First International Conference on advances in Mechanical, Materials, Mechatronics and Energy Engineering (ICAME-24)

Book of Abstracts

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ISBN : 978 - 627 - 94520 - 0 - 9

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Table of Contents

Keynote Speakers

Professor Ir
Dr Mohd Sapuan Salit

Prof. Dr.Lida
Shen

Dr. Müslüm Arıcı

Prof. Dr. Mehmet
Karahan

Dr. Mohammad Ismail
Hammouda

Dr. Vladimir Vukovic

Dr. Shoaib Ahmad Malik

Engr. Maqsood Ali
Kamboh

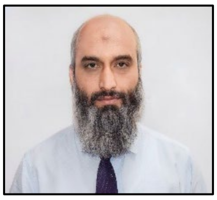
Prof. Dr. Yasir Nawab

Prof. Dr. Nadeem
Ahmed Sheikh

Prof. Dr. Muhammad
Tufail

Prof. Dr.
Muhammad Abid

Dr. Mohsan Haider



Dr. Taqi Ahmad Cheema

Dr. Muhammad
Ramzan Abdul Karim

Prof. Dr. Mohsin
Ali Raza

Dr. Hafiz Farhan
Maqbool

Prof. Dr. Emad
Ud Din

Prof. Dr. Rizwan
Mehmood Gul

Prof. Dr. Umar
Shahbaz Khan

Dr. Noman Naseer

Prof. Dr. Adeel Waqas

Engr. Dr. Khuram
Pervez Amber

Dr. Hafiz Muhammad Ali

Advantages and Challenges of 3D Printed Components for Aerospace Applications

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ABSTRACT

3D printing has become one of the major focuses in the aerospace domain, and a considerable amount of integrated components have been manufactured with innovation in design and functionalization. The main focus of the presentation will be on the Voronoi and triply periodic minimal surface TPMS-based 3D-printed components for aerospace applications. Furthermore, the advantages and the potential methods to solve challenges in this research direction will be highlighted and discussed. The Voronoi and TPMS-based lightweight porous structures can be fabricated via 3D printing with various porosity distributions and similar structural strength as solid structures. Particularly, integrated performance such as vibration isolation, and heat management can also be realized based on innovative structures. Based on these two aspects, functional components such as heat exchangers with low volume, and enhanced heat transfer performance can be obtained, while L-PBF could ensure the interior design of the component. However, challenges remain for 3D printing, especially the deformation control for thin-walled structures. The high-temperature gradient and residual stress could give rise to severe deformation. In addition, the fatigue performance of components is strongly associated with defects such as micropores introduced during the printing process. Therefore, the presentation will discuss the genetic algorithm neural network which is a potential approach to regulate deformation and defects simultaneously. The information shared in this talk is intended to stimulate more research development and provide engineering solutions to 3D-printed parts for aerospace applications.

Role of phase change materials in sustainable development goals: Performance evaluation indexes and performance comparison with conventional methods

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ABSTRACT

Considering the ongoing energy crisis throughout the world and expected shortages in energy production as well as supply in the upcoming years, it is obvious that the development of the methodologies regarding the energy saving/reduction in buildings has great of importance. To combat such highly potential risks associated with energy and reach sustainable development goals, different materials and methods are proposed by researchers in literature. One of the novel methods is the utilization of phase change materials (PCM) to store energy and shift peak loading period. PCMs have high latent heat capacity which can be benefited during solid-liquid (or vice versa) phase change process. Besides, they are available in a wide range of phase change temperatures making them proper candidates in different fields from cryogenic applications to concentrated solar power plants. In this talk, we will focus on PCM applications in buildings. Since the performance of PCM is affected by several parameters, i.e., phase change temperature, latent heat content, besides to other thermophysical properties, existing methods used for thermal performance evaluation are inadequate and a novel index or evaluation method is necessary to quantify the effectiveness of PCM. Besides, in this talk, a comparison based on a case study will be presented to reveal the advantages or

disadvantages of each method/parameter so that they can be interpreted more insightfully. Moreover, the performance of PCM will be compared with the conventional materials, and the synergetic effect will be addressed.

Recent Advances in Biocomposites in Engineering Applications: Piezoelectric Sensor and Electric Vehicles Battery Casing

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ABSTRACT

Biocomposites, materials derived from a combination of natural fibers and biodegradable polymers, have emerged as a sustainable and promising alternative in engineering applications. This presentation will highlight the recent advances in the utilization of biocomposites, focusing on two critical applications: Piezoelectric Sensor and Electric Vehicles (EVs) Battery Casing. In the realm of sensing technology, biocomposite materials exhibit exceptional properties conducive to the development of efficient and environmentally friendly Piezoelectric Sensors. The integration of these sensors into structural components allows for the conversion of mechanical energy into electrical signals, presenting novel opportunities for smart structures, health monitoring, and energy harvesting. Furthermore, in this presentation, we will explore into the application of biocomposites in the fabrication of Electric Vehicles Battery Casings. As the demand for sustainable transportation grows, the development of lightweight, durable, and eco-friendly materials becomes imperative. Biocomposites offer a compelling solution by providing a balance between structural integrity, thermal management, and environmental impact, contributing to the evolution of electric vehicle technologies. This comprehensive exploration of Recent Advances in Biocomposites showcases their potential in enhancing the performance, sustainability, and versatility of engineering applications. The findings presented in this presentation aim to contribute to the ongoing discourse on biocomposite materials and inspire further research in the quest for innovative and ecoconscious engineering solutions.

