flight time. Ultimately, its design has a notable weight, drag, and additional power consumption. Consequently, it is necessary to integrate the system directly into the design process through a multi-disciplinary approach.

Key Words: Electric Aircraft, Thermal Management, Emission Reduction

Thermo-Hydrodynamic Analysis of Slippery Action Based Rough-Porous Hydrodynamic Inclined Plate Slider Bearing Lubricated with Non-Newtonian Lubricants

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ABSTRACT

In the present investigation, the modified Reynolds equation for a hydrodynamic inclined plate slider bearing, considering the influence of random surface roughness, surface porosity, lubricant rheology, and lubricant slippage, is solved. In addition, the impact of viscous heating on the tribological performance of the hydrodynamic bearing is observed. To perform this investigation, the Elrod cavitation algorithm-based 1-D modified Reynolds equation and adiabatic energy equation has been simultaneously solved. For clearly understanding the combined impact of modified bearing surface and lubricant attributes, the variation of important tribological performance parameters such as peak pressure, minimum film thickness, average lubricant temperature rise, and lubricant-bearing friction force is observed. The findings of the study indicate that under suitable operating conditions, the slippery action-based rough-porous bearing lubricated with rheological lubricants is efficient in improving the tribological performance characteristics.

Key Words: Random Roughness, Lubricant Rheology, Lubricant Slippage, Surface Porosity, Viscous Heating, Hydrodynamic Inclined Slider Bearing

Thermal Management of Electric Vehicle Batteries Using Magnetic Hybrid-Nanofluid Flow and Configurable Magnetic Baffles

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ABSTRACT

This study investigates into the computational exploration of the impact of magnetic intensity, magnetic nanofluid, flow rates, and heat transfer coefficient in the form of Nusselt number on inclined ribbed channels with both parallel and staggered configurations for the electric vehicles. Employing Fe3O4/CuO as the working fluid, within a mini-channel with multiple magnets at different locations namely 15.0 mm, 25.0 mm and 15.0 mm and 25.0 mm. The parallel and staggered inclined ribbed channels Nusselt number (Nu) increased with increasing magnetic field intensity. Similarly, the skin friction also experienced an increment with magnetic field intensity for staggered ribbed and for parallel ribbed minichannel when both the magnets were placed at the location of 15.0 mm and 25.0 mm from the inlet but decreased with increasing Reynolds number. Notably, the Thermal Enhancement Factor (TEF) consistently surpassed greater than unity for all investigated cases. These findings carry significant implications, particularly in EV cooling, offering valuable insights for developing more efficient and tailored cooling solutions for advanced EV battery thermal management.

Key Words: EV battery, cooling, BTMS, heat transfer, nanofluid, magnets

Data-Driven Neural Network Models for Rapid Evaluation of Compact Heat Exchanger Performance for Wavy Fin Configuration

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ABSTRACT

This study presents a Neural Network (NN)-based approach to develop a performance evaluation model for compact heat exchangers (CHEs) in MATLAB with wavy fin configurations both with and without perforations. Traditional methods for assessing CHE performance, such as analytical equations or numerical simulations, are often computationally intensive and time-consuming. By iteratively developing NN models, this research explores the effectiveness of various approaches, including using inlet conditions like flow rate and temperature and incorporating geometry-based parameters such as fin dimensions and surface areas, to predict key performance evaluation by evaluating outlet temperatures and pressure drop. The NN-based performance evaluation model significantly reduces system-solving time while maintaining accuracy, making it particularly suited for applications involving simultaneous CHEs in larger systems. Practical, data-driven methods, such as leveraging sensor data and fixed geometry parameters, are integrated to enhance model reliability. This streamlined methodology demonstrates the potential of NN models to support rapid design and optimization of CHEs, with significant implications for industries requiring high-efficiency thermal systems, such as aerospace and automotive sectors.

Key Words: Compact Heat Exchangers, Wavy Fins, Neural Networks, Performance Evaluation, System Optimization.

Performance Investigation and Comparative Exergetic Analysis of Vapor Compression Refrigeration System Using Refrigerant R134a, R1234yf, CO2 and R410a

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ABSTRACT

The exergy analysis is widely accepted as a useful tool in obtaining the improved understanding of the overall performance of any system and its components. In this paper, four different refrigerants including R134a, R1234yf, CO2, and R410a have been studied. The equations of exergetic efficiency and exergy destruction for the main system components such as compressor, condenser expansion device and evaporator are developed. Ecosim Proosis software is used to solve the thermodynamic equations. In this paper it is analysed about influence of evaporation temperatures and condenser temperature on exergetic efficiency and on exergy losses in the system. The results are obtained when evaporator temperature varies in the range (248-298) K and condenser temperature varies in the range (313-338) K. The results of this analysis are shown graphically. Based on the results, exergetic efficiencies for R134a are higher than the other refrigerants. Also, the exergy efficiencies will be decreased with increasing the condensing temperature and increasing the evaporating temperature.

Key words: Exegetic Efficiency, Total Exergy Destruction, Exergy Loss, COP

Solar Concentrator with Ganged Heliostats on a Rotating Platform and Performance Validation Using Solar Pilot Simulation

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ABSTRACT

A solar concentrator that has ganged heliostats positioned on a rotating platform relates to a system that concentrates and harvests solar energy. A central receiver is positioned at the center of the solar concentrator. A horizontal rotating platform, rotatable about its vertical axis, is rotatable about the central receiver for tracking the azimuthal movement of the sun in the sky. A plurality of parallel reflecting units is positioned on the rotating platform and is arrayed relative to the central receiver. Each reflecting unit contains an array of mechanically linked heliostats (ganged heliostats) that are synchronously maneuverable on a horizontal axis for tracking a changed elevational position of the sun in the sky. A central processing unit generates controlling commands for tracking the moving sun in the sky such that the incident solar radiation on heliostats is reflected and focused on the central receiver. SolarPILOT software is employed to simulate and analyze this setup, providing advanced tools for fine-tuning the optical performance of the heliostat field. It allows detailed simulations of solar reflections, evaluating factors such as cosine loss, shading, and atmospheric attenuation. By modeling sunlight's interaction with each heliostat, SolarPILOT ensures efficient solar energy concentration on the central receiver. This comprehensive simulation approach enhances the system's optical performance and energy capture. The proposed solar concentrator system, validated through SolarPILOT simulations, demonstrated high efficiency, achieving a solar field optical efficiency of 69.32% and an overall system efficiency of 65.16%.

