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Advanced and Smart Sustainable Materials

Advanced Manufacturing Techniques

Advanced Mechanical Engineering Systems

Advanced Mechatronics Systems

Sustainable Energy Resources and Policies



ABSTRACTS OF PAPERS OFFERED TO THE CONFERENCE ICAM4E – 2025



Message from Organising Secretary

On behalf of the organising committee, I would like to cordially welcome you all to International Conference on Advances in Materials, Manufacturing, Mechanical, Mechatronics, and Energy 2025 (ICAM4E – 2025). Organising committee has been working very hard and arrangements are well under way to ensure that the ICAM4E – 2025 conference is a resounding success. Eminent keynote and plenary speakers are going to present their view in different perspectives. I hope that the Conference Proceedings will serve as a comprehensive compilation of the present knowledge and experience and will be used widely by engineers and designers who are concerned with the subjects. The success of the conference depends ultimately on the many people who have worked with us in planning and organising this technical program. The organising committee has left no stone unturned to ensure that the conference turns out to be an occasion from which all of you carry back long lasting memories of not just scientific excellence but also warm hospitality.

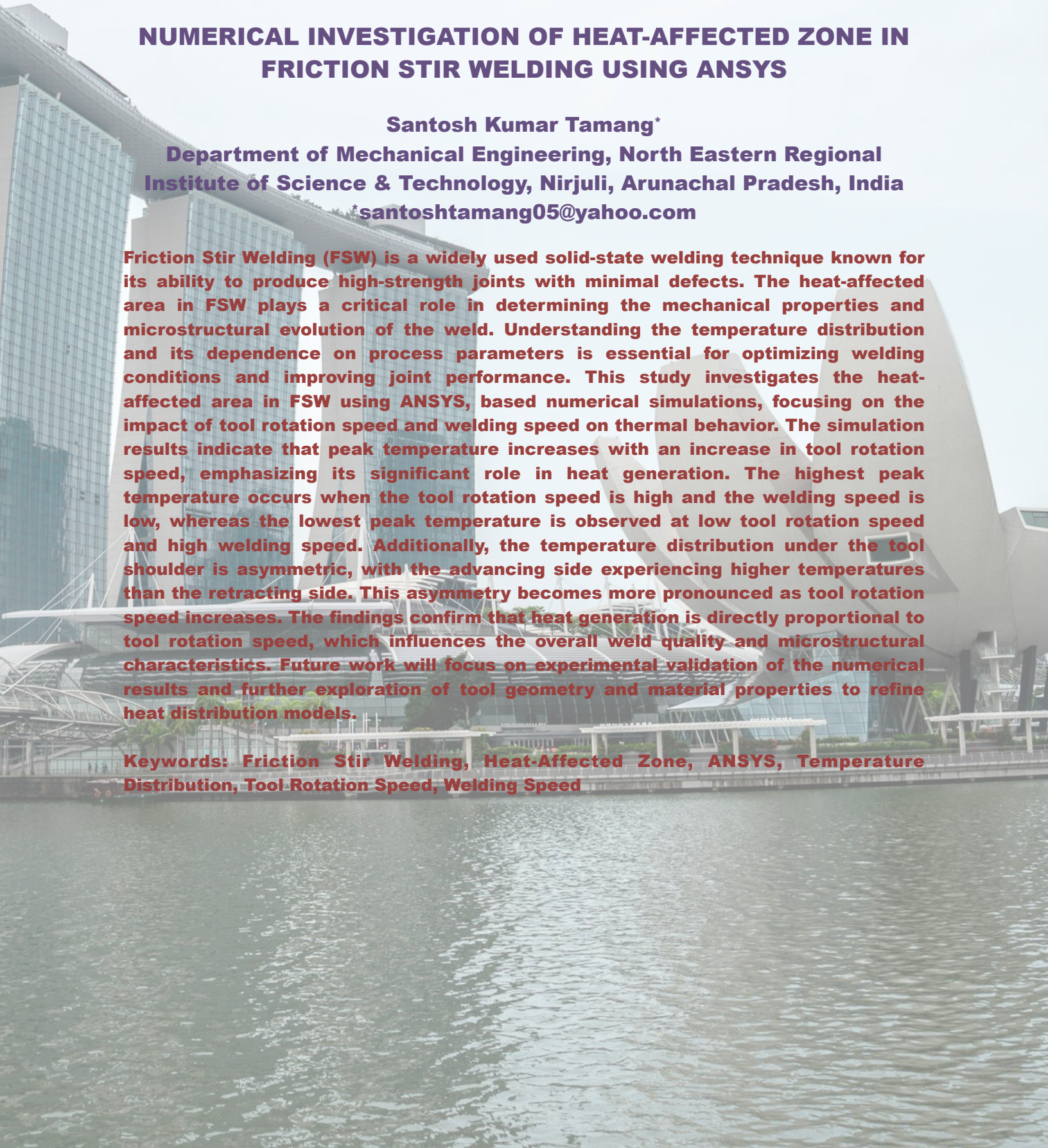
I invite all of you (academician/researchers/industry professionals/ students) working in the research fields related to Materials,

Manufacturing, Mechanical, Mechatronics, and Energy to participate and attend the event and make it a grand success. I look forward to welcome you in Singapore in August 2025.

Regards

Dr. Vishal Vasistha PhD
Organising Secretary
ICAM4E - 2025
Laescuela Education





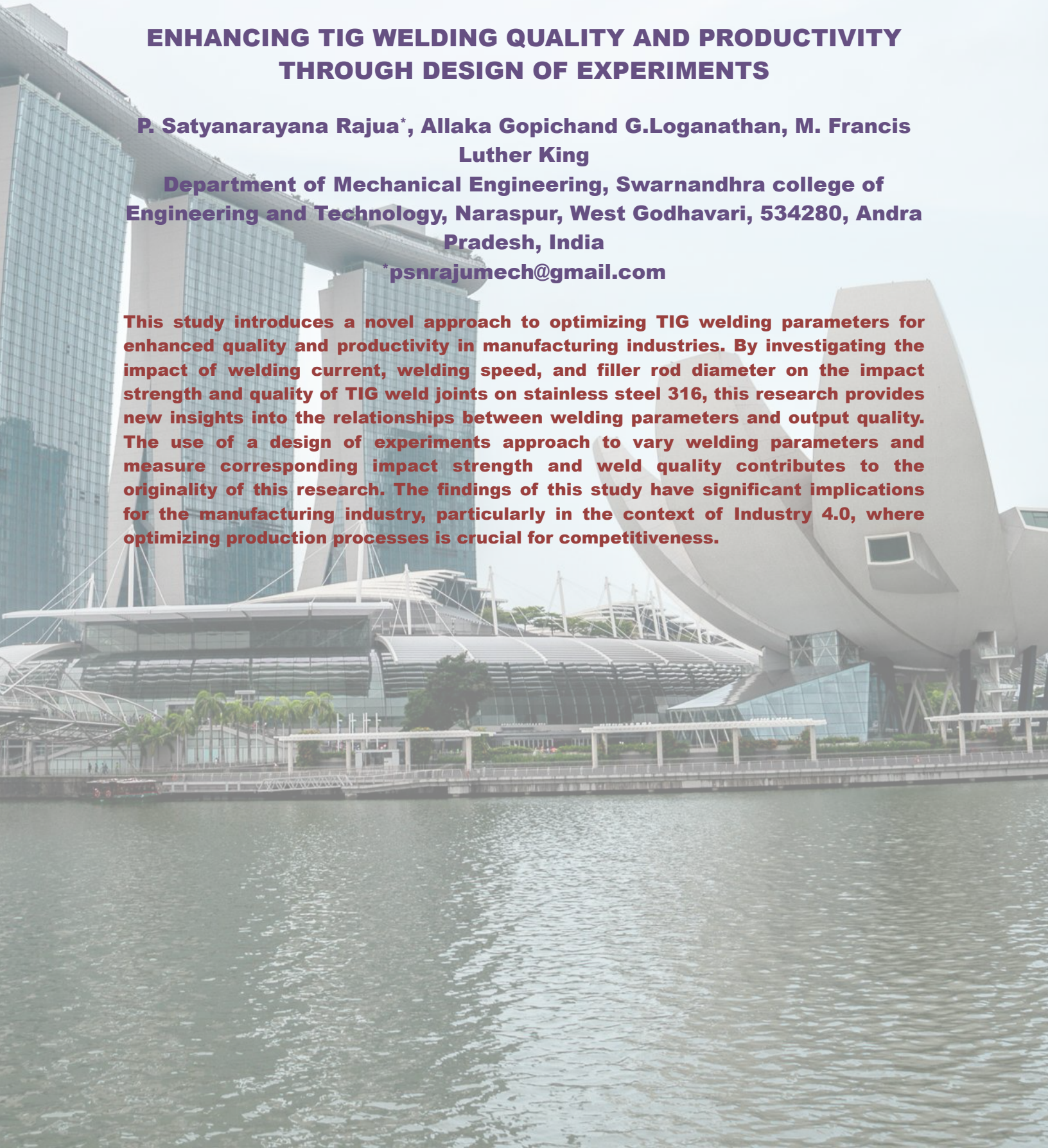
ICAM4E_2025_001

NUMERICAL INVESTIGATION OF HEAT-AFFECTED ZONE IN FRICTION STIR WELDING USING ANSYS

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Friction Stir Welding (FSW) is a widely used solid-state welding technique known for its ability to produce high-strength joints with minimal defects. The heat-affected area in FSW plays a critical role in determining the mechanical properties and microstructural evolution of the weld. Understanding the temperature distribution and its dependence on process parameters is essential for optimizing welding conditions and improving joint performance. This study investigates the heat-affected area in FSW using ANSYS, based numerical simulations, focusing on the impact of tool rotation speed and welding speed on thermal behavior. The simulation results indicate that peak temperature increases with an increase in tool rotation speed, emphasizing its significant role in heat generation. The highest peak temperature occurs when the tool rotation speed is high and the welding speed is low, whereas the lowest peak temperature is observed at low tool rotation speed and high welding speed. Additionally, the temperature distribution under the tool shoulder is asymmetric, with the advancing side experiencing higher temperatures than the retracting side. This asymmetry becomes more pronounced as tool rotation speed increases. The findings confirm that heat generation is directly proportional to tool rotation speed, which influences the overall weld quality and microstructural characteristics. Future work will focus on experimental validation of the numerical results and further exploration of tool geometry and material properties to refine heat distribution models.