Progress in condensation heat transfer on external horizontal tubes for surface condensers

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ABSTRACT

Condensation heat transfer plays a vital role in various applications, one of the major applications of condensation heat transfer is on horizontal tubes used in surface condensers of nuclear thermal power cycle to produce electricity. Surface condenser is responsible to create low pressure that provides the thrust force to steam moving to turbine for efficient power generation. Therefore, the role of condensation heat transfer on horizontal tubes has significant importance in thermal power plants. This talk will review the progress on fundamentals of condensation heat transfer by considering the various parameters that impact on condensation heat transfer such as condensate retention, tube geometries, role of fluids hydrodynamic and thermofluidic properties, type of pure or mixture of steam, limitations and advances of surface structures, free and forced convection condensation heat transfer experimental results and model developments. This talk will identify the gaps to be further explored to enhance the heat transfer performance of surface condensers horizontal tubes.

Energy Efficiency and Flexibility as Hidden Resources for Sustainable Development

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ABSTRACT

In pursuit of sustainable development, energy efficiency and flexibility can be considered as concealed yet potent resources. These low hanging fruits of sustainable energy transition are often overlooked when addressing contemporary challenges in energy security, management, and environmental sustainability. By optimizing the use of existing energy resources across diverse sectors we achieve energy efficiency. It not only reduces societal environmental impact but also enhances economic productivity. The implementation of cutting-edge technologies, (e.g. intelligent systems, digital twins), innovative policies and financial instruments all play pivotal roles in improving energy efficiency. The integration of smart grids, energy-efficient appliances, and industrial processes not only minimizes waste but also establishes a foundation for a resilient and responsive energy infrastructure. In tandem, energy flexibility emerges as a valuable resource to balance the uncertainties inherent in energy systems. Financial valuation of energy flexibility promotes seamless integration of renewable energy sources, accommodating the intermittent nature of solar and wind power. Additionally, energy flexibility empowers energy grids to adapt to fluctuating demand, unforeseen disruptions, and emerging technologies. The synergy between energy efficiency and flexibility fosters a robust and adaptive energy ecosystem, laying the groundwork for a sustainable and resilient future. As we struggle to deal with the consequences of climate change and strive to meet ambitious carbon reduction targets, leveraging energy efficiency and flexibility resources becomes imperative. The approach will be illustrated with practical examples from numerous research and innovation projects facilitating the transition to cleaner energy sources. Coupled with the optimization of energy consumption patterns and user engagement, efficient operation of flexible energy systems forms a powerful strategy for mitigating climate change and promoting environmental stewardship.

Fracture Mechanics Approach to Fatigue Crack Initiation

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ABSTRACT

A fracture mechanics approach will be presented to simulate cracking events that may have taken place at uniaxially loaded notched and unnotched components made of a two-phase alloy during the fatigue crack initiation life. The surface roughness resembles microcracks of different sizes and locations at the component surface where material grains of different phases, sizes, and strengths are distributed at random. Potential surface cracking activities are anticipated during loading cycles until the emergence of a dominant crack that propagates to failure. Thus, the duration of the experimentally defined fatigue crack initiation can be calculated. The model is applied to previously published experimental data on ferritic-pearlitic steel unnotched and notched specimens with different stress concentration factors subjected to constant and variable amplitude cyclic uniaxial stresses. Specimens with a random configuration were virtually tested. The comparison of experimental results with corresponding predictions validates the approach.

Assessment of Structural Integrity of an Aircraft Engine during a Fan-Blade off and understanding the dynamics of the event

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ABSTRACT

This paper presents a comprehensive study on the Structural Dynamics of Aircraft Engines during a Fan Blade Off (FBO) event, with a specific focus on Finite Element Explicit Analysis. An FBO event, characterized by the detachment of a fan blade from the engine during flight, is a critical scenario in aerospace engineering that can significantly impact the structural integrity and performance of aircraft engines. The study employs Finite Element Explicit Analysis, a powerful computational tool that enables the simulation of complex dynamic events such as an FBO. This method is particularly suited for analyzing high-speed dynamic events, offering a detailed understanding of the forces, vibrations, and stresses experienced by the engine during an FBO event. The paper begins by providing a detailed overview of the principles and methodologies of Finite Element Explicit Analysis. It then delves into the application of this method in simulating an FBO event, discussing the various parameters and considerations involved in the process. The simulation takes into account the intricate details of the engine structure, material properties, and operational conditions, providing a realistic representation of the event. The results of the Finite Element Explicit Analysis offer valuable insights into the structural dynamics of the aircraft engine during an FBO event. The paper discusses these results in depth, highlighting the complex interplay of forces and vibrations that occur during such an event. It further explores how these dynamics influence the structural integrity of the engine and the overall stability of the aircraft. The paper also discusses the implications of these findings on the design and maintenance of aircraft engines. It suggests potential design modifications and maintenance strategies that can enhance the resilience of the engines to FBO events. These recommendations aim to improve the safety and reliability of aircraft operations, contributing to the broader goal of enhancing aviation safety. In conclusion, this paper underscores the importance of Finite Element Explicit Analysis in understanding the structural dynamics of aircraft engines during an FBO event. It highlights the potential of this method in improving the design and maintenance of aircraft engines, ultimately contributing to safer and more reliable flights. The paper concludes with a discussion on future research directions, emphasizing the need for further advancements in computational methods and experimental validation techniques to enhance our understanding of FBO events and their impact on aircraft engines.