Key Words: solar concentrator, Ganged heliostats, Rotating platform, Central receiver, SolarPILOT simulation, Optical efficiency, Cosine loss, Shading, Atmospheric attenuation

Energy, Exergy, and Environmental (3e) Analysis of Clean Refrigerant Based Heat Pump for Hotel Application in India

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ABSTRACT

This study presents a comparative analysis of various low Global Warming Potential (GWP) refrigerants with GWP below 150, designed to supply hot water at 55°C for hotel application. Such application is perceived to have high demand in near future, especially in Indian context. The system is designed to fully meet the heating demand of 80 kW while partially utilizing its cooling capacity. Environmental impact assessment using Total Equivalent Warming Impact (TEWI) is carried out to evaluate the system's overall carbon footprint. The results indicate that in subcritical systems, the condensing temperature must be elevated to approximately 52–53°C to maintain 3K pinch point. Among all the refrigerants analyzed, R744 demonstrates the most advantageous temperature glide in the supercritical region, as heat rejection occurs in the gas cooling mode. Among the refrigerants analysed, R152a accomplishes the highest coefficient of performance (COP) of 4.96, while natural refrigerants such as RE170, R717, R600a, and R290 exhibited a lower but comparable performance. Exergy analysis further corroborates these findings, with R152a reaching a maximum exergy efficiency of 45.33%, closely followed by RE170 at 45.03%. Natural refrigerants RE170 and R717 exhibited the lowest TEWI values, reinforcing their potential as sustainable alternative for such application. The study concludes that natural refrigerants represent the most promising options, balancing energy efficiency and environmental impact.

Key words: Heat Pump; Pinch point analysis; Energy; Exergy; TEWI

Microencapsulated Phase Change Material Slurries for Cool Thermal Energy Storage

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ABSTRACT

In this study, in-situ polymerisation technique was employed for microencapsulation of ethyl cinnamate as phase change material (PCM) into polymer shell material. The obtained microcapsules exhibited near spherical morphology with size ranging from .8 μm to 2.5 μm. The differential scanning calorimetry test results show microcapsules has a latent heat of 42.6 J/g, with an onset melting temperature 4.2 °C. These microcapsules were dispersed in the carrier fluid in volume fraction of 0.1% to 0.5 % for preparation of slurries. The prepared slurry shown a maximum viscosity increase of around 3 % for volume fraction of 0.5 %. According to the experimental findings, the prepared slurry can be considered as an admirable heat transfer fluid for cool thermal energy storage for buildings.

Key Words: Microencapsulation, Phase change materials, Ethyl cinnamate

Evaluation of Roof Insulation Materials and Crop Residues for Mitigating Heat Stress in Livestock Shelters: A Dynamic Thermal Simulation Approach

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ABSTRACT

The livestock sector is a vital component of the Indian agricultural economy, yet it remains highly vulnerable to the impacts of climate change. Heat stress, resulting from inadequate shelter designs and the use of substandard materials such as tin, asbestos, aluminum, and zinc, is a significant challenge for livestock and poultry, especially in tropical and subtropical regions. Heat stress is significantly impacting livestock and poultry yield quality and quantity, reproduction, and comfort. This study investigates sustainable approaches to mitigate heat stress by evaluating two distinct strategies: (i) the use of roof insulation materials, such as polyurethane, expanded polystyrene, glass wool, etc., and (ii) the incorporation of crop residues, including those derived from pearl millet, paddy, barley, etc., to retrofit existing roofing materials. Dynamic simulations were conducted using EnergyPlus software to analyze the temperature trends within livestock shelters retrofitted with these materials. The study focused on a case study of an extensive livestock shelter in Pilani, Rajasthan, to assess the performance of each intervention in terms of (i) microclimate response and (ii) sustainability. The results revealed that polyurethane provided the most efficient insulation among commercial materials, while pearl millet crop residue emerged as the most effective sustainable option for regulating indoor temperatures. These findings underscore the importance of selecting appropriate materials to retrofit existing livestock shelters, thereby enhancing animal welfare, productivity, and resilience in the face of climate challenges, and ultimately enhancing farmers' income.

Key Words: Climate Change, Crop Residues, Dynamic Simulation, Heat Stress, Livestock, Roof Insulation, Sustainability, Farmer’s Income.

Lab Scale Experimental Observations On Flash Evaporation: Liquid Under Sub-Atmospheric Pressure

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ABSTRACT

Sub-atmospheric pressure flash evaporation is considered a promising method for rapid cooling and a significant rate of water vaporization. This article presents an experimental investigation for the detailed heat and mass characterization of a static water pool exposed to lower pressure. An experimental setup has been fabricated in the lab to investigate the effect of process parameters like initial temperature, initial vacuum tank pressure, and the water pool volume on the flashing characteristics. Results suggested that at higher initial temperature and lower initial pressure, a lower value of the equilibrium temperature obtained, and a more rapid temperature drop occurs. The initial height and superheat positively increase the evaporated mass and mass flow rate during the flashing.

Key Words: Evaporation, Phase change, Temperature, Superheat, Vacuum, Saturation.

Micro-Thermo-Fluidic with Integrated Heater for Temperature-Assisted DNA Amplification

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ABSTRACT

We present a novel integrated thermal management and DNA amplification system for molecular diagnostics on a polydimethylsiloxane (PDMS) substrate. The device allows for isothermal amplification at 37 °C in about 20 minutes, with Recombinase Polymerase Amplification (RPA) targeting the *oprL* gene to identify *Pseudomonas aeruginosa*. The amplification occurs in a microreactor under constant temperature conditions, and the resultant reaction solution is then tested using agarose gel electrophoresis to confirm the amplified template (540 bp). We propose a portable thermal management module with a sensor specifically suited for microfluidic systems requiring precise and efficient temperature control over the microreactor. This system is suited for applications that need precise heat management, such as cell lysis, polymerase chain reactions (PCR), and sterilisation.

Key Words: Microfluidics, Microreactor, Thermal Monitoring system.

Comparative Analysis of R600a, R125, and R22 Refrigerants Using MATLAB: Performance Insights for Future Applications

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ABSTRACT

This research investigates the performance of refrigerants R125, R22, and R600a for use in modern refrigeration systems, with a focus on sustainability and energy efficiency. Using MATLAB integrated with CoolProp, the study examines key performance metrics—such as Coefficient of Performance (COP), compressor work, and refrigeration effect—across various ambient temperatures. The findings highlight R600a's advantages, particularly in maintaining high COP values and lower compressor work at elevated temperatures, indicating its potential as an energy-efficient, low-GWP alternative to traditional refrigerants. The comparative analysis provides essential insights for selecting refrigerants based on application-specific energy requirements and environmental considerations, suggesting that R600a could serve as a practical, eco-friendly substitute in refrigeration and cooling technologies.

Key Words: Coefficient of Performance, Refrigeration Effect, Alternative Refrigerants.