Keywords: Friction Stir Welding, Heat-Affected Zone, ANSYS, Temperature Distribution, Tool Rotation Speed, Welding Speed



ICAM4E_2025_002

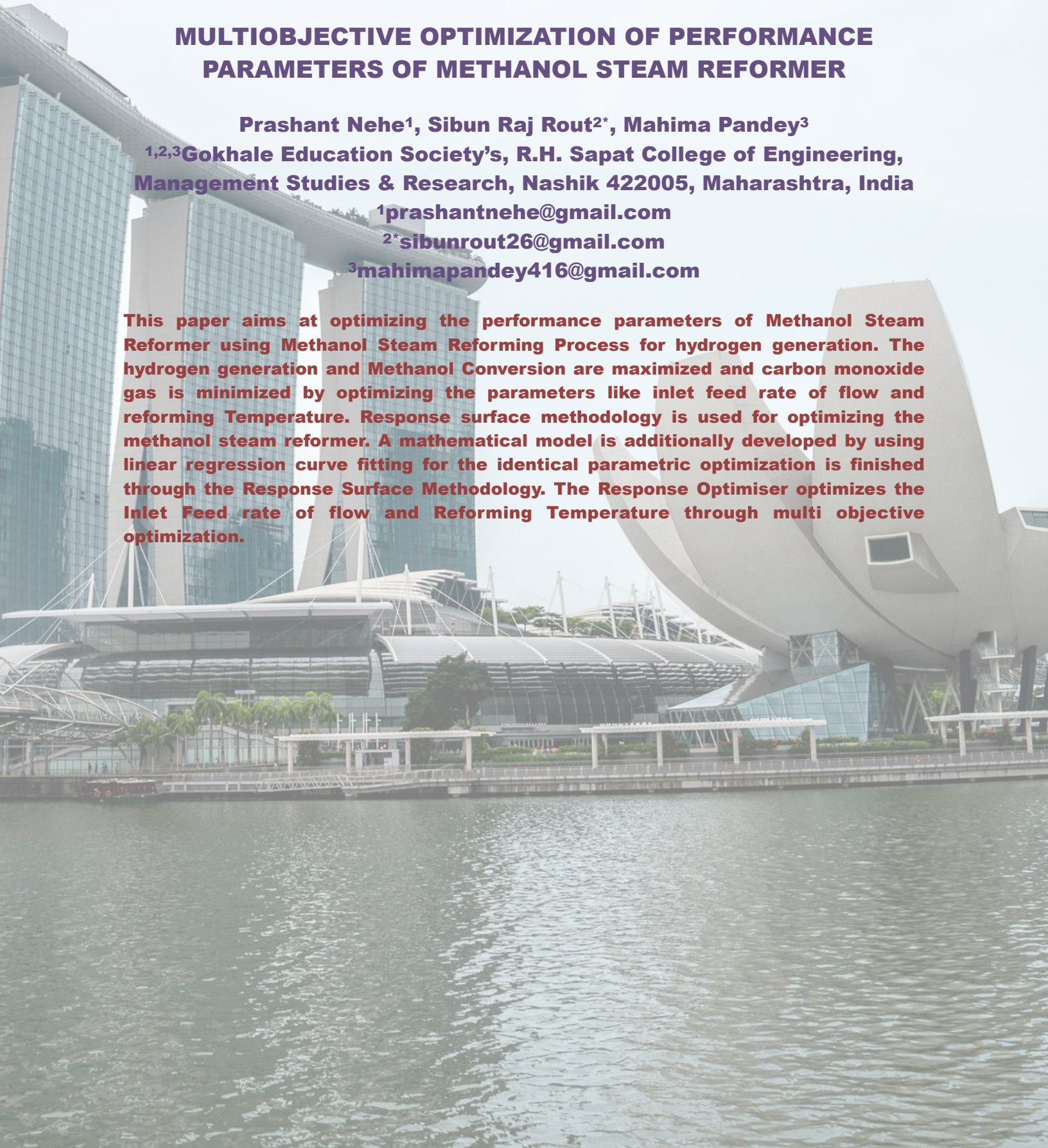
ENHANCING TIG WELDING QUALITY AND PRODUCTIVITY THROUGH DESIGN OF EXPERIMENTS

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This study introduces a novel approach to optimizing TIG welding parameters for enhanced quality and productivity in manufacturing industries. By investigating the impact of welding current, welding speed, and filler rod diameter on the impact strength and quality of TIG weld joints on stainless steel 316, this research provides new insights into the relationships between welding parameters and output quality. The use of a design of experiments approach to vary welding parameters and measure corresponding impact strength and weld quality contributes to the originality of this research. The findings of this study have significant implications for the manufacturing industry, particularly in the context of Industry 4.0, where optimizing production processes is crucial for competitiveness.



ICAM4E_2025_004

MULTIOBJECTIVE OPTIMIZATION OF PERFORMANCE PARAMETERS OF METHANOL STEAM REFORMER

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This paper aims at optimizing the performance parameters of Methanol Steam Reformer using Methanol Steam Reforming Process for hydrogen generation. The hydrogen generation and Methanol Conversion are maximized and carbon monoxide gas is minimized by optimizing the parameters like inlet feed rate of flow and reforming Temperature. Response surface methodology is used for optimizing the methanol steam reformer. A mathematical model is additionally developed by using linear regression curve fitting for the identical parametric optimization is finished through the Response Surface Methodology. The Response Optimiser optimizes the Inlet Feed rate of flow and Reforming Temperature through multi objective optimization.

ICAM4E_2025_006

NEXUS BETWEEN AGRICULTURAL CARBON FOOTPRINTS, ARABLE LAND AND FOOD SECURITY IN SOUTH AFRICA: AN EMPIRICAL ANALYSIS

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This study employed an econometric technique to investigate the relationship between arable land, agricultural carbon footprints and food security in South Africa within periods of 1990 and 2023. The collected data was estimated with the aid of the relevant technique, leading to the following conclusion. The relationship between arable land and food security is negative and significant, which implies that arable land does not support food security. Whereas agricultural footprints and food production index have a positive and significant relationship. This shows that agricultural carbon footprints are not inimical to food security in South Africa. Also, population growth and food production index have an insignificant negative relationship. And trade openness and food production possess a positive relationship which is not significant. Therefore, in view of these findings, this study makes the following recommendations to the policymakers in South Africa. Firstly, policymakers should embark on policy measures that will drive full utilization of the country`s arable land in the direction of agricultural practices that will ensure a sustainable food security in the country. In the same vein, all hands must be on deck by the country`s policymakers in building resilient agricultural sector that is insulated from the adverse threats of future agricultural carbon footprints on food security in the country. And import of sufficient food supply from outside the shores of South Africa, especially neighboring countries could also be an option that could aid sustainable food security in the country.

Keywords: Arable Land, Carbon Footprints, Food Security, Trade Openness, South Africa.

ICAM4E_2025_007

THE VALUE-ADDED TRADE BETWEEN CHINA AND AFRICA AND ITS IMPACT ON BILATERAL ECONOMIC GROWTH

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In recent years, the global economy has become increasingly interconnected through global value chains (GVCs), with countries' economic growth more deeply tied to trade dynamics. Due to this, value-added trade (VAT) has gained prominence as a measure of countries' true developmental levels and the economic impacts, both positive and negative, derived from international trade. However, while most raw materials flow from less developed to developed economies, existing studies have predominantly focused on major economies, neglecting developing regions, particularly Africa. This study examines the dynamics of VAT between China and Africa and its impact on bilateral economic growth by decomposing trade flows into domestic and foreign value-added components, identifying key sectoral linkages in GVCs, and assessing VAT's contribution to bilateral growth using Eora-MRIO data (1990–2021). Three key findings emerge: (1) Gross trade metrics significantly overstate China's export surplus to Africa by 455.31% and Africa's export deficit to China by 555.31%, obscuring Africa's structural constraints in low-value GVC roles. (2) China's exports to Africa exhibit a higher domestic value-added share, whereas Africa's exports to China contain a larger foreign value-added share. (3) China's economic gains from VAT with Africa far exceed Africa's gains from trade with China. These findings suggest the need for Africa to shift from raw exports to value-added production via local processing hubs, leverage trade agreements for equitable terms, invest in skills and R&D, and strengthen intra-African supply chains to promote sustainable growth and reduce trade imbalances with China.

Keywords: Value-added trade, China-Africa, Economic growth, Global value chains

ICAM4E_2025_008

ENHANCEMENT OF FRUIT WASTE ETHANOL PRODUCTION BY CO-CULTIVATION OF THERMOTOLERANT WILD YEASTS UNDER STATISTICALLY OPTIMIZED FERMENTATION CONDITIONS

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Population development and industrialization have increased energy consumption over the last forty years, and waste disposal is still a big problem in growing counties like Ethiopia. This study aimed to enhance ethanol production from banana peel (BP) and pineapple peel (PAP) hydrolysates using newly isolated co-cultures of thermotolerant wild yeast species (Saccharomyces cerevisiae and Scheffersomyces stipitis) from natural forests of Southwest Ethiopia. The process involved using autoclave steam to hydrolyze BP and PAP with acid, followed by the aforementioned yeasts fermenting the peel hydrolysate. Using Response Surface Methodology (RSM), the fermentation conditions—such as temperature, pH, incubation duration, and substrate concentration—were improved. The amount of ethanol and reducing sugar was measured using a UV-vis spectrophotometer with a mass spectrometer and a digital refractometer, respectively. Under optimized conditions co-culture of S. cerevisiae 9Li2 and S. stipitis 39L1 enhanced the ethanol production by 18.7% (34 g/L to 41.8 g/L) and 17.1% (26 g/L to 31.35 g/L), respectively from sugar concentrations extracted from BP and PAP hydrolysates. With BP hydrolysates, the ethanol yield, productivity, and yield efficiency were 0.5 g/g, 1.16 g/L/h, and 98%, compared to PAP hydrolysates' 0.39 g/g, 0.87 g/L, and 76.47%, respectively. It is possible to efficiently transform fruit peel waste into bio-ethanol, reducing organic waste in the environment and offering a substitute energy source.