Effect of ZnO Filler Modification on Aging and Mechanical Properties of Carbon-Epoxy Composites

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ABSTRACT

Polymer composites tend to age over time, which leads to a decrease in their mechanical properties. Both internal and external factors can cause this, such as high temperature, humidity, ultraviolet rays, ozone, chain structure, combination, and aggregation. To prevent the aging of polymer matrix composite materials due to moisture and ozone, chemical fillers have been used. The purpose of this study is to demonstrate through experimental studies, tests, and analyses that the use of aging retarding or preventive agents in composite production can extend the life and improve the safety of composite materials. The study investigates the aging effect of carbon/epoxy composites at different humidity and ozone concentrations and determines the effect of ZnO added to the epoxy resin on the aging life. The results showed that ZnO used as a filler reacted with ozone and improved the mechanical properties of the composite material. The tensile strengths of samples exposed to ozone and to which ZnO powder was added at the rates of 1%, 2%, and 4% increased by 2.26%, 10.62% and 20.08%, respectively, compared to pure samples. This experiment was repeated at different ozone and humidity concentrations and the results were recorded. Tensile strengths increased and mechanical properties improved as a result of ozone exposure in all ZnO-doped samples.

Advancement in Sustainable Composites Embedded with Smart Electronics

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ABSTRACT

The development of natural fiber composites (NFCs) has poised to redefine industries with having a sustainable material possessing favorable specific properties i.e., high strength to weight ratio which is due to their being lightweight, high-strength, and sustainable properties. Although, composite materials have already revolutionized major sectors like aerospace, construction, sports, and automotive industry where the weight of the component/part is considered to be very crucial. To further expand the benefits of the composite materials, the integration of embedded electronics into these composites had opened groundbreaking avenues wherein proper feedback mechanisms are incorporated in these materials. However, an optimized mechanism or process for incorporating these feedback systems into composite materials is still considered as a significant concern. Although there are several techniques to produce textile fabric, weaving is mainly considered due to the reason that they offer better control over fabric resulting in better stability and strength which is essential as reinforcement. These smart composites hold immense potential to transform diverse fields, from structural engineering to wearable technology, offering a sustainable and technologically advanced alternative in industries such as automotive, construction, and packaging. The integration of electronics into woven composites offers not only enhanced functionality but also opens avenues for environmentally friendly manufacturing processes. Not only limited to research basis, but smart composite is also one of the trendy topics in current era for Industries focused upon IR 4.0 and IR 5.0, which further validates the significance of the topic. Recent advancements in textile technology, driven by the demand for high-quality products, have led to the use of fibers with special characteristics such as energy collection, color tuning, health monitoring, shape memory, and heat storage. This new generation of textiles includes passive smart textiles (sensing external conditions), active smart textiles (responding to external conditions), and ultra-smart textiles (sensing, reacting, and adapting to conditions). Applications range from basic reinforcement in composites to sophisticated functionalities such as conductive or antibacterial properties, energy harvesting, energy storage, and thermo-regulated fabrics. Smart textiles represent a significant leap in the versatility and adaptability of textile materials in response to modern societal needs. Despite recent advancements in composite materials, there remains a gap in bringing a seamless integration of embedded electronics with functional fibers through a sustainable and intelligent manner. This research aims to address this gap by exploring novel weaving techniques for creating smart and sustainable composites.

Thermal Management of the Batteries for Electric Vehicles

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ABSTRACT

Efficient thermal management of batteries is paramount for maximizing the performance, longevity, and safety of Electric Vehicles (EVs). In this context, a comprehensive approach integrating passive and active cooling techniques alongside advanced materials and intelligent control systems emerges as essential. Passive methods, such as effective insulation and material selection, offer initial cost-effectiveness by reducing heat transfer, yet may falter under extreme conditions or high-power demands. Conversely, active cooling systems like liquid cooling, which circulates coolants within the battery pack, and air cooling, utilizing fans or heat exchangers, provide more robust solutions, with liquid cooling excelling in high-demand scenarios while air cooling offers simplicity and reduced weight. Additionally, advanced strategies incorporating phase change materials (PCMs) and thermoelectric cooling exhibit promise; PCMs stabilize temperatures via latent heat absorption/release, particularly beneficial during charging and discharging cycles, while thermoelectric cooling enables precise temperature control albeit with energy efficiency considerations. Furthermore, the integration of predictive modeling and control algorithms enables dynamic optimization of thermal management systems, leveraging real-time data on ambient conditions, battery usage patterns, and internal temperatures to adapt cooling strategies proactively, thereby enhancing overall battery performance and extending lifespan. Ultimately, a comprehensive approach to thermal management, combining diverse cooling techniques with advanced materials and intelligent control, is essential for ensuring the reliability and efficiency of EV batteries across varied operating conditions, advancing the widespread adoption and sustainability of electric mobility. In current research we have investigated a novel battery management system which is based on the evaporative cooling technique. The system provides maximum cooling with minimum energy utilization.