Comparative Experimental Investigation of Fluid Flow Behaviour of Diverse Nano Fluid Flow Inside Concentric Tube Heat Exchanger Having Spiral Tube with or Without Diverse Inserts

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ABSTRACT

This study presents a comparative experimental analysis of heat transfer and fluid flow characteristics in a concentric spiral tube heat exchanger (CSTHE) equipped with various shaped inserts, including conical, hemispherical, and helical designs. The performance of the system was evaluated under turbulent counter-flow conditions using water as the working fluid. Cold water at 304 K with a flow rate of 0.725–2.955 L/min circulated through the spiral tube, while hot water at 333 K flowed across the shell at 4.025 L/min. Inserts were assessed for their influence on thermal performance, friction factor, Nusselt number, and effectiveness. The helical insert exhibited superior performance, enhancing heat transfer rate by 18.5% compared to a plain spiral tube and outperforming conical and hemispherical inserts by 15.5% and 11.5%, respectively. The study further explored nanofluids based on combination of Zinc Oxide, Aluminium Oxide, and Cupric Oxide with a 10 nm particle size and 0.08% volume fraction to evaluates the effect of nanofluids flowing inside concentric spiral copper tube heat exchanger (CTHE) equipped with optimum helical insert. Among the tested nanofluids, Aluminium Oxide and Cupric Oxide with water demonstrated the best thermal and fluid flow performance, achieving a maximum heat transfer rate of 3316.4 W, a Nusselt number of 160, and an effectiveness of 0.84. This comprehensive analysis highlights the potential of helical inserts and nanofluids to optimize heat exchanger performance.

Key Words: Concentric Spiral Tube Heat Exchanger (CSTHE), Nano Fluids, Inserts, Fluid Flow Behaviour, Thermal Performance.

Colburn 'J' Factor Analysis for Offset Strip Fins in Compact Heat Exchangers

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ABSTRACT

This paper discusses the development of a thermo-hydraulic correlation for rectangular offset strip fin compact heat exchangers, aimed at improving the accuracy of performance predictions. The research utilizes numerical modeling with ANSYS Fluent 2024, which is applied to analyze and validate existing empirical 'j' factor data. The study investigates the behavior of the 'j' factor in both laminar and turbulent flow regimes, identifying key trends that are plotted for a clear understanding of the heat transfer and fluid flow dynamics. Special attention is given to the influence of geometric parameters, including fin flow length (l), height (h), thickness (t), and spacing (s) as shown in Fig. 1 & 2, on the 'j' factor. Using these insights, the asymptotes of j are shown to be correlated by power law expressions in terms of the Reynolds number (Re) and the dimensionless geometric parameters. The resulting continuous expressions are applicable across both laminar flow ($300 \leq Re \leq 1500$) and turbulent flow ($2000 \leq Re \leq 6000$) regimes with air being used as the fluid medium for the analysis, providing a valuable tool for optimizing heat exchanger performance.

Key Words: Compact Heat Exchangers, Offset Strip Fins, Colburn factor, Friction factor, Correlation.

Performance Evaluation of Various Air Cycle Systems for Aircraft Environmental Control System Using Endo-Reversible Thermodynamic Model

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ABSTRACT

To save fuel and energy, the aviation sector is currently working to create sustainable technologies for aircraft systems. The environmental control system (ECS) utilizes an aircraft's air cycle refrigeration system (ACS) to regulate the temperature of the cabin and avionics, ensuring a pleasant environment. The aircraft cabin temperature and pressure are often controlled using engine-bleed air via an ECS. In this study, analytical correlations for the coefficient of performance (COP) were established using the endo-reversible thermodynamic model (ETM) literature to evaluate the performance of various ACSs. The thermal performance of ACSs can be precisely predicted using these analytical correlations without the need for system modelling and simulation. This is done by considering changes in operating conditions and input variables, such as the temperatures of fresh air, bleed air, and ram air, the ratio of the mass flow rates of fresh and ram air, and component parameters, such as the fan and compressor pressure ratios, and the primary and secondary heat exchanger efficiencies. The solutions revealed the mechanism of thermal power conversion in the ECS, which is helpful for component selection, ECS integration, and aircraft conceptual design.

Key Words: Coefficient of performance, Environmental control system, Endo-reversible thermodynamic model, Air cycle system.

Numerical and Experimental Investigations to Understand Melting Behaviour of Phase Change Materials in the Annular Space of Double Pipe Heat Exchangers Used as Thermal Energy Storage System

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ABSTRACT

Phase change Materials (PCM) based thermal energy storage systems has become one of the popular areas of research in recent times due to its affordable cost, easy availability, large cyclic stability, higher storage effectiveness etc.,. Geometry of the storage and angular position of PCM storage containers are investigated to understand the melting process and time. In the present work, melting behavior of PCM stored in the annular space of a double pipe heat exchanger is studied to understand the effect of angular inclination on melting behavior of PCM in the thermal energy storage system (TESS). Numerical simulation and experimental investigations are carried out to understand the melting behavior at 0O, 30O, 45O, 60O, and 90O inclinations. Investigations are also carried out to understand the effect of outer tube materials on melting behavior. The inclination angle influences the melting time and is observed minimum at an angle of 450. Copper as an outer shell material has taken minimum time to melt the PCM, but it is not suggested to use copper economically. Aluminium shows promising results for melting PCM faster in terms of economics, as copper is three times costlier than aluminium.

Key Words: Thermal Energy Storage System, Phase Change Material, Computational Fluid Dynamics

Colburn 'J' Factor Correlation Development for Microchannel Heat Exchanger

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ABSTRACT

Everyone is seeking for better, faster, and effective solutions in the energy conversion, storage, and recovery field. The microchannel heat exchanger (MCHE) is one the most promising filed as it is expected to grow to $37B in next decade from current $16B with forecasted cumulative average growth rate (CAGR) of 10%, due to various benefits like higher heat transfer rate, compact design, higher pressure sustaining capability, and higher surface to volume ratio [1]. An attempt has been made to explore different channel shapes and develop respective correlations for Colburn 'j' factor. In this research, detailed and robust methodology has been developed for virtual exploration by validating the numerical analysis results with old published data for the published geometry. Later this methodology has been used for the exploration of various shapes through 3-Dimensional computation fluid dynamics (CFD). The numerical output from detailed CFD, the correlations for the Colburn 'j' factor have been developed for all explored shapes.

Key Words: Heat exchanger, MCHE, Venturi channel, Converging-diverging channel, Micro heat exchanger, Forced convection, Microchannel heat exchanger, Numerical analysis, CFD-ACE

Health Monitoring of An Aircraft Environmental Control System Heat Exchanger

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ABSTRACT

An environmental control system (ECS) is one of the most complex flight-critical aircraft systems mainly used to regulate the cabin environment and avionics cooling. It consists of multiple components which are interdependent on each other. These components include valves, heat exchangers, cold air units, water separators, pressure & temperature sensors, etc. The wide variety of components also means higher chances of malfunctions. The control logic of the ECS is designed in such a way that it tries to regulate the output from a component within a specified range. The control logic of ECS can mask fault in any component. Typically, in an ECS, most aircraft limit the output temperature from the first heat exchanger within a certain range. This is because the ECS components downstream are designed to work within a stipulated range of temperature output. Lower output temperatures from heat exchangers can lead to undesirably low-temperature output or condensation in ECS components. Higher temperature output can affect the performance of ECS components and their material properties downstream. The temperature regulation is done by either an upstream bypass mixing valve or through a ram door actuator. This regulation of output temperature by the control logic of the ECS controller can mask faults in the ram door actuator and heat exchanger.