ICAM4E_2025_009

ENHANCING BIOGAS GENERATION VIA ANAEROBIC DIGESTION OF FRUIT AND VEGETABLE RESIDUES: A VIABLE APPROACH FOR RENEWABLE ENERGY AND WASTE MITIGATION

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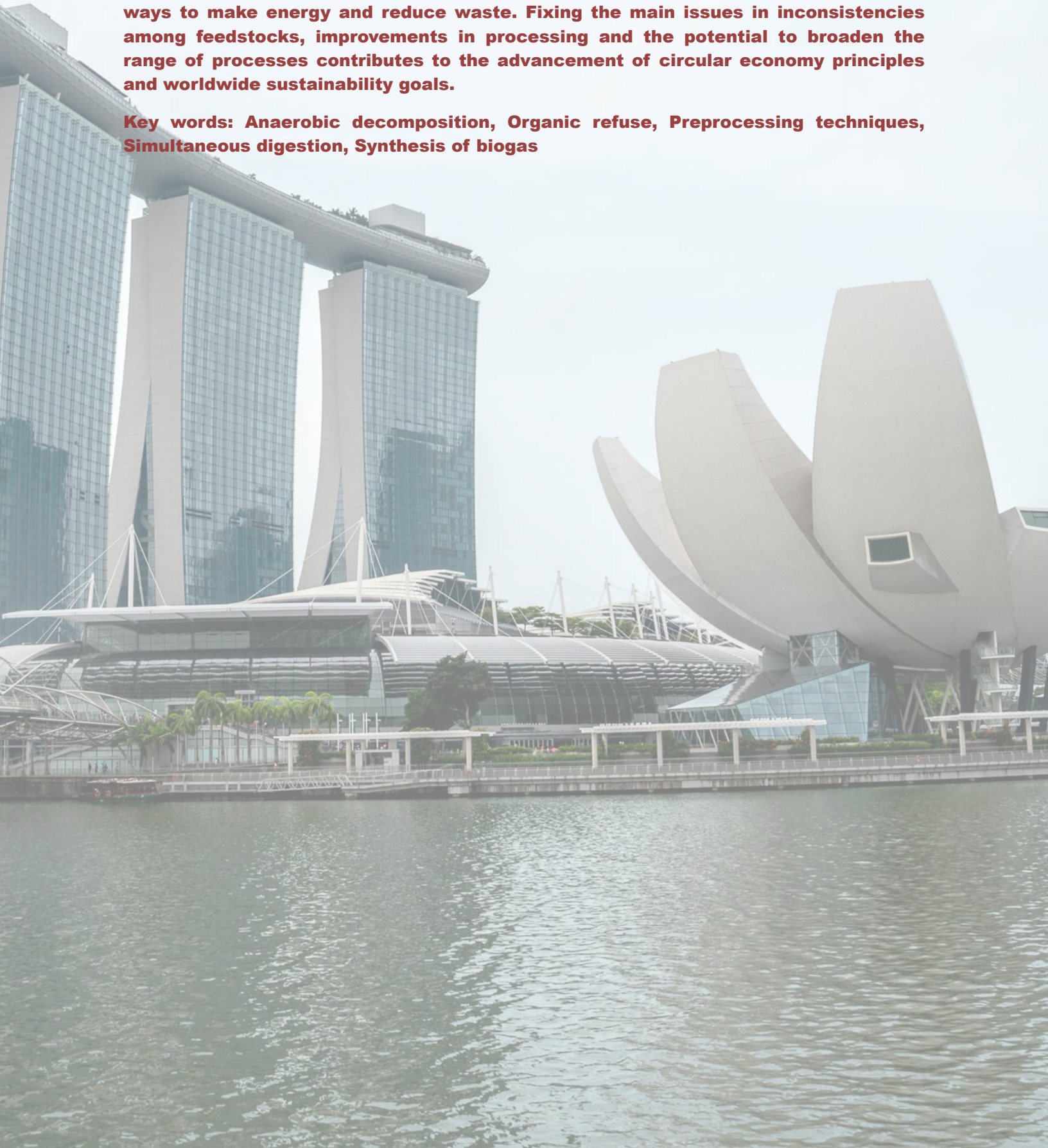
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More and more, people are interested in producing biogas using anaerobic gigestion (AD) since renewable energy and eco-friendly waste disposal are key concerns today. This research looks into increasing the amount of biogas produced from fruit and vegetable waste (FVW) within municipal solid refuse. Experiments were carried out in a lab, at a pilot scale and by calculating economics to find out the best feedstock, pre-treatment practices, operating parameters and ways to co-digest them in terms of biogas yield and stability. High-sugar fruits such as apples and bananas produced more biogas in the beginning (ranging from 450 to 500 L/kg VS). The addition of 4% sodium hydroxide (NaOH) during chemical pretreatment significantly improved biogas production, reaching 390 L/kg volatile solids (VS), more than the untreated samples that produced 300 L/kg VS. Finding an HRT of 20 days and OLR of 2 g VS/L/day optimized biogas output and kept the process steady. When fruit and vegetable waste was digested with cow manure in the same ratio, the biogas output increased (450 L/kg) and greenhouse gas emissions were kept to a minimum. The results of the statistical analysis showed that pretreatment and co-digestion significantly improved the amount of biogas made during the study process

(p < 0.001). According to the testing, these systems are feasible in technology, economics and ecology for waste from fruits and vegetables, allowing sustainable ways to make energy and reduce waste. Fixing the main issues in inconsistencies among feedstocks, improvements in processing and the potential to broaden the range of processes contributes to the advancement of circular economy principles and worldwide sustainability goals.

Key words: Anaerobic decomposition, Organic refuse, Preprocessing techniques, Simultaneous digestion, Synthesis of biogas





ICAM4E_2025_010

INFLUENCE OF MARTENSITE FRACTION AND TEMPERING TEMPERATURE ON THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF DUAL-PHASE X52 STEEL

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This study investigates the influence of martensite fraction and tempering temperature on the microstructure and mechanical properties of dual-phase X52 steel. Dual-phase microstructures (ferrite + martensite) were produced through intermediate quenching IQ at 760°C and 800°C, followed by tempering between 200°C and 500°C. The results show that the volume fraction of martensite and the tempering temperature significantly affect both microstructural evolution and mechanical behavior. At 200 °C, the microstructure is mainly composed of tempered martensite, while higher tempering temperatures promote carbide precipitation and carbon depletion in martensite. This leads to a decrease in hardness and tensile strength (YTS and UTS) with increasing tempering temperature, while ductility, indicated by elongation, improves. These findings highlight the balance between strength and ductility achievable in X52 dual-phase steel by controlling martensite content and tempering conditions.

ICAM4E_2025_012

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF TEMPERATURE AND VOLUME CONCENTRATION OF NANOPARTICLE IN ELECTROLYTE SOLUTION ON HYDROGEN YIELD RATE OF A PVT BASED HYDROGEN PRODUCTION SYSTEM

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Hydrogen is a significant alternative energy source to satisfy energy demands and address the challenges associated with fossil fuels. The generation of hydrogen by the electrolysis of water with a Photovoltaic-Thermal (PVT) solar collector presents a significant difficulty due to intermittent solar radiation and insufficient solar panel performance. This paper involves an experimental investigation to examine the impacts of temperature and volume concentrations of nanoparticle-dispersed electrolyte solutions. The required electrolyte solutions were synthesised by using a two-step technique, including 0.05, 0.1, and 0.2 vol.% of CuO nanoparticles into deionised water. The thermophysical characteristics, including thermal conductivity, viscosity, and stability, of the nanoparticle-dispersed electrolyte solution were measured at various temperatures. The findings indicated that the thermal conductivity and viscosity of the electrolyte solution were directly affected by temperature and the concentration of nanoparticles in the base deionized water. The zeta potential measurements indicated a significant electrostatic repulsive force between the particles, resulting in reduced particle agglomeration. The substantial improvement in hydrogen production rate was observed, ranging from 0.83±10% to 2.28±10% for 0.05 vol.%, 1.45±10% to 2.85±10% for 0.1 vol.%, and 2.07±10% to 3.56±10% for 0.2 vol.% of CuO nanoparticles incorporated into the base electrolyte solution, achieved by adjusting the temperature from 35°C to 55°C. This significant

enhancement was achieved mainly owing to the improved electrochemical and catalytic characteristics of the system.



ICAM4E_2025_013

HUMAN-CENTERED ARTIFICIAL INTELLIGENCE IN INDIAN TOURISM: DESIGNING ETHICAL AND EMPATHETIC EXPERIENCES THROUGH SMART TECHNOLOGIES

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The integration of Artificial Intelligence (AI) in the tourism sector has reshaped travel experiences, operational efficiency, and destination management. In culturally rich nations like India, the widespread adoption of AI often prioritizes automation and data-driven decision-making over emotional resonance, empathy, and cultural sensitivity. This paper explores the intersection of AI and humanity in the context of Indian tourism, emphasizing the need for ethical, human-centered AI systems that respect local values and promote inclusive experiences. Drawing on secondary research, policy documents, and emerging tourism case studies, including the Incredible India chatbot, facial recognition trials at Indian airports, and Rajasthan's tourism analytics dashboards, this study analyzes how AI can either enhance or diminish the human experience in tourism. It adopts a conceptual framework based on Human-Centered AI and Value-Sensitive Design to critically examine the role of empathy, ethical concerns, and emotional intelligence in AI-enabled tourism tools. The paper argues for the development of emotion-aware and culturally adaptive AI systems that enhance personalization without compromising authenticity or human dignity. Through this approach, the paper contributes to broader debates on digital transformation, responsible AI, and the preservation of humanity within technology-driven tourism environments. The findings have direct implications for policymakers, technology developers, and cultural tourism stakeholders across India and beyond.
Keywords: Emotional Intelligence, Ethical AI, Human-Centered AI, Indian Tourism, Smart Tourism

ICAM4E_2025_014

THE INFLUENCE OF ARTIFICIAL INTELLIGENCE (AI) AND DIGITAL TECHNOLOGIES ON EXPORT PERFORMANCE OF MSMES: AN EMPIRICAL STUDY

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In the fast and volatile modern world, the use of artificial intelligence (AI) and advanced digital technology services is significantly influencing the export performance of Micro, Small, and Medium Enterprises (MSMEs). For MSMEs, AI and advanced digital technologies continuously reshape international trade patterns. These enterprises play a significant role in the country's economic development through exports. This study evaluated the influence of AI and advanced digital technology adoption on the export competitiveness of MSMEs. However, MSMEs are lagging in the adoption of AI due to challenges such as limited digital infrastructure, financial barriers, lack of training programs, and knowledge gaps. The study recognizes key digital tools such as e-commerce channels, AI-driven analytics, and digital marketing platforms to mitigate these challenges. The study was based on secondary data. For data analysis, the paper employed the ANOVA test. The findings indicate that MSMEs are positively influenced by AI through wider market access, faster transactions, improved decision making, compliance support, enhanced efficiency, and cost reduction. The results of the study will provide in-depth insights for MSMEs and various government agencies to revamp their strategies in the current changing global scenario.