Interactions Between Fluids and Flexible Bodies: Engineering Insights from Nature

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ABSTRACT

The interplay between fluid dynamics and flexible structures, as observed in nature's flapping wings and flags, provides a fascinating lens to understand fluid-structure interactions. This study delves into the hydrodynamics of fish schooling, a behavior enhancing movement efficiency in fluid environments. By modeling a group of flexible bodies in tandem and sideby-side formations, we uncover how vortices shed from an upstream body significantly affect downstream counterparts through complex vortex interactions. Employing an advanced immersed boundary method, our investigation focuses on flexible flags in viscous flows across triangular, diamond, and conical formations—mimicking the fundamental patterns of fish schooling. Our findings reveal that strategic adjustments in gap distances and flag flexibility can significantly reduce the drag on downstream flags, influenced by the interplay between upstream shed vortices and those encircling downstream flags. This work extends to examining the drag reduction mechanisms and the optimal positioning of trailing flags under various conditions. Notably, we observe single- and multi-frequency modes corresponding to constructive and destructive vortex interactions, which elucidate the drag variations on downstream flags. Further exploration into the active flapping behaviors of fish and cetaceans reveals the propulsive and maneuvering forces generated, drawing parallels to a combined pitch-andheave motion of the tail fin. The study investigates the intricate interactions when an actively flapping flexible flag is introduced downstream of a passively flapping one, focusing on the effects of phase differences, amplitudes, and frequency on drag coefficient. The findings highlight the nuanced interplay between constructive and destructive vortex interactions, alongside slaloming and vortex interception modes, offering novel insights into drag variation mechanisms. This research not only enhances our understanding of fluid flexible body interactions but also informs the design and optimization of bio-inspired engineering applications.

Efficient techniques to recover power from waste using CO2 as working fluid

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ABSTRACT

As the world progresses towards sustainable production and usage, the amount of waste generated, and the end use of waste is becoming one core challenge. Several wastes to fuel/energy conversion technologies are available depending on the type of waste and content of energy available. One key challenge to convert waste low-to-medium energy density waste into electricity

is the unavailability of technology, which is compact, economical and can be scaled according to size and availability. In this regard, a compact and efficient waste to electricity generation can be achieved using super critical sCO2 based working fluid in a Bryton cycle configuration. The sCO2 based cycle is not only compact, but it can also be scaled according to size of the plant from micro to mini size power generation set with possibility of off-grid as well as on-grid integration. Here we present the thermodynamic assessment of sCO2 based cycles using CO2 as working fluid. The recovered power can be used for diverse applications including electricity generation for green Hydrogen production.

Graphene Oxide: From Coatings to Composites and Beyond

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ABSTRACT

Graphene, with remarkable properties such as high surface area, mechanical strength, electrical and thermal conductivity, has gained enormous attraction for electronics, energy, coatings, biomedical and aerospace applications. Graphene oxide (GO), derived from natural graphite through chemical exfoliation, represents a promising low-cost alternative to graphene with significant potential across diverse applications. This talk will give an overview of research activities carried out in our laboratory. The first segment of the talk will present anti-corrosive behavior of GO coatings deposited on copper, steel, magnesium and neodymium iron boron substrates, achieved through techniques like electrophoretic deposition or chemical vapor deposition. The subsequent part of the talk will focus on utilization of GO as filler in epoxy, polyester and acrylonitrile butadiene styrene composites. The factors such as dispersion, functionalization, processing parameters as well as potential applications of GO/polymer composites will also be highlighted. The final part of the talk will explain the application of GO, doped GO or reduced GO in supercapacitors and biomedical applications.

Sedimentation: A Threat to Water-Energy-Food Nexus

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ABSTRACT

Tarbela dam is one of the largest earths filled dams in the world used for power generation and irrigation purposes. Indus basin is also regarded as backbone of Pakistan as it is the biggest source of electricity generation and is called as a food factory for Pakistan. Like all reservoirs the sediments inflow in the Tarbela reservoir has also resulted in reduction in water storage capacity and is also causing damage to the tunnels, the power generating units and ultimately to the plant equipment. The main source of the River Indus is the glacial melt water from the Himalayas with an annual flow rate of 94 MAF which carries along huge number of sediments, and the gross capacity of the reservoir has reduced. The annual suspended sediment load is about 430 million tons meaning that, over time, the reservoir will fill. The life of the dam and reservoir was estimated to be somewhere around fifty years in 1976 when the dam was constructed, meaning that the reservoir will be full of sediments by 2030 and will not be functional anymore unless maintained. This study presents life prediction of Tarbela reservoir in terms of its storage capacity, erosion rate and strength of the tunnels for different times of the year i.e. during flooding (summer) and drought (winter) situations. In addition to the reservoirs of Tarbela and Mangla Dams, almost all barrages and most canals are reasonably full of sediments. An important issue with reservoirs to dredge out sediments is the closing of the dams as they are a major source of electric power as per most recommendations of experts. In addition, sediments are increased observed going into the tunnels hence damaging inner liners and turbine machinery and choking filters etc. This means without closing the power supply, there is a great need to study the sediments flow patterns, dredging patterns, land slide patterns and many others. As such kind of work has not been done so far in any of the hydel power plants in Pakistan; the numerical methods developed provide a base for the study of the behavior of water and sediment flows in Tarbela Dam reservoir, spillways and tunnels and strength analysis of the tunnels using FSI. The developed methodology can also be implemented to study the water and sediment flow behavior of water in other reservoirs, dams, rivers, barrages and canals present throughout in Pakistan in specific; provided the required data for those are available. As Erosion is observed in the tunnels and of turbine blades and

other components; so erosion rate density measurement studies due to sediments and cavitation are carried out with different compositions of sediments (Sand, silt, clay); different flow rates i.e. quantity of flow of sediments through tunnels; different sizes and shapes of particles (circular, triangular, square, etc) for line and area cutting; different injection techniques and others parameters. The Sedimentation Issue needs Serious Consideration as projects on other tunnels, and that can result in delta initiation for movement and suction of sediment. Inlets on Tunnels need to be raised to control sediments. Dredging of sediments needs to be considered through simulations. A comprehensive integrated plan for power generation and water management considering sediments needs attention. Academia / research organizations can help in indigenous studies and can help saving huge amount of foreign exchange.