Key Words: Environmental Control System, Heat Exchanger, Fault, Control logic

Thermodynamic Analysis of only NH_3 And NH_3-CO_2 Cascade Refrigeration System in Context of Low Charge NH_3 for Indian Climate Conditions

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ABSTRACT

In the present scenario, the refrigeration industries are strolling due to the use of high Global Warming Potential Refrigerants. In this context, NH3 and CO2 are getting attention as eco-friendly and suitable refrigerants. However, the inferior performance of CO2 systems typically in warmer climates like India, and the toxic nature of NH3 become a major challenge. Therefore, the mid-way solution could be the use of NH3-CO2 combined which increases the performance as well as reduce the charge of NH3. This work compares the thermodynamic analysis of standalone ammonia refrigeration systems and CO_2/NH_3 modulation cascade systems under typical Indian climatic conditions. The performance of both systems was evaluated for five major Indian cities—Delhi, Ahmedabad, Bangalore, Chennai, and Kolkata—considering 25 distinct operating conditions. A detailed thermodynamic model was developed and simulated using MATLAB®, with refrigerant properties extracted from REFPROP 9.0 via a customized subroutine. The analysis focused on key performance indicators, including the coefficient of performance (COP), exergy efficiency, and Seasonal Energy Efficiency Ratio (SEER) with low charge NH3. The result reveals for the almost similar performance the char of NH3 can be reduced up to 20-22% at different operating conditions.

Keywords: Cascade System, CO_2-NH_3 modulation cascade, Low Charge NH3, Low GWP, Eco-friendly system

Influence of Enclosure Shape on MHD Nanofluid Flow Behavior and Entropy Generation in Geometrically Constrained Trapezoidal System

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ABSTRACT

This work examines the impact of the slope of the opposite wall in a sinusoidally heated porous trapezoidal enclosures with constant volume (square, trapezoidal, and triangular shapes) on the magneto hydrodynamic nanofluid (Al2O3-water) flow, heat transfer, and irreversibility, with the goal of optimizing thermal performance for various practical applications. The left vertical wall is heated sinusoidally and right opposite wall is cooled isothermally. The performance of the volume constrained thermal system is analysed using the finite element based solution technique. The analysis is carried out to scrutinise how the key factors such as frequency (f), and amplitude (A) of nonuniform heating, Rayleigh-Darcy number (Ram), Darcey number (Da), Hartmann number (Ha), and the orientation of the magnetic field (γ) influence heat transfer characteristics and entropy generation. The findings demonstrate that the geometry shape plays a crucial role in determining fluid velocity, heat transfer efficiency, and irreversibility. Trapezoidal systems outperform square ones, with triangular enclosures yielding the best thermal performance enhancement. The addition of nanoparticles improves heat transfer and fluid flow, especially at higher Rayleigh numbers. The magnetic field strength, represented by the Hartmann number, significantly affects the fluid dynamics and heat transfer rate, with stronger magnetic fields leading to reduced flow strength and lower heat transfer. The study also investigates the effects of various parameters on thermodynamic entropy generation. This research contributes to the understanding of heat dissipation behaviors and offers valuable insights for the design of effective cooling systems, such as those used in electronics and power generation.

Key Words: Trapezoidal thermal systems; Fluid volume constraints; MHD nanofluid flow; Heat transfer; Entropy generation.

Fluid-structure-thermal interaction study of a laboratory scale minichannel heat exchanger for moderately high temperature applications

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ABSTRACT

This paper is based on the fluid structure thermal interaction studies performed on the laboratory scale minichannel heat exchanger using ANSYS workbench 18.1 software. This heat exchanger is made of AlSi10Mg, and this study specifically aims to understand its structural characteristics at different operating conditions. The heat exchanger core consists of one each hot and cold channel networks, and each of these networks have 10 straight semicircular minichannels connected with diverging and converging triangular headers at the inlet and outlet. Hot inlet temperature has been varied from 50 ˚C to 150 ˚C keeping the same balanced flow rates and cold inlet temperature at 30 ˚C. Linear elasticity model predicts the maximum principal stress exceeds the yield stress of the material between 100 ˚C to 125 ˚C. The corresponding maximum deformation is found to be between 24.3 to 32.1 μm, both are located at the hot inlet header. However, a non-linear elasticity model predicts that the maximum principal stress does not exceed the yield stress even at 125 ˚C and at this condition, although the maximum deformation is found to be 57.6 μm, which is again, located at the hot inlet header. Based on the detailed analysis of the results, the linear elastic results have been chosen for estimating the safe operating temperature for the present heat exchanger which is equal to 100 ˚C.

Key words: Fluid structure thermal interaction; mini-channel heat exchanger; maximum principal stress; maximum deformation; safe operating temperature.

On the Role of Electric Conductivity During Interaction of Drops Under Electric Fields

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ABSTRACT

It has been experimentally observed that droplets with opposite charges do not coalesce under an external electric field. The capillary pressure inside the thin neck that forms when the droplets are near to each other has been attributed as the reason for non-coalescence. In this work, we aim to investigate the process of non-coalescence of oppositely charged droplets. Results show that switching of the direction of electric forces leads to pulling of the droplets which leads to non coalescence behavior. The underlying reason for switching the direction of electric forces is the charge transfer at the contact area between two droplets. Coalescence or non-coalescence depends upon the charge transfer rate relative to the action of capillary forces. It also depends upon the magnitude of the electric forces relative to the surface tension forces. Additionally, droplets that do not form sharp cone angles at the start of coalescence are finally pulled apart by the action of electric forces under sufficiently high electric field strengths. The current work has applications in the stability of emulsions, separation of water-crude oil, inkjet printing, electrospraying etc.

Key Words: Electrohydrodynamics, Non-Coalescence of drops, Electric field, Volume-of-fluid method.

Exploring Unaccounted Factors in Thermal and Ablation Dynamics of High-Speed Projectile Coatings

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ABSTRACT

Ablative materials are essential for thermal protection in high-speed aerospace projectiles, shielding them from extreme thermal and chemical environments. The ablation process involves material decomposition through pyrolysis and surface erosion, which is crucial for maintaining integrity during high-speed flight. However, many current ablation models simplify key factors, such as temperature-dependent material properties, radiation heat transfer, and changes in the flow field due to geometry evolution. This study explores the contribution of these factors to better address the predictions of heat transfer, pyrolysis rates, and material degradation. This analysis highlights the importance of incorporating these elements into ablation models, ensuring the development of more accurate and efficient thermal protection systems (TPS) for supersonic projectiles.

Key Words: Ablation, Heat Transfer, Pyrolysis, Supersonic Flow, Recession Rate.

Numerical Simulation of Solidification of a Droplet on Solid Surface in the Presence of Gaseous Phase

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ABSTRACT

In this paper, we develop a numerical method for three phase flows with phase change. The three phases involved are the solid, liquid and gaseous phase. Specifically, we simulate the solidification of a liquid droplet on a cold solid surface in presence of a gaseous phase. In our method, the interfaces among the three phases are captured with the help of Volume-of-fluid method. The Finite volume method is used for discretizing the governing equations. For solving the velocity field, the Bell-Collela-Glaz scheme (flux based advection scheme) is used. This scheme is 2nd order, unsplit, upwind scheme. Adaptive mesh refinement (AMR) technique is used for capturing the fine physics and reducing the computational cost in the simulation. The open source software, Basilisk (http://basilisk.fr/) is used for developing the numerical technique. Results on the shape of the droplet, velocity field, temperature distribution etc. at different times are discussed.