Keywords: Artificial intelligence (AI), digital technology, exports, MSMEs



ICAM4E_2025_015

COMPREHENSIVE INVESTIGATION INTO THE MECHANISMS OF PEROVSKITE SOLAR CELLS' DETERIORATION AND DURABILITY IMPROVEMENT

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One solution to the current energy conflict is solar cells. Various kinds of solar cells have been developed till now. Perovskite materials with an ABX3 structure, typically organic lead halide, have been used as absorber materials for perovskite solar cell production for the past few years which gives higher PCE (photo-conversion efficiency). Organic lead halide perovskite materials are an excellent light absorber due to their impressive optoelectronic features like long charge carrier diffusion lengths, significantly higher value of absorption coefficients, and a sharp optical band gap. The primary roadblocks to commercialization of PS (perovskite solar) cells, despite its high efficiency, are its cost, stability, thermal degradation, higher sensitivity towards moisture and toxicity from the inclusion of hazardous components like lead (Pb). In the present article, the prevailing knowledge of how PS cells might deteriorate when exposed to heat, oxygen, and moisture is examined, along with the methods that researchers have used to increase the durability of PS cells', such as compositional tuning and encapsulation. The review proceeds by outlining many possibilities for tackling present challenges and bringing PS cells towards their full commercial viability through future research targeted at improving and enhancing its performance and stability.

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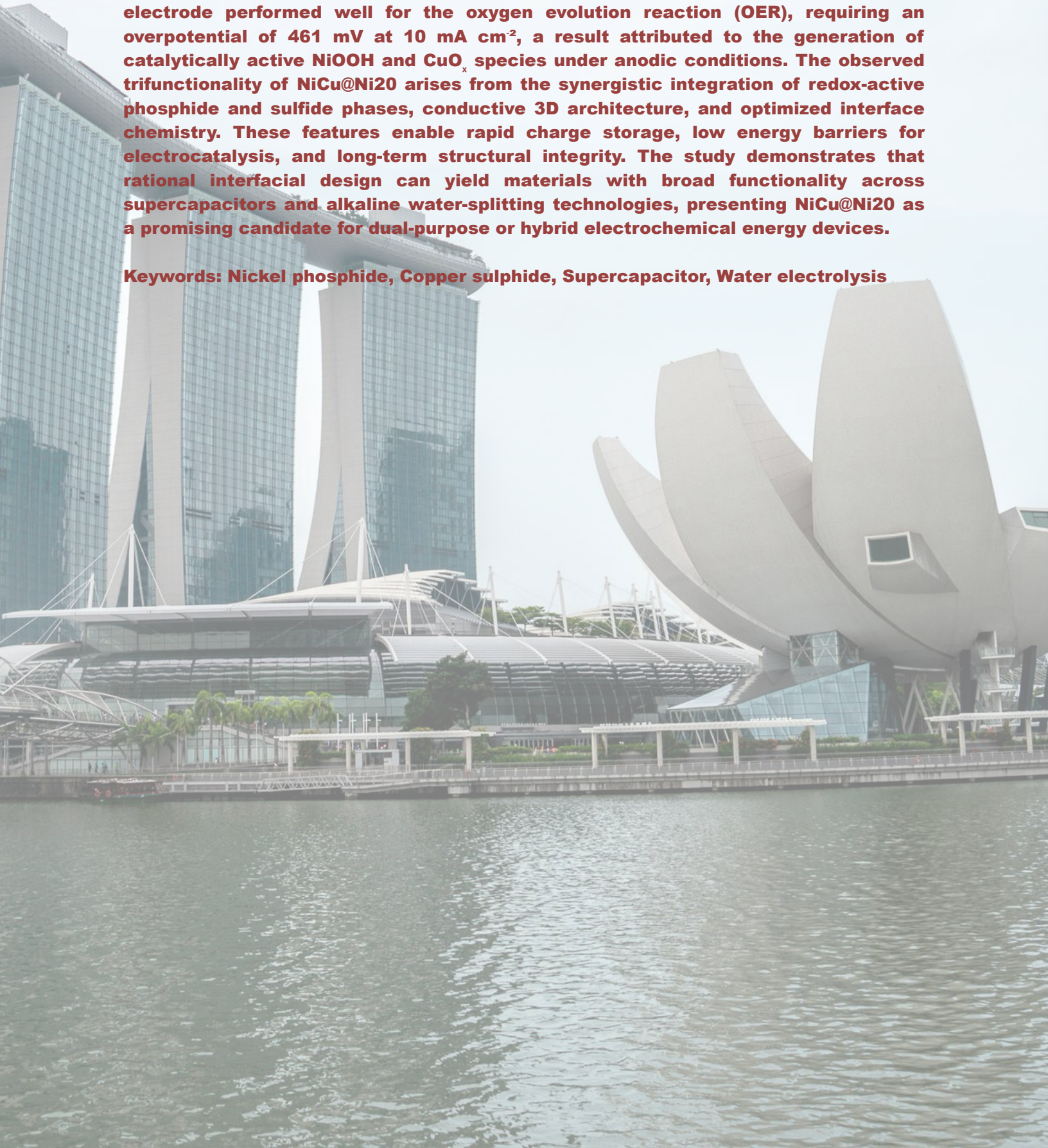
HIERARCHICALLY STRUCTURED Ni_3P–CUS/Cu_9S_5 ON NI FOAM: A MULTIFUNCTIONAL ELECTRODE FOR ALKALINE SUPERCAPACITORS AND ELECTROLYZERS

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Multifunctional electrode materials that effectively combine energy storage and electrocatalytic capabilities are of increasing importance for sustainable electrochemical systems. In this study, we report a hierarchical hybrid electrode, NiCu@Ni20, composed of nickel phosphide (Ni_3P) nanoparticles interfaced with CuS/Cu_9S_5 nanosheets grown on a 3D nickel foam substrate. The structure was synthesized through a two-step process: hydrothermal sulfidation followed by low-temperature phosphidation for 20 minutes. This approach yielded a robust, porous architecture with intimate phosphide–sulfide interfaces and high electrochemical accessibility. Structural and surface characterizations confirmed the successful formation and integration of the composite phases. X-ray diffraction (XRD) indicated crystalline features corresponding to both Cu-based sulfides and Ni_3P. FESEM and HRTEM analyses revealed a well-distributed network of Ni_3P nanoparticles anchored onto vertically aligned CuS/Cu_9S_5 nanosheets. X-ray photoelectron spectroscopy (XPS) verified the presence of multivalent Ni and Cu species, confirming the formation of electrochemically active interfaces. Electrochemical testing demonstrated that NiCu@Ni20 is a highly versatile electrode. As a supercapacitor, it delivered a specific capacitance of 1341 F g^{-1} at 2 A g^{-1}, attributed to reversible redox transitions of Ni^{2+}/Ni^{3+} and Cu^{+}/Cu^{2+} coupled with excellent ionic diffusion through the porous structure. The material also maintained good rate capability and structural stability during cycling. In water-splitting applications, NiCu@Ni20 exhibited outstanding activity toward the hydrogen evolution reaction (HER), with a low overpotential of 42.9 mV at 10 mA cm^{-2} and a Tafel slope of 155.1 mV dec^{-1}, indicating Volmer–Heyrovsky-type kinetics. The phosphide component contributes

significantly to water dissociation and intermediate stabilization, while the conductive sulfide matrix facilitates efficient electron transfer. Additionally, the electrode performed well for the oxygen evolution reaction (OER), requiring an overpotential of 461 mV at 10 mA cm^{-2}, a result attributed to the generation of catalytically active NiOOH and CuO_x species under anodic conditions. The observed trifunctionality of NiCu@Ni20 arises from the synergistic integration of redox-active phosphide and sulfide phases, conductive 3D architecture, and optimized interface chemistry. These features enable rapid charge storage, low energy barriers for electrocatalysis, and long-term structural integrity. The study demonstrates that rational interfacial design can yield materials with broad functionality across supercapacitors and alkaline water-splitting technologies, presenting NiCu@Ni20 as a promising candidate for dual-purpose or hybrid electrochemical energy devices.

Keywords: Nickel phosphide, Copper sulphide, Supercapacitor, Water electrolysis



ICAM4E_2025_017

ROLE OF SUSTAINABLE HRM PRACTICES IN REDUCING EMPLOYEE-RELATED CARBON EMISSIONS

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Sustainable Human Resource Management (HRM) practices are increasingly vital in addressing environmental challenges by reducing employee-related carbon emissions. This study explores how sustainable HRM practices such as green recruitment and selection, green training and development, green performance management, green rewards and incentives, flexible work arrangements and employee engagement in environmental programs can mitigate carbon footprints associated with employee commuting, workplace energy use, and business travel. For instance, some of the HRM practices such as green recruitment attracts candidates with strong environmental values, while green training enhances employees' capabilities to adopt low-carbon practices in daily operations. Flexible work options like telecommuting reduce transportation-related emissions, and green performance appraisals incentivize sustainable behavior. Using a conceptual framework grounded in the Ability-Motivation-Opportunity (AMO) theory and Social Exchange Theory (SET), this paper proposes that sustainable HRM enhances employees' environmental competence, motivation, and opportunities, leading to reduced carbon-intensive behavior. The study draws on secondary data from published literature, policy reports, and sustainability disclosures to support the proposed relationships.