Composite Materials Research and Applications: A Focus on Global Trends and the Landscape in Pakistan

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ABSTRACT

Fiber reinforced polymeric composites are one of the highly value-added applications of textiles and considered as the major type of Technical Textiles. These are one of the emerging materials replacing metals rapidly in engineering applications especially in sports equipment, marine, wind turbine, aerospace, defense and automotive applications. The global market for composite materials is projected to reach $130.8 billion by 2024, with a compound annual growth rate of 7.8%. This growth is fueled by ongoing research and development efforts aimed at meeting specific industry requirements. In the aerospace sector, there is a continuous quest for innovative solutions to enhance the structural integrity and protective capabilities of composite materials. Recent advancements include the development of Fiber Metal Laminates (FML), Composite Metal joining techniques, and the incorporation of nano reinforcements for structural health monitoring, to achieve electromagnetic interference (EMI) shielding, structural stability, etc. In Pakistan, 120 to 150 small and medium sized organizations related to composites are operating but their share to global market is minute due to unavailability of well-trained human resource, research & development facilities, testing facilities and lack of new entrants/startups in the domains. These are mainly operating in sports, automotive, aerospace, and civil structural applications. This paper provides an overview of global trends in composite materials research and applications, with a focus on the status and prospects in Pakistan.

Navigating Tomorrow: Pakistan's Robotic Odyssey

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(Pride of Performance)
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ABSTRACT

Robotics stands at the forefront of technological evolution, promising to revolutionize industries, redefine human interaction, and reshape our world. This presentation delves into the significance of robotics as an emerging field, tracing its historical roots to its current expansive applications. From manufacturing to healthcare, from exploration to entertainment, robots are increasingly becoming indispensable partners in our daily lives. Through collaborative efforts across academia, industry, and government sectors, Pakistan is harnessing the power of robotics to address societal challenges, enhance productivity, and foster economic growth. From agricultural automation to disaster response, Pakistani innovators are crafting tailored solutions that resonate with local needs and aspirations. Join us on a journey of exploration and inspiration as we uncover the untold stories of Pakistani robotics pioneers. Discover how they are leveraging their talents, resources, and cultural heritage to shape a brighter future for Pakistan and the world at large. Together, let us celebrate the spirit of innovation and collaboration that propels us towards a future where robots and humans coexist harmoniously, enriching each other's lives in ways yet to be imagined.

Advance In Use of UHMWPE in Total Joint Replacements

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ABSTRACT

Ultra-high molecular weight polyethylene (UHMWPE) has been widely used as acetabular cup in total hip replacement (THR) and tibial component in total knee replacement (TKR). Crosslinking of UHMWPE has been successfully used to improve its wear performance leading to longer life of orthopedic implants. Crosslinking can be performed by radiation or organic peroxides. To address the issue of the long-term stability of these materials; vitamin E has been successfully used in this application. A review of the use of UHMWPE in total joint replacements and recent development in this field will be covered in this presentation.

Tessellations in Thermal Energy Systems

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ABSTRACT

A tessellation or tiling is the covering of a surface, often a plane, using one or more geometric shapes, called tiles, with no overlaps and no gaps. In mathematics, tessellation can be generalized to higher dimensions and a variety of geometries. Periodic tessellation has a repeating pattern, whereas Aperiodic tessellation is a non-repeating arrangement of shapes covering a surface that lacks regularity. Unlike periodic tessellations, it forms intricate, irregular patterns, often observed in nature, and utilized in fields like mathematics, art, and materials science for their unique properties and aesthetic appeal. Notable examples include Penrose tiles, which showcase complex yet ordered structures without repeating motifs. Tessellation serves as the foundation for creating diverse lattice structures, which find application in a wide range of mechanical engineering fields. For example, heat sinks, heat exchangers, solar collectors, auxetic structures, etc. From a thermal energy exchange point of view, fluid paths are needed to flow through such structures. Due to variations in the pattern of each structure, the spacing thus created as a result of fabrication processes such as 3D printing, can be used as flow paths. With the introduction of different fluids in different passages, heat exchange processes can be conducted to enhance device performance in all dimensions, more effectively. The advancement in manufacturing processes such as additive manufacturing has enabled effortless creation of various aperiodic patterns, flow structures, and channels. Experimental studies on heat sinks and heat exchangers demonstrate that aperiodic structures exhibit superior performance compared to their regularly shaped structures. Aperiodic structures offer greater design freedom, allowing to tailor properties and optimize performance for specific needs. This flexibility can lead to innovative solutions and improved overall system efficiency. Moreover, by optimizing the geometry and arrangement of aperiodic structures, it's often possible to achieve the desired functionality using less material compared to regular structures. Aperiodic structures can exhibit improved resilience to stress concentrations and fatigue, leading to longer lifespans and increased reliability in various engineering applications. The key-note speech will also cover a few relevant case-studies on the design and development of novel Delta-Nabla-Trapezoidal structured solar collectors, heat exchangers and heat sinks, based on the tessellations.