Key Words: Drop solidification, three phase flows with phase change, Volume-of-fluid method, Basilisk flow solve

Innovative and Sustainable Temperature Controlled Healthcare Logistic Solution

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ABSTRACT

Phase change materials (PCMs) are speciality materials capable of absorbing or releasing thermal energy during their transition between different phases. One notable application of PCMs is in the passive, temperature-controlled transportation of goods. Sustainable logistics fundamentally aims to enhance the sustainability of logistics processes, goods, and transportation methods while minimizing their environmental impact. This paper focuses on use of sustainable insulation packaging derived out of recycled PET Fibre derivatives as one of the functional units of passive temperature controlled logistic solutions. The insulation panels in combination with Phase changing materials (PCM) has been studied for a sustainable logistics solution for maintaining temperature of the payload volume in the range of 2-8°C for a minimum duration of 48 hours which upholds a great potential as vaccine carrier.

Key Words: Phase changing material, recycled insulation, healthcare logistics

Track:

Collaborative Efforts and Policy Integration

Evaluating Ethanol Blending Strategies for India: A Multi-Criteria Decision-Making Approach

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ABSTRACT

India faces growing energy challenges driven by increasing demand, environmental concerns, and economic dependencies on fossil fuel imports. This study investigates ethanol blending as a sustainable fuel strategy, evaluating its potential to address these challenges through economic, technological, environmental, and social dimensions. Using a hybrid multi-criteria decision-making (MCDM) framework, the research combines the Analytic Hierarchy Process (AHP) to prioritize evaluation criteria and the VIKOR method to rank ethanol-petrol blends (E5, E8, E10, and E12). Expert insights and stakeholder inputs enhance the framework's practical relevance. The findings identify E10-a 10% ethanol blend-as the optimal alternative, offering balanced advantages across all evaluated dimensions. Economically, E10 avoids costly infrastructure overhauls by leveraging existing fuel systems. Technologically, it competes with most internal combustion engines and current distribution networks. Environmentally, E10 reduces greenhouse gas emissions by up to 20% compared to pure petrol, contributing to India's climate commitments. Socially, ethanol blending supports rural economies by utilizing agricultural residues, mitigating stubble burning, and improving public health by lowering vehicular emissions. While the study focuses on specific blends, it acknowledges further need to explore higher ethanol concentrations, such as E20, to uncover additional opportunities and challenges. Limitations also include the reliance on expert driven subjectivity in the decision-making process. Future research should expand stakeholder engagement and assess the scalability of higher ethanol blends. This research provides a novel application of the AHP-VIKOR methodology, offering a structured evaluation framework for ethanol blending strategies in India and similar developing countries. Balancing practical trade-offs with stakeholder-driven insights bridges a critical gap in the literature on renewable energy solutions, providing actionable guidance for policymakers and industry leaders aiming to achieve sustainable energy goals.

Key Words: Ethanol blending, Multi-criteria decision-making (MCDM), AHP, VIKOR, Renewable energy, Fossil fuel alternatives, Environmental sustainability.

Fostering Agricultural Unity: Digital Technologies for Collaboration Re-interpreted.

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ABSTRACT

This study aims to evaluate and rank emerging digital technologies, such as blockchain, IoT, and artificial intelligence (AI), in improving collaboration within agricultural supply chains. The study focuses on critical collaboration-enhancing criteria, including transparency, information sharing, stakeholder accessibility, and trust-building, to guide technology adoption for efficient and sustainable agricultural supply chain management. The research employs a multi-criteria decision-making (MCDM) framework integrating expert judgment and advanced analytical methods such as the Analytic Hierarchy Process (AHP). Criteria for ranking are identified through an extensive literature review and validated by industry experts. Data is collected through structured interviews with stakeholders in agricultural supply chains, including farmers, cooperatives, and technology providers. The study is limited to expert evaluations, which may not fully generalize across diverse geographical and operational contexts. Future research should explore larger datasets and cross-regional comparisons to validate findings further. This research provides actionable insights for policymakers, cooperatives, and agribusinesses, enabling targeted investments in digital technologies that address key collaboration challenges. The ranking framework can guide strategic decisions to optimize technology adoption and improve supply chain performance, especially for smallholder farmers and resource-constrained stakeholders. This study is novel in providing a structured ranking of digital technologies based on collaboration-specific criteria tailored to agricultural supply chains. Unlike existing studies that examine technologies in isolation, this research integrates a comparative framework that evaluates the relative effectiveness of technologies in fostering transparency, trust, and collaboration. The findings contribute to the growing discourse on digital transformation in agriculture and offer a valuable roadmap for achieving smarter, more connected supply chains.

Track:

Case Studies and Best Practices

Greening Mind for a Greener Future: Utilizing Deep Learning for the Reconstruction and Preservation of Shekhawati Heritage Paintings

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ABSTRACT

As the world grapples with the impacts of climate change and the degradation of cultural heritage, the intersection of technology and environmental sustainability becomes increasingly vital. This paper explores the innovative application of deep learning algorithms in the reconstruction and preservation of heritage paintings found in the Shekhawati Havelis of Rajasthan, India. These exquisite murals are not only artistic treasures but also crucial to understanding the region's historical and cultural identity. Proposed study emphasizes a "greening mind" approach, aiming to utilize technology for reconstruction and preservation of the heritage paintings in Shekhawati region. The authors will explore the critical painting sites and draw the insights for their effective restoration. The proposer will have a MFM methodology that includes analysis of different painting styles and also the application of deep learning algorithms to felicitate the restoration and preservation. As a process the authors will also take the advantage of the dataset composed of high resolution images of intact murals. The proposed study will contribute how modern technology can support cultural sustainability, prioritize environmental considerations and foster a greening mind for the future.

Key Words: Deep learning, heritage painting, Shekhawati Haveli, art preservation, sustainable practices, cultural heritage

Evaluating Portfolio Optimization Techniques in The Green Economy: A Case Study of Renewable Energy Stocks in the Indian Market

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ABSTRACT

Proper investment strategies in renewable energy sectors can help to make a smooth transition towards a greener economy. This paper aims to select a portfolio optimization technique that could be used in developing sustainable portfolios. A set of 10 renewable energy stocks from the Indian market was select ed, and a comparison of the traditional approach known as Modern Portfolio Theory with entropy maximization—the new approach that would give preference to diversification and minimize uncertainty— was performed. Using two years of historical data (2023-2025), the study compares asset weights for five different portfolios created by five different strategies, one MPT, one minimum risk and three entropy maximization techniques, and applies stress testing and back testing to evaluate portfolio performance under adverse market conditions and previous market conditions. Maximum entropy & minimum risk portfolio technique has proven to be the best strategy with an annualized return of 56.53%, a volatility of 26.16%, and a Sharpe ratio of 2.16 with backtesting and moderate resilience in stress testing across crash, volatility spike, and rate shock scenarios for balanced investors. The maximum entropy, maxi mum return and minimum risk portfolio technique proves to be best suited for risk-aware investors with a 50.88% return after backtesting and good resilience in stress testing. The MPT Portfolio gives an annualized 42.84% return with backtesting and with moderate resilience, making it suitable for aggressive investors. For conservative investors, a minimum-risk portfolio proves to be the best with the least volatility of 25.49% after backtesting and excellent resilience with stress testing. This work aims to contribute towards the emerging field of sustainable finance, focused critically on the role that portfolio optimization plays in directing capital to environmentally responsible investments.