This research contributes to the growing body of knowledge on green HRM by linking HR interventions with quantifiable environmental outcomes. It highlights the strategic importance of HRM in operationalizing corporate sustainability, particularly through employee-centric approaches. The findings are relevant for HR professionals, sustainability managers, and policy-makers aiming to embed low-

carbon practices within organizational culture and everyday operations. Future empirical studies are encouraged to validate the proposed framework across sectors and regions.

Keywords: Sustainable Human Resource Management, Green HRM Practices, Employee-related Carbon Emissions, Ability-Motivation-Opportunity (AMO) Theory, Corporate Environmental Sustainability



ICAM4E_2025_018

HEAVY METALS CONCENTRATION IN FISH FEED AND ASSESSMENT OF HEALTH RISK

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The present study evaluated the concentration of heavy metals i.e., Chromium (Cr), Lead (Pb), Nickel (Ni), Copper (Cu) and Zinc (Zn) in fish feed, fish body part samples (fish flesh and bone samples) collected from Gazipur and Savar area. Both the locations are compatible with our present study because of availability of fish feed samples along with farmed fish ponds and hatchery with different cultured fish specially Tilapia (Oreochromis niloticus). Potential health risks from the consumption of these studied samples were also estimated. The analyzed samples were randomly collected, processed and analyzed for heavy metals determinations using Atomic Absorption Spectrophotometry (AAS). Mean concentrations of Cr, Pb, Ni, Cu and Zn in fish feed samples were ranged from 0.00-20.94, 0.00-1.00, 0.00-2.11, 5.85-11.75, 42.87-123.27 mg/kg, respectively. Most of the fish feed samples collected from Gazipur and Savar area contained Cr more than the Maximum Permissible Limit (MPL) set by FAO/WHO. In comparison with fish flesh, fish bone samples contained at least 5 to 7 times higher concentration of Cr. The Pb concentration in some fish flesh and bone samples were obtained higher than the MPL set by FAO/WHO (2009). The Hazard Quotient (HQ) and Hazard Index (HI) values for all fish bone samples were higher than 1 which denotes that consumption of samples may have potential health risks (carcinogenic). The high concentrations of heavy metals in fish parts samples may be due to the metals inadvertently entering the food chain. No matter how low the level of heavy metals is in edible samples, their presence is not desirable. Therefore, this study suggests the regular monitoring and assessment of heavy metal concentrations in different fish feed from the market as well as farming and production sites and also require more extensive studies for assessing the risk of health hazards to the human beings and to prevent excessive buildup of these heavy metals in the human food chain.

ICAM4E_2025_019

A COMPARATIVE REVIEW OF MECHANICAL PROPERTIES AND ENVIRONMENTAL SUSTAINABILITY FOR THERMOPLASTICS PROCESSED BY FUSED DEPOSITION MODELING AND SELECTIVE LASER SINTERING

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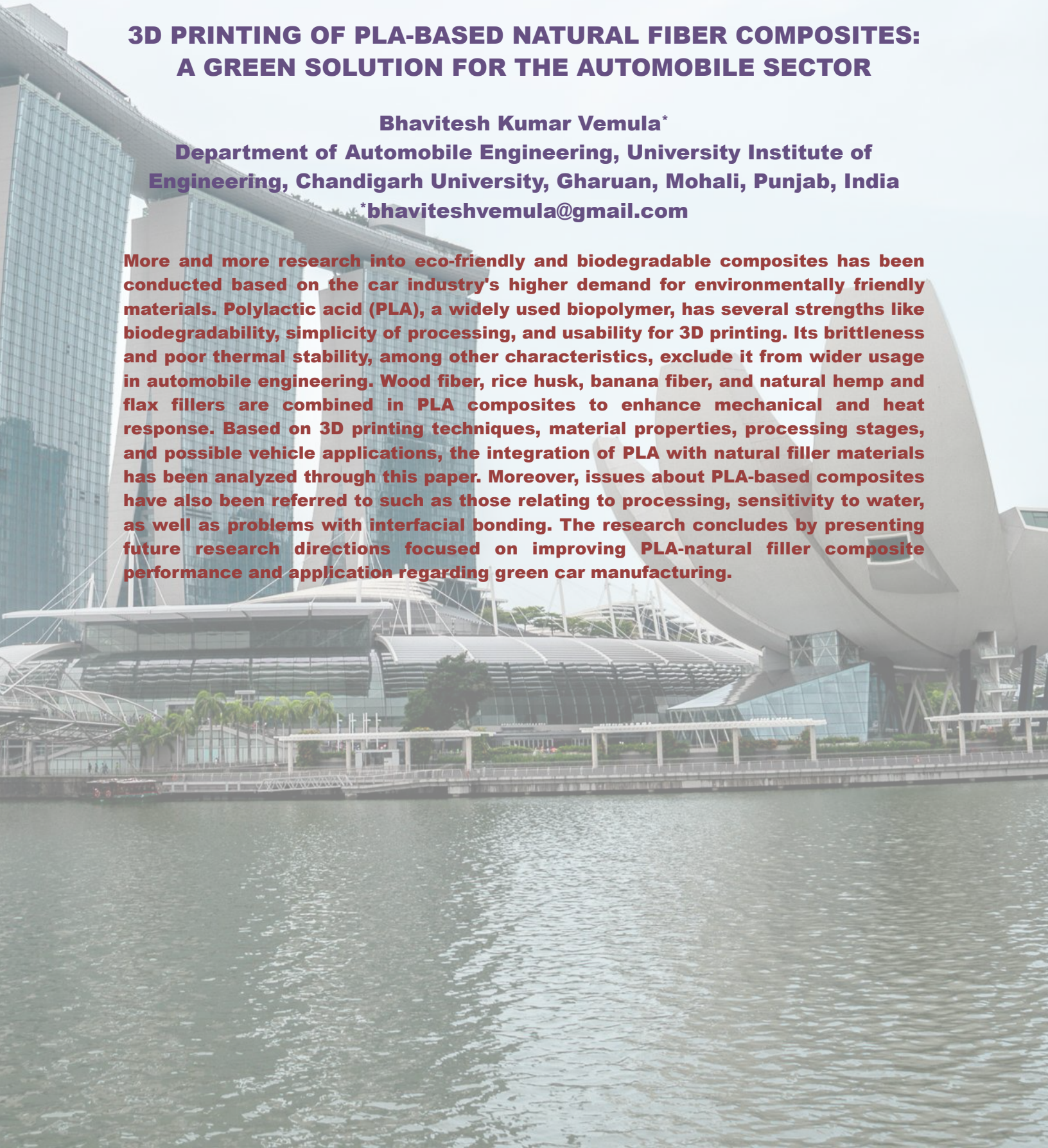
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This paper presents a comparative review of Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS) for thermoplastic additive manufacturing, focusing on mechanical properties and environmental sustainability. FDM is valued for its affordability, ease of use, and wide material compatibility, but its mechanical performance is hindered by significant anisotropy. SLS, while more costly and energy-intensive, produces stronger and more isotropic parts suitable for functional applications. The review synthesizes recent research on tensile, flexural, and fatigue properties, as well as energy consumption, material efficiency, and waste generation. The findings underscore the need for application-specific process selection and further investigation into sustainable materials and long-term performance metrics. FDM and SLS both provide unique benefits that make them more complementary to each other, rather than rivals in the larger construct of additive manufacturing. Future progress in material science and process optimization are critical in addressing performance and reducing environmental impact for many others to come.

Keywords: Additive Manufacturing, Fused Deposition Modeling, Selective Laser Sintering, Thermoplastics, Mechanical Properties, Sustainability, 3D Printing, Lifecycle Assessment