Empowering Energy Storage: Unveiling the Potential of Transition Metal Based electrode materials for Supercapacitors

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ABSTRACT

Supercapacitors are proven as energy storage devices with more energy density than capacitors, and better power density than batteries (lithium-ion batteries (LIBs), sodium-ion batteries (SIBs) with highrate performance. Transition metal compounds (TMCs) and Transition metal based organic frameworks (TMOFs) are being researched as promising electrode materials for supercapacitors. Among different TMCs, transition metal sulfides (TMSs), transition metal oxides (TMOs), transition metal hydroxides (TMHs), transition metal nitrides (TMNs), transition metal phosphates (TMPs) and their nanocomposites with carbonaceous materials like carbon nanotubes (CNTs), graphene nanoplatelets (GNPs), reduced graphene oxides (rGO), and graphitic carbon (GC) are generally being employed. Similarly, among different TMOFs, Ni, Co, Zn, Mn etc. based unary, binary, and ternary frameworks and their composites with CNTs, GOs, GNPs etc. are being researched for their electrochemical energy potentials. The proposed topic would include covering these various types of transition metal compounds and TMOFs based electrode materials in general while Cu, Ni, Co, Mn, Zn based TMOFs and transition metal phosphates (TMPs) in particular, prepared through various synthesis routes. TMPs and TMOFs based electrode materials have feasible structures, good surface area due to engrossed porosity, rich active redox reaction sites and variable valance metallic ions that make them ideal to be used for supercapacitor electrode materials. Moreover, their composites with CNTs, rGO, GC and other carbon-based materials further enhance surface area, and the excellent electrical conductivity of carbon materials combined with the variable valency of metallic ions in transition metal-based structures enhance their electrochemical performance.

Applications of advanced composite materials towards aerostructure design and manufacturing

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ABSTRACT

The aerospace industry, over a span of more than 100 years of its history, has been a pioneer in pushing the boundaries of technological innovations. Many technologies that were developed for the primary use in aerospace applications later on found their applications in many other industries. Same is the case with advanced structural materials including composites. Aerospace structures have very stringent performance requirements that require superior material properties. Furthermore, strength-to-weight and stiffness-to-weight ratios are important design criteria for aerostructure designs where lower structural weights are considered ideal for minimizing platform operational costs and to achieve mission goals. Advanced composite materials are materials of choice for aerospace structures due to their superior specific stiffness, strength and fatigue properties compared with conventional materials. Use of these materials also give designers the choice to design monolithic structures which are structurally superior with reduced part and fastener count. This all seems like a perfect match between composites and aerostructures, however it is not as straightforward as it appears. The choice of best material and best manufacturing process is critical for the success of a platform. This talk is aimed at covering state of the technology in terms of advanced composite materials and associated manufacturing processes in use today in the aerospace industry. This will also cover some of the challenges and issues with in-use materials and processes, and further where innovations in materials and processes need to go to address current and future challenges. We will also establish the strong link between engineering design, materials, manufacturing processes and quality assurance in light of design-formanufacturing, design-for-cost and design-for-repairability aspects of advanced composite materials.

Machine Learning for Neurorobotics

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ABSTRACT

This talk will focus on the basics of machine learning and its applications. A specific application of machine learning for Neurorobotics will be discussed in detail. Neurorobotics is the combined study of neuroscience, robotics and artificially intelligent systems. It can be used to provide a means of communication for people suffering from severe motor disabilities or with limb amputation. The talk will include using machine learning algorithms for development of electromyography (EMG)-based control of prosthetic arm and electroencephalography (EEG)- based control of external devices including a wheelchair for rehabilitation of mobility in paralyzed individuals. Details of a recently developed functional near-infrared spectroscopy (fNIRS) system for brain-imaging and its application for brain-computer interface will be presented. All necessary steps involved in developing EMG-, EEG- and fNIRS-based neurorobotics interfaces including bioinstrumentation, filtering, machine learning and control command generation will be discussed. Some recent works done at Air University; Islamabad will be presented as well.

Objective Evaluation of Lower Limb Amputees using Inertial Measurement Units

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ABSTRACT

Numbers of individuals undergo the amputation of their lower limbs every year as a result of vascular disease and complications associated with conditions such as diabetes, cancer and trauma have increased worldwide. Limb loss has a significant impact on individual's physical, mental and vocational abilities, generally resulting in the degradation of amputees' quality of life (QOL). Following an amputation, prosthetic devices can improve the amputees' QOL. Rapid technological advancement in the prosthetic field over the last few decades has caused prosthetic devices to evolve from purely passive (mechanical) devices to more advanced devices incorporating microprocessor controlled and powered components. Wearable sensors are frequently used to assess spatio-temporal, kinematic and kinetic parameters providing the means to establish an interactive control of the amputee-prosthesis-environment system. Human gait can be divided into a sequence of repeated phases and events associated with its cyclic nature with the stance and swing phases being the two main phases of the gait cycle. In terms of events, initial contact (IC) and toe off (TO) mark the beginning of a stance and swing phase respectively and provide information about stance time, swing time, cycle duration and gait asymmetry. They are thus important assessment parameters and are frequently used in clinical studies as objective measures for evaluating the efficiency of the rehabilitative processes. The timing of these events supports the analysis of temporal parameters such as stride time and periods of single and double support. The talk will revolve around the utility of IMU based data acquisition platform that could potentially be used for objective evaluation of lower limb amputees when performing activities of daily livings.