Key Words: Portfolio Optimization, Green Economy, Entropy Maximization, Renewable Energy Stocks, Stress Testing

Smart Vibrating Beam – An Innovative Educating Tool For Active Vibration Controls

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ABSTRACT

As the structures are being optimized further by utilizing lightweight materials, thinner (optimized) cross-sections, their dynamic responses have become crucial for structures sustainability. To improve their systems dynamic response such as minimal vibrations, several new techniques are being explored in mechanical and civil industry utilizing the smart materials. It makes it imperative for engineers to know the fundamentals of smart materials. However, there is a clear gap between the field of engineering education to introduce smart materials to students via hands-on demonstrations. This results in graduates with just theoretical knowledge of smart materials, which limits to development and deployment of innovative smart material systems. This paper discusses the functionality of the smart vibrating beam (SVB) integrated with piezoelectric actuator and sensor, highlighting its potential as innovative teaching tool. It is crucial for future engineers and designers to understand the system dynamics and methodologies to control these vibrations. The SVB is a hands-on device for the purpose and a precursor to various applications related to vibrations using piezoelectric elements (a smart material). The developed SVB consists of a vertically suspended cantilever beam made of stainless steel with piezo-electric sensor and actuators attached near its base to sense and control the vibrations, respectively. In the system, the piezo actuator can expand and contract to cause stress loading and unloading in the beam which can cause or dampens the vibrations produced in the beam. The piezo sensor near beam senses the vibration amplitude to provide the feedback to control system for corrective actuation of the piezo actuator for vibration suppression. The present work visually demonstrates both the commencement and suppression of vibration of a cantilever beam using piezo transducers. Visual aid shall help students learn the fields such as smart material (piezo), instrumentation, system dynamics and controls. The demonstration will provide an alternative to verbal explanations and has potential to help students make abstract ideas more concrete. The SVB can become an effective teaching tool for students in field of civil, mechanical, and electrical engineering.

Key Words: Smart Materials, Piezo, Vibration Controls

From Manufacturing to Marketing: Enhancing University Students' Advertising Literacy to Combat Greenwashing

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ABSTRACT

Green marketing involves sustainable principles to promote products or services that are environmentally friendly, have a positive impact on the planet, and create a brand image. However, these days, through false claims and misleading labels, greenwashing deceives consumers and undermines the effort to reduce emissions and address the climate crisis. To tackle the situation, consumers must be able to identify legitimate claims of sustainable practices to make informed and eco-friendly purchases. Thus, this study examines the journey of sustainability claims from manufacturing processes to marketing communications and highlights the role of education in fostering critical thinking skills. The authors employed a pre-post experimental design to assess the impact of advertising literacy measures on greenwashing awareness among college students. The study was conducted on college students as they enter into the age of independence and make decisions for themselves. They need to be educated in informed product consumption. In this methodology, students in the intervention group received training to increase their ability to identify greenwashing tactics, while a control group received no intervention. This design aims to equip the students with the tools to discern genuine environmental initiatives from deceptive tactics and build a more informed and skeptical consumer base capable of holding companies accountable and promoting authentic sustainability efforts in the market. The findings indicate that advertising literacy plays an important role in improving students' ability to identify greenwashing tactics. Integrating MIL in the classroom generates critical thinking and informed consumer behaviour. The research aims to guide the changes in existing policies and set an example of how to put educational efforts into supporting genuine corporate accountability.

Key Words: Green Marketing, Greenwashing, Advertising Literacy, Sustainability, College Students

Numerical Analysis on Heat Transfer Characteristics Over a NACA2412 Airfoil

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ABSTRACT

A comprehensive study was conducted to investigate the heat transfer and drag variations over a NACA2412 airfoil. A 2D computational fluid dynamics (CFD) simulation was performed to simulate realistic aerodynamic and thermal conditions over the airfoil under varying flow conditions and angles of attack using ANSYS Fluent 2024 R2. The net force acting on the airfoil due to air can be divided into two components, lift force and drag force. The Drag Force opposes the motion of the airfoil against the airflow, whereas the Lift Force is generated against the direction of gravity. The Drag force acting on an airfoil depends on a geometry-dependent coefficient called, drag coefficient. However, the drag coefficient varies with changes in Reynolds number and is dependent on the surface temperature and the surface characteristics of the airfoil. Hence, understating the heat transfer characteristics such as the Nusselt number over an airfoil surface is necessary. The Drag and Lift coefficients have then been computed at different attack angles for 2 different Reynolds numbers. Optimising more Lift-to-Drag ratio can be vital in improving fuel efficiency. The Lift-to-drag ratios have been calculated to find the optimal attack angle. The variation of the Nusselt number with Reynolds number is also computed. From the numerical simulations, the Drag coefficient increases with an increase in the angle of attack, and the Lift Coefficient increases till it reaches a stall angle of around 16 degrees. The optimal angle for the NACA2412 airfoil can be observed around 10 degrees. The Nusselt number increases with an increase in the Reynolds number. Our study provides insights on the interaction between aerodynamics and heat transfer, and determine critical angles of attack where lift can be maximized or where stall occurs, helping in the design of efficient airfoils.

Key Words: Drag Coefficient, Lift Coefficient, Angle of attack, Nusselt number, Reynolds number

Solar Assisted Fluidized Bed Drying Process for Pearl Millet: A Sustainable Approach

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ABSTRACT

This study investigates the utilization of a solar photovoltaic (PV) assisted fluidized bed dryer for drying various agricultural produces under diverse operating conditions. Specifically, the research focuses on examining the effects of different parameters such as moisture percentage, weight percentage, and operating temperature on power consumption. The experimental setup involves subjecting different agricultural products to drying processes within the fluidized bed dryer, with the assistance of solar PV technology. Through systematic experimentation and analysis, the study aims to observe how variations in moisture content, weight, and temperature impact the efficiency and energy consumption of the drying system. By optimizing these operating parameters, the research seeks to minimize power consumption while maintaining optimal drying performance. The findings from this investigation hold significant implications for enhancing the sustainability and cost-effectiveness of drying processes for various millets such as pearl millet, particularly in regions with abundant solar energy resources. Overall, this research contributes to the advancement of renewable energy integration in post-harvesting process, offering insights into the optimization of solar PV assisted drying technologies for diverse agricultural produce under varying operating conditions.

Key Words: Solar PV, Fluidized Bed Dryer, Pearl Millet Drying, Sustainable Post-Harvest Operations.