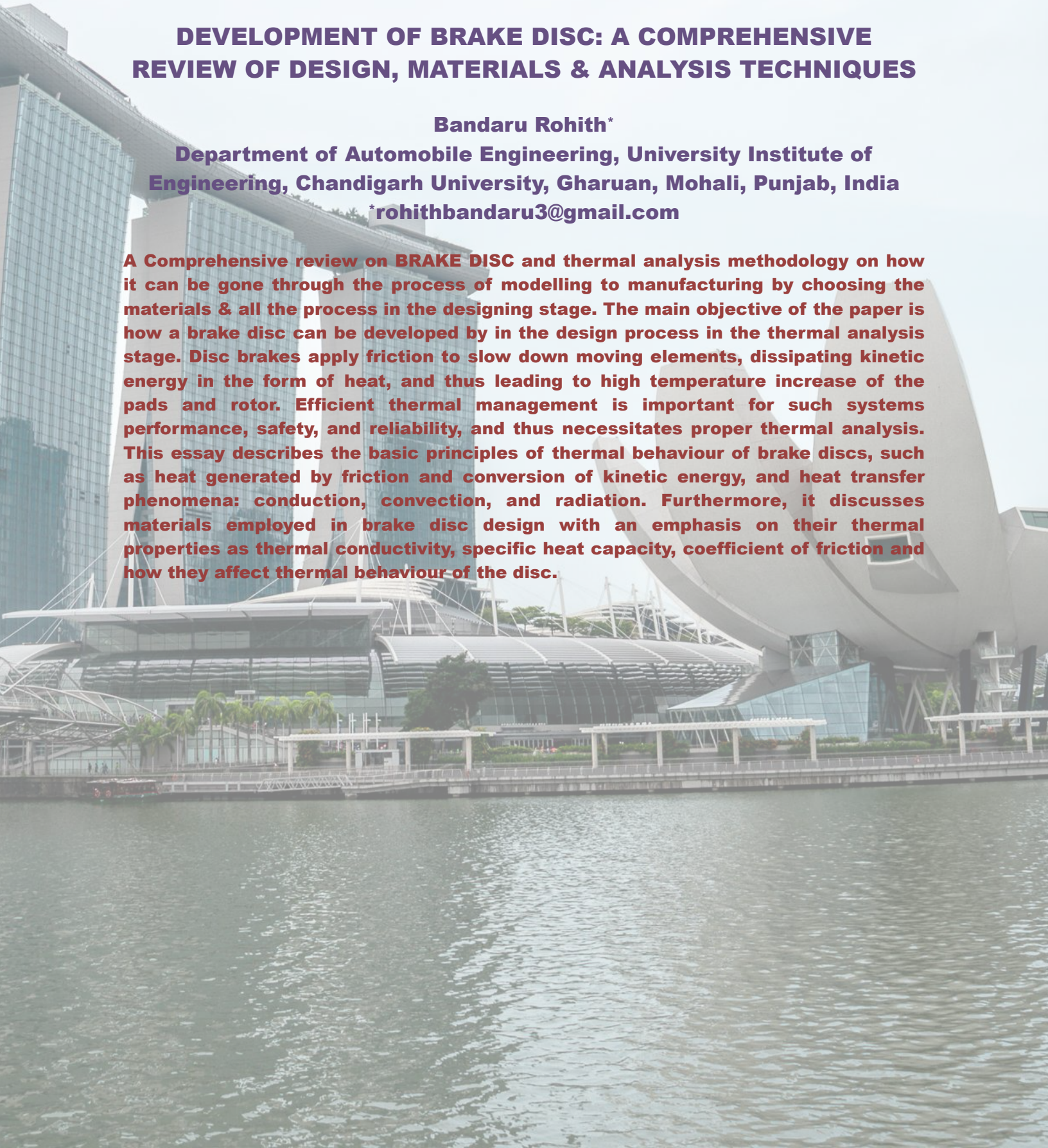


ICAM4E_2025_020

3D PRINTING OF PLA-BASED NATURAL FIBER COMPOSITES: A GREEN SOLUTION FOR THE AUTOMOBILE SECTOR

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More and more research into eco-friendly and biodegradable composites has been conducted based on the car industry's higher demand for environmentally friendly materials. Polylactic acid (PLA), a widely used biopolymer, has several strengths like biodegradability, simplicity of processing, and usability for 3D printing. Its brittleness and poor thermal stability, among other characteristics, exclude it from wider usage in automobile engineering. Wood fiber, rice husk, banana fiber, and natural hemp and flax fillers are combined in PLA composites to enhance mechanical and heat response. Based on 3D printing techniques, material properties, processing stages, and possible vehicle applications, the integration of PLA with natural filler materials has been analyzed through this paper. Moreover, issues about PLA-based composites have also been referred to such as those relating to processing, sensitivity to water, as well as problems with interfacial bonding. The research concludes by presenting future research directions focused on improving PLA-natural filler composite performance and application regarding green car manufacturing.

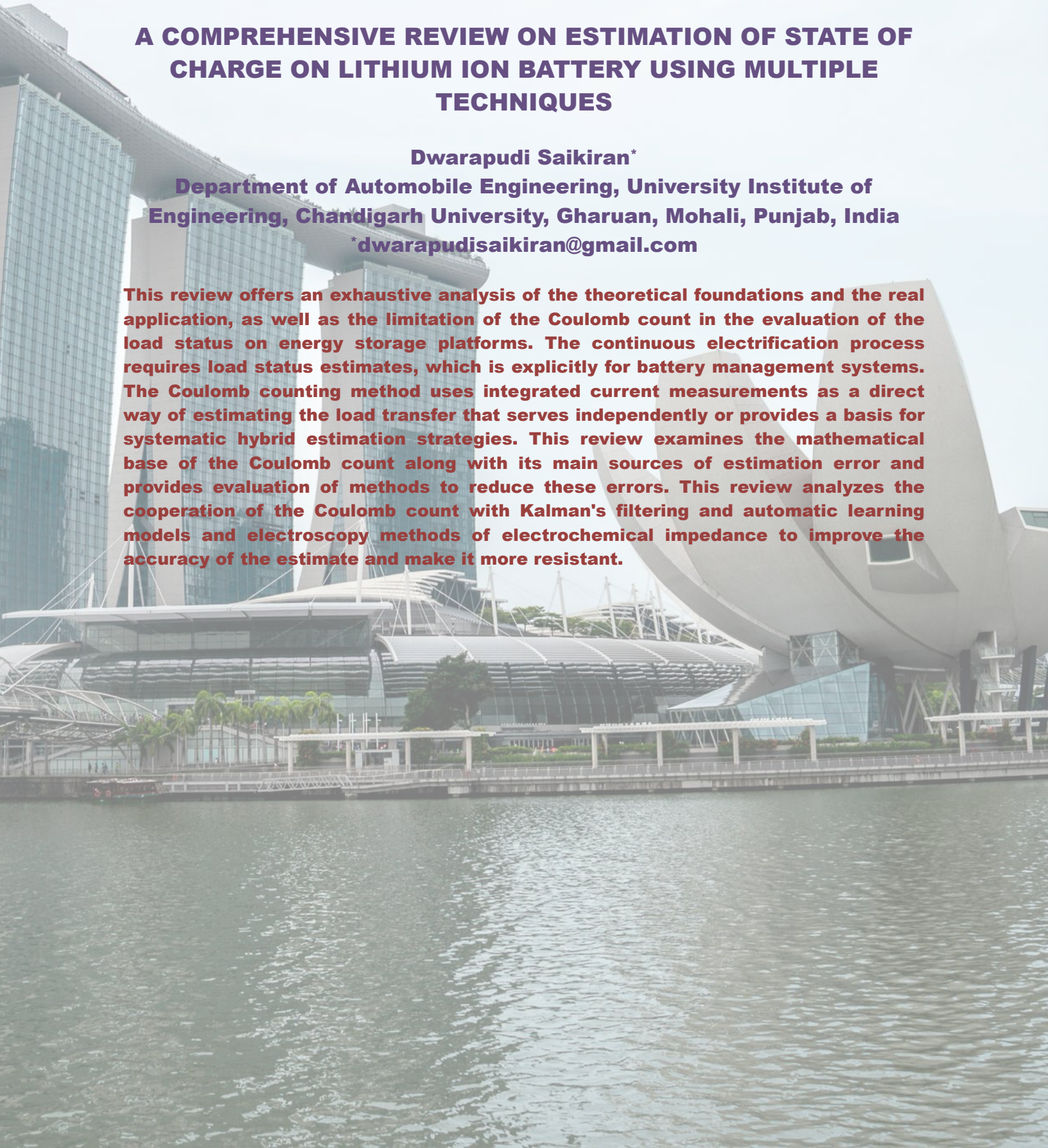


ICAM4E_2025_021

DEVELOPMENT OF BRAKE DISC: A COMPREHENSIVE REVIEW OF DESIGN, MATERIALS & ANALYSIS TECHNIQUES

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A Comprehensive review on BRAKE DISC and thermal analysis methodology on how it can be gone through the process of modelling to manufacturing by choosing the materials & all the process in the designing stage. The main objective of the paper is how a brake disc can be developed by in the design process in the thermal analysis stage. Disc brakes apply friction to slow down moving elements, dissipating kinetic energy in the form of heat, and thus leading to high temperature increase of the pads and rotor. Efficient thermal management is important for such systems performance, safety, and reliability, and thus necessitates proper thermal analysis. This essay describes the basic principles of thermal behaviour of brake discs, such as heat generated by friction and conversion of kinetic energy, and heat transfer phenomena: conduction, convection, and radiation. Furthermore, it discusses materials employed in brake disc design with an emphasis on their thermal properties as thermal conductivity, specific heat capacity, coefficient of friction and how they affect thermal behaviour of the disc.



ICAM4E_2025_022

A COMPREHENSIVE REVIEW ON ESTIMATION OF STATE OF CHARGE ON LITHIUM ION BATTERY USING MULTIPLE TECHNIQUES

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This review offers an exhaustive analysis of the theoretical foundations and the real application, as well as the limitation of the Coulomb count in the evaluation of the load status on energy storage platforms. The continuous electrification process requires load status estimates, which is explicitly for battery management systems. The Coulomb counting method uses integrated current measurements as a direct way of estimating the load transfer that serves independently or provides a basis for systematic hybrid estimation strategies. This review examines the mathematical base of the Coulomb count along with its main sources of estimation error and provides evaluation of methods to reduce these errors. This review analyzes the cooperation of the Coulomb count with Kalman's filtering and automatic learning models and electroscopy methods of electrochemical impedance to improve the accuracy of the estimate and make it more resistant.

ICAM4E_2025_023

MECHATRONIC RESPONSIVENESS IN BUILDING ENVELOPES: ENHANCING DAYLIGHTING AND ENERGY PERFORMANCE THROUGH ADAPTIVE DESIGN IN EDUCATIONAL BUILDINGS

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In hot-humid climatic regions, conventional static building envelopes often lead to excessive solar heat gain, sub-optimal daylight distribution, and inefficient energy performance, especially in educational buildings with high daytime occupancy and functional variability. This study addresses these challenges by proposing a climate-responsive design solution that integrates mechatronic systems into the building envelope to enhance both daylighting and energy performance through real-time adaptability. Focusing on a multi-storeyed educational building, the research identifies key challenges in the existing envelope system, such as fixed louvre inefficiency on the southern façade, neglected solar potential on the north side, over east–west solar control, and limited cross-ventilation. Using simulation-based analysis, the design evaluates thermal loads and daylighting integration potential to identify performance bottlenecks across classrooms, studios, and circulation spaces. In response, the study introduces an adaptive envelope system incorporating kinetic shading devices, daylight-redirecting panels, and operable

ventilation modules controlled by embedded sensor-actuator networks. These mechatronic components respond dynamically to real-time environmental inputs, such as solar angle, illuminance levels, temperature, and airflow, using programmable logic systems. The adaptive envelope system not only regulates daylight penetration to reduce glare and artificial lighting needs but also moderates internal temperatures, thereby reducing HVAC loads. Results demonstrate significant improvements in spatial daylight autonomy (sDA), annual sunlight exposure (ASE), and a substantial reduction in energy use intensity (EUI). The research exemplifies the potential of integrating adaptive mechatronic intelligence into façade design to create high-performance, low-energy learning environments. It contributes to the broader discourse on smart, sustainable architecture by bridging environmental control and digital responsiveness in building systems.