Energy Consumption in Pakistani Residential Buildings: Insights from Degree Days Analysis and Appliance Consumption Patterns

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ABSTRACT

The presentation will offer a comprehensive exploration of energy consumption dynamics in Pakistani residential buildings, integrating innovative approaches such as Degree Days analysis and appliance consumption patterns to inform policy and practice towards greater energy efficiency. The session will commence with an examination of Degree Days maps of Pakistan, highlighting regional variations in heating and cooling requirements based on climatic conditions. By leveraging Degree Days data, attendees will gain insights into the predictive capabilities for energy consumption across diverse regions, facilitating informed decision-making for energy planning and resource allocation. Subsequently, an overview of Pakistan's energy mix and consumption patterns will be provided, contextualizing the challenges and opportunities inherent in the country's energy landscape. Special emphasis will be placed on residential electricity consumption patterns, with a detailed analysis of the impact of various appliances on energy demand. Through comparative studies between AC and non-AC homes, attendees will elucidate the differential energy consumption patterns driven by climatic factors and appliance usage. Furthermore, the presentation will delve into the electricity usage intensity of domestic buildings, exploring factors influencing energy intensity and identifying opportunities for efficiency improvements. By examining key determinants such as building size, occupancy patterns, and appliance usage, participants will uncover actionable insights for optimizing energy performance in residential settings. A pivotal aspect of the discussion will revolve around the imperative for effective building energy codes and policies in Pakistan. By highlighting the benefits of robust regulatory frameworks, including enhanced energy efficiency, reduced carbon emissions, and improved comfort levels for occupants, attendees will be encouraged to advocate for the implementation of stringent building standards. In conclusion, the presentation will empower stakeholders with practical strategies and evidence-based insights to promote energy efficiency in Pakistani residential buildings. By harnessing the predictive capabilities of Degree Days analysis, understanding appliance consumption patterns, and advocating for effective policy interventions, participants will contribute to the realization of a sustainable and resilient built environment in Pakistan.

Mechanical Research-101; Incorporating Power Law for The Estimation of Maximum Strain Under Pressure Loading for Solid Propellent Grain in Conjunction With FEM

Syed Faiq Musharraf[1*], Faizan Ali[1], Obaid Ur Rehman[1], Ahmed Abdul Moeed[1], Muhammad Adnan[2], Riffat Asim Pasha[1]
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ABSTRACT

The primary objective of this study is to critically examine the propellant grain's structural integrity in solid propellant star grain under pressure loading. Structural integrity is crucial for applications like space launch vehicles and military missile systems. As FEA needs a lot of time at the design stage, the research method gives almost equal results without the use of FEA

but with only 3 to 4% deviation. The research encompasses structural analysis, stress mitigation, finite element analysis, parametric analysis, and the derivation of a power law equation to model propellant strain. Several simulations have been performed on star grain shape by doing parametric analysis on FEA tool to drive the equation for power law which will predict the maximum principal strain of star grain shape within a minute, instead of an hour using FEA. This study facilitates efficient exploration of grain geometry, benefiting design consideration in rocket motor development.

Mechanical Research-102; Supply Chain Management in Oil & Gas Field in Pakistan - Challenges and Solutions

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ABSTRACT

The research explores the significance of supply chain management (SCM) in the oil & gas industry. It outlines various stages involved in oil & gas supply chain, encompassing exploration, production, transportation, refining, storage, and distribution design networks. The case study of Sui Northern Gas Pipelines Limited (SNGPL) in Pakistan exemplifies the intricacies of natural gas supply chain management. Furthermore, the research emphasizes the importance of SCM in ensuring operational efficiency, cost reduction, and environmental sustainability within the oil & gas field. It also highlights challenges faced by the industry, such as inadequate infrastructure, fluctuating regulations, and skilled manpower shortage, alongside potential solutions like infrastructure development, technology adoption, and robust risk mitigation strategies.

Mechatronics Research-104: Temporal Assessment Box: Neurological Disease Diagnosis through Manual Dexterity Analysis

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Healthcare technology is advancing rapidly to improve the clinical measures that are currently in use, which are mainly based on subjective assessments by neurologists. Clinical measures, like UPDRS, MBRS, and NHPT, AHTD, are critical indicators and activities for assessing neurological disorders and motor impairments but, they frequently lack consistency and accuracy. In response to this, we proposed and employed a kinematic assessment procedure to describe the severity and evolution of upper limb dysfunctions in people with neurological disorders. We as a team of mechatronics engineers designed a mechanical structure that incorporated a microcontroller. We presented the Temporal Assessment Box (TAB), a quantitative tool, designed to provide us with temporal parameters of the upper limb movements in patients with neurological disorders with a special focus on manual dexterity. Therefore, as a part of our methodology, we first gathered the data on reach-to-grasp-to-lift-to-transport movement from the healthy participants. This assessment uses four distinct objects of varying grasp sizes and base holes at particular distances. Through the data analysis of participants, we aim to find consistent kinematic pattern differences between patients with mild and severe conditions, especially related to the object grasp dimensions. In conclusion, TAB will

utilize kinematic analysis and quantitative measures to determine whether the person has a neurological disorder. The expected outcomes include enhancing the accuracy of the detection of manual dexterity.

Mechanical Research-106; Quantitative Assessment of Ground Penetrating Radar for Concrete Structure Integrity

Mahmood Khan[1&3*], Ahsan Ali[3], Muhammad Athar Khan Chandia[2], Safiullah Noor[2], Abdul Moeez[2], Muhammad Shahid Aslam[2], Muhammad Nouman[3], Khurram Shahzad[3], Zahid Suleman Butt[2], Ragnhild Elizabeth Aune[1]

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ABSTRACT

Ground Penetrating Radar (GPR) is emerging as a promising tool for assessing the condition of reinforced concrete structures. This study focuses on evaluating the effectiveness of GPR mapping techniques in detecting and characterizing reinforcement bars, voids, and other anomalies within concrete structures. Utilizing a high-frequency GPR system, data was collected from various reinforced concrete specimens, including beams, columns, and slabs. The research methodology involved systematic scanning of the specimens to capture GPR signals reflected from the internal features of the concrete. Signal processing techniques were employed to enhance data clarity and extract meaningful information regarding the depth, size, and orientation of reinforcement bars, as well as the presence of voids or defects. The results of the study demonstrate the capability of GPR mapping in providing accurate imaging and assessment of reinforced concrete structures. Insights gained from the data analysis contribute to a better understanding of the structural integrity, corrosion potential, and overall health of the concrete elements. This research has implications for maintenance strategies, structural health monitoring, and non-destructive evaluation practices in the construction industry. By showcasing the efficacy and reliability of GPR in mapping reinforced concrete, this study contributes to the advancement of non-invasive inspection techniques and supports informed decision-making in structural maintenance and rehabilitation projects.