Service Quality and Price Perception Of B2C Supply Chain Among Student Community

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ABSTRACT

This paper aims to implement Structural Equation Modeling in Analysis of Moment Structures to predict and interpret customer satisfaction at Amazon, using service quality and price perception as key determinants. This study is conducted as a survey in BITS Pilani taking data from 172 students of BITS Pilani. The students answered a questionnaire containing 16 questions on services offered by Amazon. The model predicts customer satisfaction, with added attention to price sensitivity for generally price-sensitive consumers (university students), providing insights into the impacts of service quality and price perception on customer satisfaction at college (BITS Pilani) where online shopping is the most preferred method of shopping. SEM compares how customer service and pricing models affect customer satisfaction differently for students at BITS Pilani based on their varying needs, providing insights into need-specific customer behavior. The findings show that the SEM Model is overall a good fit. It indicates that Ease of Returns is the dominant factor in customer satisfaction, showing the requirement for a highly efficient returns process. Responsiveness follows closely addressing the importance of quick communication and issue resolution. Competitive Pricing reflects students' price sensitivity, requiring the importance of effective pricing strategies for sustained competitiveness. Delivery Speed, while less influential, remains a key element for meeting customer satisfaction. To the best of the author's knowledge, the current study is the first of its kind related to analyzing customer satisfaction for Amazon from internal as well as external parameters in an area with high demand for online shopping services. This research will examine the impact of Delivery Speed, Responsiveness, Ease of Returns and Competitive Pricing each having their own four observed variables on Customer Satisfaction using AMOS. This paper provides insights from model analysis to help improve Amazon’s customer service strategies for continued loyalty and satisfaction in the highly competitive e-commerce landscape with other competitors like Myntra, Flipkart, Ajio, E-kart.

Key Words: Customer satisfaction, Service Quality, Price Perception, Customer Retention

RGA with RWUP for Sustainable Future

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ABSTRACT

In the automotive industry, two major factors influence a customer's decision while purchasing a vehicle: 1. Vehicle Reliability 2. Service Cost The brand image is largely built upon these two key aftermarket elements. All Original Equipment Manufacturers (OEMs) focus heavily on these parameters. Industries conduct extensive validation, testing, and design verification at both the component and vehicle levels to meet all reliability and regulatory requirements. However, even after successfully meeting these requirements, a product's success or failure ultimately depends on customer experience and word-of-mouth publicity. To address this, a study has been conducted to validate vehicle performance based on Real World Usage Patterns (RWUP).

Key words: vehicle reliability, service cost, sustainability

Comparative Analysis of Machine Learning Models for Prediction of Maize Production

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ABSTRACT

Accurate prediction of crop produce is essential for effective farm management and policy decision-making. This study investigates the comparative predictive capabilities of four distinct machine learning techniques in forecasting maize production. This study evaluates the performance of four machine learning models in predicting Maize production using non-farmer-controlled variables. Data collected was from five of the highest maize producing states of India. Machine learning models were implemented using predictive analytics module of Minitab Software. The best model in terms of R-squared value was found to be Multivariate Adaptive Regression Splines (~85%), followed by Multiple Regression, TreeNet Gradient Boosting, Random Forest and Classification & Regression Trees. Farmer controlled variables such as irrigation frequency, type of seed used, etc were not considered. The study only finds the impact of non-farmer-controlled variables.

Key Words: Agricultural Supply Chain, Comparative Analysis, Machine learning, Gradient Boosting, Random Forest

Robust Checks for the Product Build, Concern Tracking and Resolution During its Lifecycle

Amol Wagh, Prajact Yadav, Pramod Patil, Issac Jayakumar

ABSTRACT

The product development in Automobile industries faces numerous challenges during the vehicle development & production process. One of the significant concerns is the tracking and management of vehicle build issues. We propose a systematic approach to track and manage vehicle build concerns, ensuring timely identification, analysis, and resolution of the problems consequently leading to reduced losses in terms of time, rework, money, and material.

Importance of GNOVA-C in Automotive for Defect-Free Product

Prakash Dharkar, Soham Brahme, Pramod Patil, Issac Jaykumar

ABSTRACT

A product undergoes several quality audits / Checks during it's lifecycle of development. Though quality improvement is continuous process, timely part quality maturity helps in achieving sustainable results and lesser rejections. So timely or advanced quality defect reduction is imperative.

CRF- Clamping with Care, Routing innovation & Drive with Confidence for Greener Automotive

Kulbhushan Dalal, Pramod Patil, Issac Jayakumar, R Surendra

ABSTRACT

CRF (Clamping, Routing, Fouling) is one of important parameter in Vehicle design & Customer Quality. Now a days Automotive is more equipped greener vehicles with ECU (Electronic Control unit), High voltage, Low voltage cables & Software. To interconnect these ECU(s) need a complicated skeleton of wiring harness. Major challenge is to Package such a complex wiring skeleton along with Mechanical & Electronic components. In case of any failure of wiring because of touching, rubbing, clamping & pulling leads to functionality failure of component as well as consequences failure of relative component(s). this will be effect on Customer(s) by Safety, thermal incidence, immobilization, Unscheduled dealer visit, discomfort because of walk to home failure & Premium feel. Find out root cause & repair is very difficult in such case considering time, effort & cost.

Scenario analysis of alternate fuels and technology mix for automobile sustainability: Case study of India

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ABSTRACT

Sustainable automobile solutions are imperative for reducing harmful greenhouse gas (GHG) emissions, air pollution and combating climate change. Conforming to the global trends, India is aggressively pursuing zero emission technologies like fully electric vehicles (FEVs) and hydrogen fuel cell vehicles (FCEVs). Simultaneously it is promoting low emission alternate fuels like compressed natural gas (CNG), biofuels and technologies like hydrogen-powered vehicles (HPVs), fully hybrid vehicles (HEVs). These alternate fuel and technology mix solutions apart from bolstering sustainability, must also encompass reliability, cost-effectiveness, circularity, longevity and mainly optimality. To address above challenges, this case study for India adopts a scenarios analysis for deriving the optimal alternate fuels and technology mix till year 2035.

Key words: Scenario analysis, optimal alternate fuel and technology `mix, study model, TOPSIS, net zero targets.

Automotive Lighting Design and Policy Framework for Product Lifecycle End of Life -A Case Study

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ABSTRACT

The automotive lighting design with modern advancements incorporating LEDs, OLEDs, and adaptive systems that enhance vehicle aesthetics and safety. Amalgamation of these technologies and innovations also introduce complexities in manufacturing and process design. The Product Lifecycle End-of-Life (EoL) management, particularly within the European regulatory framework that emphasizes sustainability and circular economy principles; necessitates a comprehensive approach to EoL management, aligning with policy and regulatory frameworks that promote sustainability and circularity.

Key Words: End of Life, Modular Design, Design for Disassembly, Mono-material, Hazardous substances.