Keywords: Adaptive façade systems, Mechatronic building design, Daylighting optimization, Energy-efficient architecture, Climate-responsive envelope



ICAM4E_2025_024

INTEGRATING NATURAL WAXES IN MULTI-PCM THERMAL STORAGE: A SUSTAINABLE APPROACH

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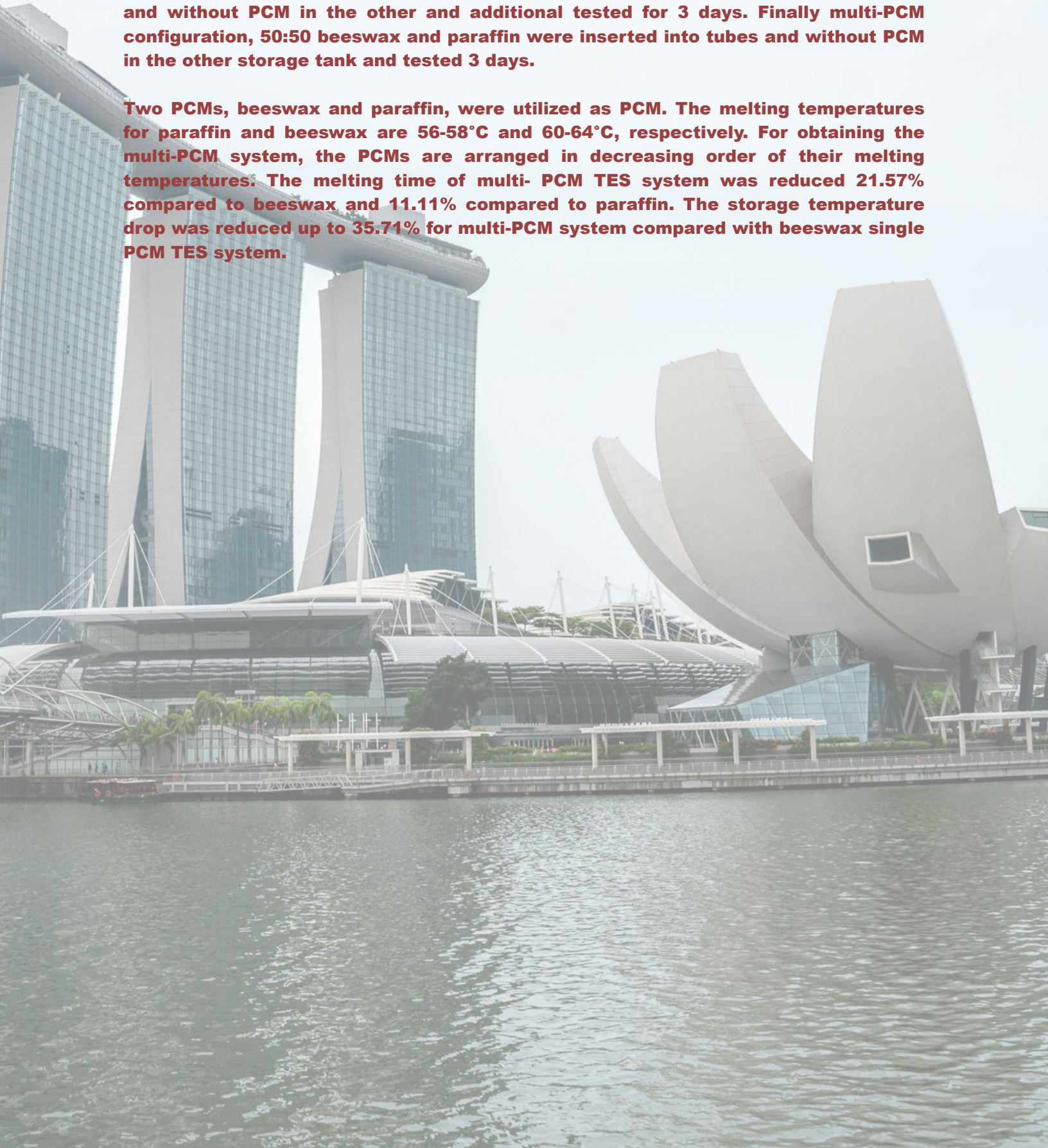
The exploration of renewable energy sources is needed to reduce the harmful effect on the environment of fossil fuels. The main limitations of renewable energy are variable nature and often insignificant and unpredictable variation. To reduce the supply demand mismatch and provide reliable energy supply, latent heat thermal energy storage utilizing phase change materials (PCMs) is a promising choice. A better way to improve the performance of thermal energy storage (TES) system is utilizing multiple PCMs organized in series by decreasing their melting temperatures. The PCM materials which have utilized are mostly different kinds of paraffins and carbonates. The fact that these materials originate from non-renewable resources is a disadvantage. One promising PCM that is commonly accessible is beeswax. Because of its high thermal energy storage capacity and thermal stability, naturally occurring PCM holds great promise.

Thermal storage tank was developed with glass wool insulation. There were 33 number of tubes in the storage tank that contain PCM. Copper is selected for tube materials due to its high thermal performance. Water was employed as heat transfer fluid. PCM was inserted into tubes for storage purpose. Electrical heater was used to heat the water. Firstly, storage tank without PCM was tested for 3 days. Then paraffin was inserted into copper tube and tested for again 3 days.

Three thermal storage tanks were investigated in this study. 20 liters of water and a bundle of thirty-three copper tubes with an equal amount of PCMs were placed in the first tank. The only difference between the first and second tanks was that the first one had PCM, the second one doesn't. Two tanks had the same dimensions and was evenly insulated with glass wool. In the first experiment, a 1500-watt electrical heater was placed inside each tank to raise the temperature to a predetermined

level. An experiment was conducted for 3 days using beeswax PCM in one storage tank and without PCM in the other. Subsequently, Beeswax was also used as PCM and without PCM in the other and additional tested for 3 days. Finally multi-PCM configuration, 50:50 beeswax and paraffin were inserted into tubes and without PCM in the other storage tank and tested 3 days.

Two PCMs, beeswax and paraffin, were utilized as PCM. The melting temperatures for paraffin and beeswax are 56-58°C and 60-64°C, respectively. For obtaining the multi-PCM system, the PCMs are arranged in decreasing order of their melting temperatures. The melting time of multi- PCM TES system was reduced 21.57% compared to beeswax and 11.11% compared to paraffin. The storage temperature drop was reduced up to 35.71% for multi-PCM system compared with beeswax single PCM TES system.



ICAM4E_2025_025

MECHANICAL AND MICROSTRUCTURAL EVALUATION OF FUSED FILAMENT FABRICATED CFR-PEEK COMPOSITE FOR ORTHOPEDIC IMPLANT APPLICATION

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Orthopedic implants have long relied on metals for their exceptional strength and durability, particularly in load-bearing roles. But the usage of metals increases the overall cost and the difference of elastic modulus between metal and bone often triggers stress shielding which disrupts natural load distribution. Polymers are a suitable alternative that offer an elastic modulus similar to the bone. But polymers have lower mechanical strength which limits their structural utility. Carbon fiber reinforced polyether-ether ketone (CFRPEEK) has been observed to have a similar elastic property as that of human cortical bone and thus, it is a promising candidate for the replacement of metal implants. Additionally, CFRPEEK is fully compatible with fused filament fabrication (FFF) of additive manufacturing (3D printing) which provides additional flexibility in enabling low-cost production with greater degree of freedom in fabrication of patient-specific implants with complex geometry. The mechanical properties of products fabricated through additive manufacturing are dependent on 3D printing parameters such as infill density, infill geometry, and layer thickness. Thus, this investigation is an endeavor to explore the effects of 3D printing parameters on the tensile properties of the fabricated CFRPEEK composites using Taguchi orthogonal array design. A total of nine specimens were fabricated with the variation of infill geometry (hexagon, grid, and triangle), infill density (50%, 70%, and 90%) and layer thickness (0.1 mm, 0.2 mm, and 0.3 mm). The tensile test was performed to study the behavior of 3D printed specimens under uniaxial tensile loading. Scanning electron microscopy (SEM) was carried out on fracture cross-section of the specimen to investigate the key failure mechanisms such as fiber pull-out, interlayer delamination, and void propagation.

ICAM4E_2025_026

NUMERICAL ASSESSMENT OF HEAT TRANSFER AND FLOW DYNAMICS IN NANOFLUID ENHANCED WAVY DUCTED PIN-FINNED SOLAR AIR HEATER

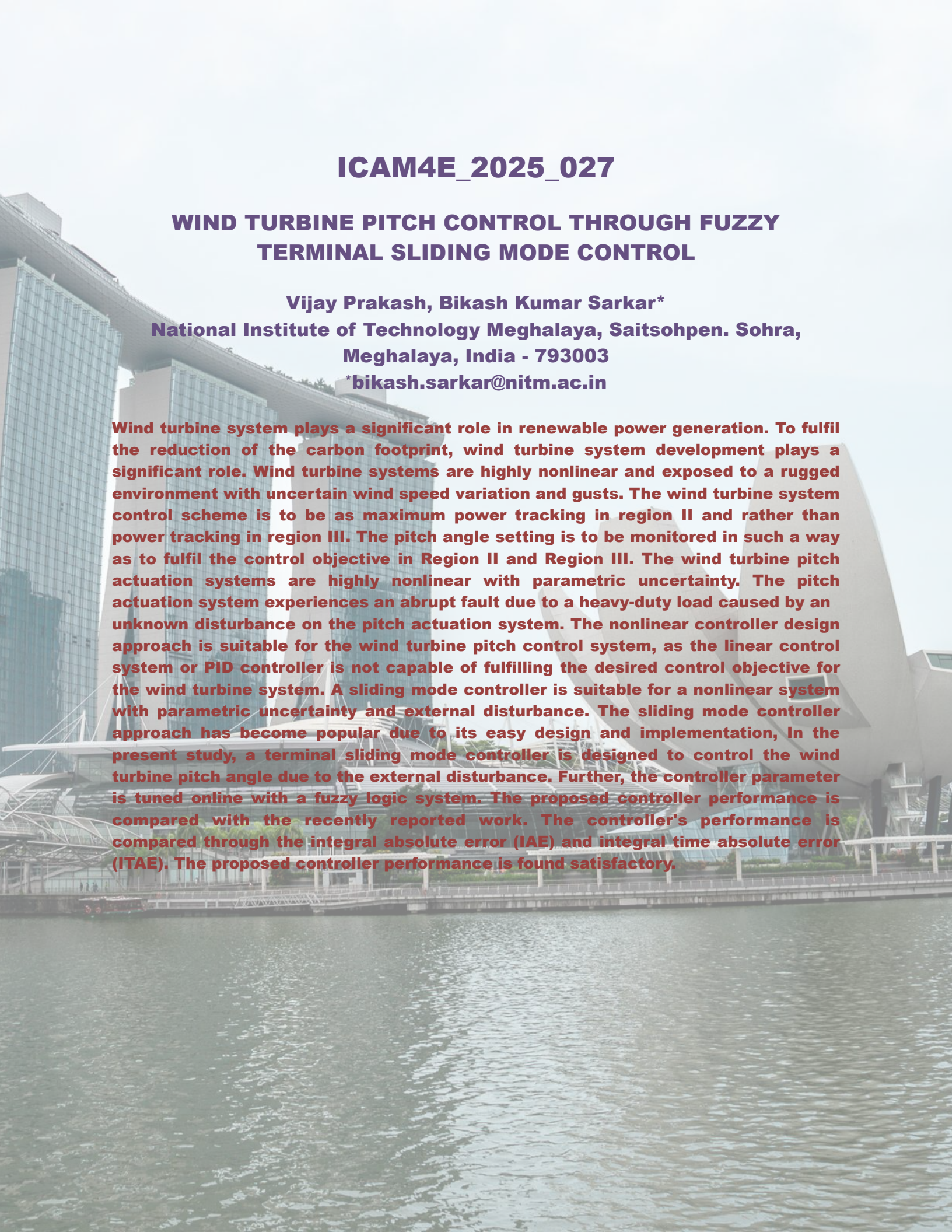
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This study presents a comprehensive CFD investigation on the thermal and hydraulic performance of an artificially roughened solar air heater (SAH) utilizing air and Al_2O_3 nanofluids (2% and 4% vol.) as working fluids. The SAH comprising of wavy duct equipped with pin fin type turbulators has been evaluated over a turbulent Reynolds number (Re) range of 3,500–16,000. The influence of base fluid properties, nanoparticle concentration, and duct configuration on flow behaviour, heat transfer amplification, and frictional penalties have been assessed using Reynolds-Averaged Navier–Stokes (RANS) modeling with the standard k–ε turbulence model. Results indicate that the wavy profiled absorber plate within the flow domain, demonstrated superior heat transfer characteristics compared to the flat duct due to extended heat transfer area and enhanced wall shear near the apex. Air with nanofluid volume fraction consistently outperformed the plain air, achieving higher Nusselt numbers and heat transfer coefficients. For instance, air + 4% Al_2O_3 in a pin fins wavy duct yielded the highest Nusselt number of ~155 at Re = 16,000. However, this performance gain was accompanied by higher friction factors, especially at lower Re and higher nanoparticle concentrations. A detailed thermo-hydraulic analysis revealed that 3–4% Al_2O_3 offered an optimal balance between heat transfer enhancement and flow resistance. The highest thermo-hydraulic performance parameter (THPP ≈ 1.7) was recorded for air + 4% Al_2O_3 at Re = 16,000 in a wavy duct. Temperature, velocity, and turbulent kinetic energy (TKE) contour analysis revealed significant modifications in flow structure due to duct shape alteration and nanoparticle interaction. The present work concludes that the combined use of air and Al_2O_3 nanofluids, and pin finned wavy duct geometry enables substantial

performance improvement in SAHs, providing a route for compact and thermally efficient energy systems in solar thermal applications.

Keywords: Pin fin, Wavy duct, Al_2O_3 Nanofluids, Nusselt number, Friction factor, Thermo-hydraulic performance parameter





ICAM4E_2025_027

WIND TURBINE PITCH CONTROL THROUGH FUZZY TERMINAL SLIDING MODE CONTROL

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Wind turbine system plays a significant role in renewable power generation. To fulfil the reduction of the carbon footprint, wind turbine system development plays a significant role. Wind turbine systems are highly nonlinear and exposed to a rugged environment with uncertain wind speed variation and gusts. The wind turbine system control scheme is to be as maximum power tracking in region II and rather than power tracking in region III. The pitch angle setting is to be monitored in such a way as to fulfil the control objective in Region II and Region III. The wind turbine pitch actuation systems are highly nonlinear with parametric uncertainty. The pitch actuation system experiences an abrupt fault due to a heavy-duty load caused by an unknown disturbance on the pitch actuation system. The nonlinear controller design approach is suitable for the wind turbine pitch control system, as the linear control system or PID controller is not capable of fulfilling the desired control objective for the wind turbine system. A sliding mode controller is suitable for a nonlinear system with parametric uncertainty and external disturbance. The sliding mode controller approach has become popular due to its easy design and implementation, In the present study, a terminal sliding mode controller is designed to control the wind turbine pitch angle due to the external disturbance. Further, the controller parameter is tuned online with a fuzzy logic system. The proposed controller performance is compared with the recently reported work. The controller's performance is compared through the integral absolute error (IAE) and integral time absolute error (ITAE). The proposed controller performance is found satisfactory.



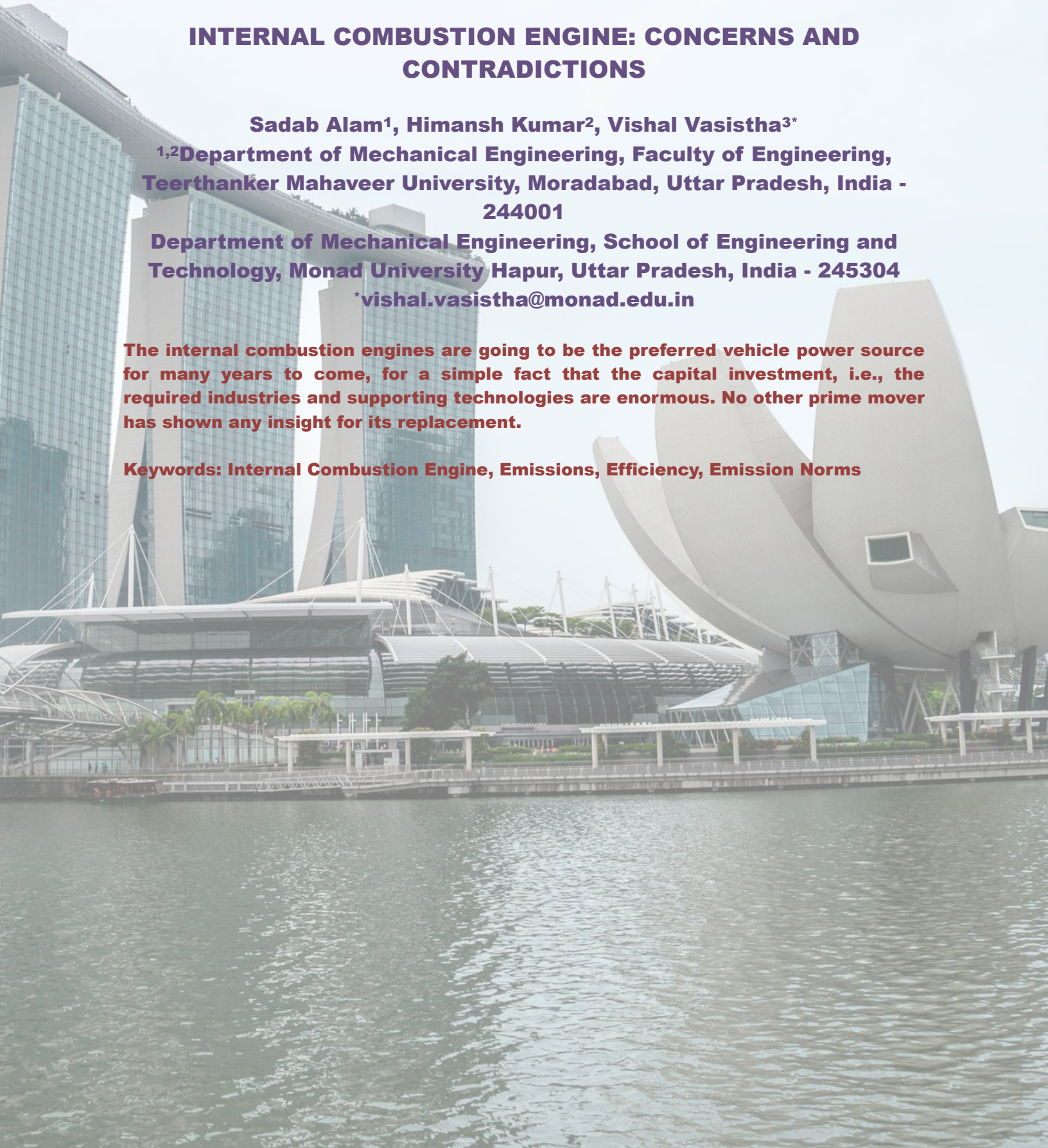
ICAM4E_2025_028

STRUCTURAL, MECHANICAL, ELECTRONIC, OPTICAL, GRAVIMETRIC AND THERMODYNAMIC PROPERTIES OF AYH_3 COMPOUNDS: A DFT STUDY

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This work presents a study based on density functional theory (DFT), focusing on the simple perovskite AYH_3. Using the CASTEP software, we performed ab initio calculations to investigate the properties of these materials in the context of hydrogen storage. The structural, mechanical, electronic, optical, gravimetric and Thermodynamic properties of AYH_3 were thoroughly evaluated. The electronic results reveal metallic behavior for both compounds. The formation energies, calculated indicate that these materials are thermodynamically stable and potentially synthesizable. Regarding hydrogen storage capacity, Furthermore, the calculated elastic constants confirm their mechanical stability. This study highlights the potential of AYH_3 perovskites as promising candidates for hydrogen storage applications.

Keywords: DFT, CASTEP, Structural, mechanical, electronic, optical, gravimetric and Thermodynamic properties



ICAM4E_2025_031

INTERNAL COMBUSTION ENGINE: CONCERNS AND CONTRADICTIONS

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The internal combustion engines are going to be the preferred vehicle power source for many years to come, for a simple fact that the capital investment, i.e., the required industries and supporting technologies are enormous. No other prime mover has shown any insight for its replacement.

Keywords: Internal Combustion Engine, Emissions, Efficiency, Emission Norms