Design and Development of Fodder Pellets Using Locally Available Leaves for Livestock Feeding: A Sustainable Approach

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ABSTRACT

Open burning of crop residues and leaves is a common practice in many agricultural regions, contributing significantly to air pollution and the release of harmful greenhouse gases. This research aims to address these environmental challenges by designing fodder pellets using locally available leaves and crop residues. The study explores the potential of converting agricultural waste into a sustainable, low-cost, and nutritious source of fodder for livestock. By utilizing locally sourced materials, this approach not only reduces the environmental impact of open burning but also provides a consistent, year-round supply of fodder, benefiting farmers who often struggle with seasonal shortages of feed. The pelletization process involves selecting and processing various leaves and crop residues to produce compact, durable, and nutrient-rich pellets. These pellets are tested for their suitability as livestock feed, ensuring they meet the nutritional needs of animals. The research also focuses on optimizing pelletization parameters to maximize efficiency and minimize production costs. By reducing reliance on expensive commercial fodder and utilizing locally available materials, farmers can lower feed costs while maintaining livestock health and productivity both in terms meat and milk which in turn will enhance farmer income. This approach aligns with the broader objective of doubling farmer incomes by promoting value-added agricultural practices that are both environmentally and economically beneficial. This work discusses the various aspects of the solution and environmental sustainability. The use of locally available leaves and residues for fodder pellet production presents a viable, low-cost, and eco-friendly strategy that benefits farmers, livestock, and the environment.

Key words: Crop residue, pallets, livestock, sustainable practice, envirnomental sustainability

Green Hydrogen Production Potential and its Supply Chain in India

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ABSTRACT

Green hydrogen stands out as an appealing alternative to the existing carbon-based energy system. It can be generated from various renewable sources and serves as a carbon-free energy carrier suitable for industrial, residential, and transportation applications. This study conducts a comprehensive and critical review of prior research on the green hydrogen economy, utilizing multiple databases such as Scopus and Web of Science, along with other published materials. It provides an in-depth analysis of India's green hydrogen value chain. Moreover, the study identifies key sectors where green hydrogen can be strategically leveraged as a powerful economic and political instrument to build smart and sustainable cities and communities. It also outlines policy recommendations aimed at benefiting stakeholders, including government entities, industry collaborators, and research organizations. India requires actionable strategies to stimulate green hydrogen demand in critical sectors such as shipping, road transport, steel production, fertilizer manufacturing, refineries, and other industries. The government must offer targeted support and financial incentives to encourage the commercial production of green hydrogen. Establishing a robust green hydrogen value chain will create additional employment opportunities, decrease reliance on fossil fuel imports, reduce trade deficits, eradicate energy poverty, foster energy inclusion, lower greenhouse gas emissions, and enhance energy governance. This study examines the potential of green hydrogen to enable India to achieve energy independence and self-sufficiency. By integrating technological innovations, economic assessments, and policy frameworks, it provides a detailed exploration of India's green hydrogen landscape. The review focuses on reductions in electrolyzer costs, opportunities for renewable energy integration, and the socio-economic advantages of adopting green hydrogen.

Key words: Green Hydrogen Production, Sustainable Production, Hydrogen Supply Chain

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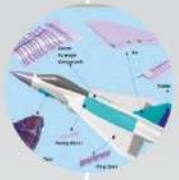

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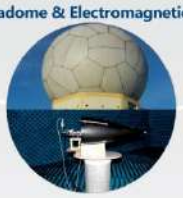

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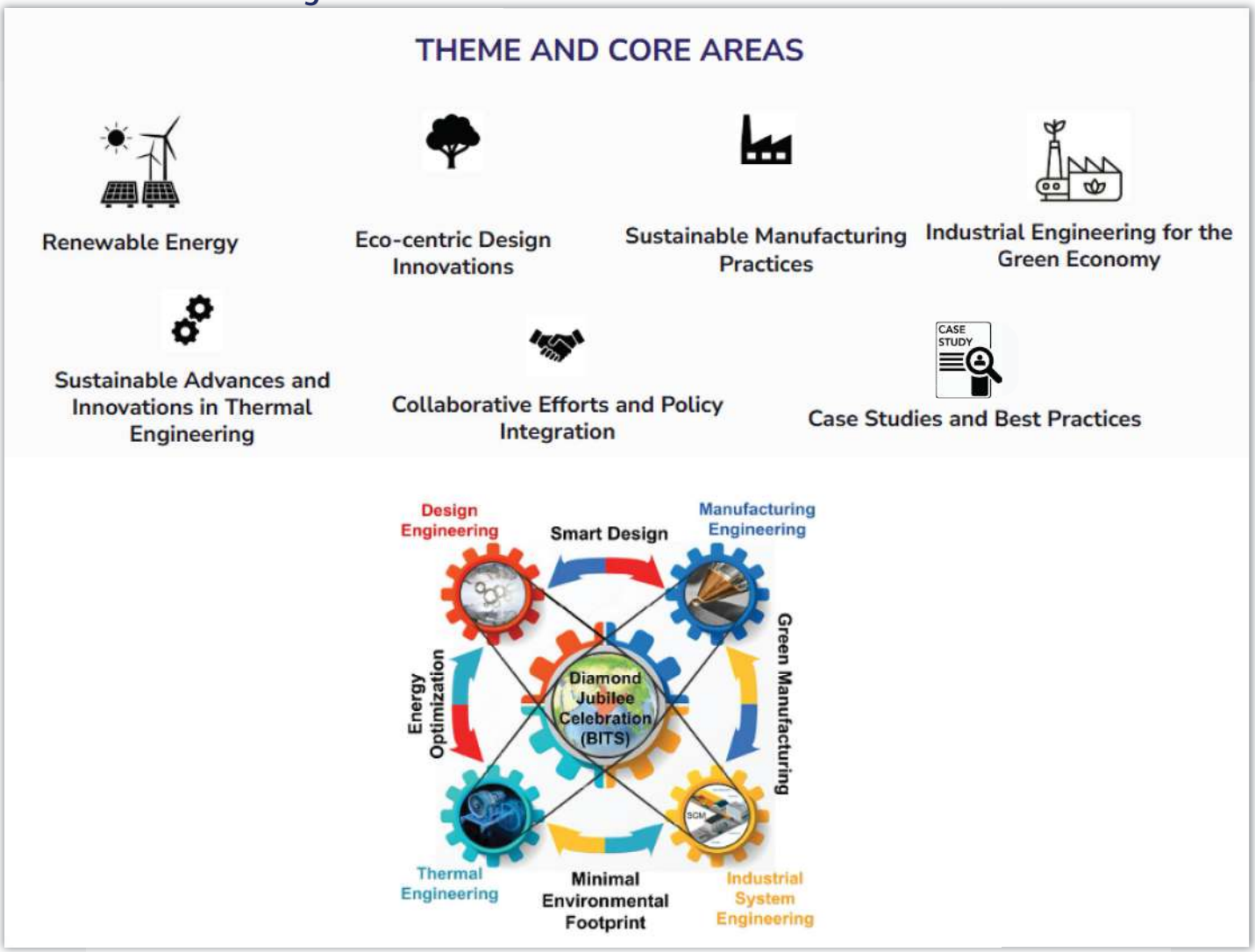

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