Mechanical Research-107; Electromagnetic Testing: Prospects and Advancements for Industrial Inspections

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ABSTRACT

Electromagnetic testing methods cover a video range of Non-Destructive Testing (NDT) of engineering components installed in petrochemicals, power plants, fertilizer and many other. Heat exchanger tubes are the center of operation, w.r.t heat transfer and chemical reactions. Generally, the degradation mechanisms prefer thinnest pressure boundaries subject to failures. The present study covers the major four NDT methods of tubes testing, namely, Eddy Current testing, Remote field testing, Alternating current field measurement and Magnetic flux leakage. These techniques offer a wide range of coverage of the suspected areas of degradation. The choice of inspection and testing parameters lead to successful detection of flaws and corrective maintenance procedures. Recent developments in engineering technology have helped in detecting very subtle damage and defects in structures and materials, Robotics system, Smart Multi-Modal approach and utilization of physical principles of magnetism. Incorporation of Data Analysis techniques via artificial intelligence and machine learning algorithms results in the ability to read information faster, identify trends and patterns, predictive maintenance practices and the swift management of the assets making them more reliable. The features of electromagnetic methods of being portable and field-deployable systems enable quick inspections at multiple locations on the site which further expedites evaluations and prevents undue downtime. The integration with Industry 4.0 technologies with IoT platforms and cloud systems connected in real time, monitoring, remote inspection, and data sharing can be done to collaboratively and ensure quality measurement by networking. In the present study we will cover the basics of electromagnetic testing, there impact and detectability of industrial defects which can hinder the safe and reliable operation of the plants and efforts concerning the continual growth of electromagnetic testing technologies.

Mechanical Research-188; Effect of Pressure on Rough Piston Skirt in Iso-Thermal Hydrodynamic Lubrication Case for High Torque Low Speed Diesel Engine

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ABSTRACT

Performance, consistency and life of a high-torque low-speed internal combustion (IC) diesel engine are affected by adhesive wear which occurs due to friction, insufficient lubrication and contact of rough piston and cylinder liner surfaces. The heat generation due to viscous shearing increases the engine lubricant temperature which reduces its viscosity, film thickness and load carrying capacity. Under steady conditions 2-D Reynolds Equation is modified by introducing pressure factor for Iso-thermal condition. Finite difference method (FDM) based numerical technique is employed to determine the pressure distributions in the lubricant film formed between the rough piston surfaces interacting with the cylinder liner. The study determines hydrodynamic pressures generated at different speeds due to lateral motion and wedge action of sliding piston skirts.

Materials Research-108; Parametric Optimization and Comparison of Digital Radiography with Conventional Radiographic Testing

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ABSTRACT

Radiographic testing specializes in internal flaws and structure revelation. It has proven peerless w.r.t details and inspection capabilities. However, the hazards associated with the ionizing radiation have limited the scope of radiographic testing. Efforts are underway to oust undue exposures by advancements in technology. Nevertheless, the majority of classical terminology and basis of conceptual advancements originate from conventional film radiographic method. Digital Radiography (DR) advanced directly to computers via software, enabling control on many operations parameters. The National Centre for Non-Destructive Testing is equipped with all the conventional NDT methods as well as state-of-the-art DR setup. A merger of both technologies for the better resolution and comparative approach is aimed hereby in this study. Optimizing DR for weld detection in pipes involves careful selection of exposure parameters, such as voltage, current, and exposure time, to ensure adequate penetration and contrast. Positioning the detector and X-ray source at optimal angles relative to the weld and using appropriate image processing techniques can enhance defect visibility. Contrast of the film, Graininess, sensitivity, IQI are specific to conventional radiographic testing. These terms have lost their core meaning in DR due to special phosphor screens or flat panels containing micro-electronic sensors or phase array diodes. However, the impact of radiographic image and their interpretation still requires the concepts and evaluation of these implicit parameters of radiation exposure. The study aims to demonstrate improvements in defect detection sensitivity and accuracy compared to conventional radiographic methods. Optimizing digital radiography involves calibrating, selecting appropriate exposure techniques and beam energy, utilizing image processing, multiple focus, dimensional scaling, and integrating with conventional RT for comprehensive results.

Mechanical Research-109; Finite Element Analysis of Portable Grain Segregation System

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ABSTRACT

Manufacturers of high-density polyethylene (HDPE) pipes are facing the challenge of maintaining consistent quality and sizes. This is due to the presence of contaminants in the HDPE grains that are added during the recycling process. When it comes to cleaning a 130 kg grain load by hand, can be a time-consuming process. As a solution to this problem, the prototype of a portable segregation system has been proposed. The purpose of the current research is to investigate the Static Structural and Modal Analysis of portable segregation systems, to ensure that they are designed safely for industrial purposes. The main objective of this research is to analyze the strength and handling of the machine so that it can work well under different conditions and loads without failure. Structural damage due to the weight of the material or its components is analyzed by investigating the strength of the links, hopper, and frame. In addition to this, the research also emphasizes investigating the failure of the frame due to vibrations, by incorporating modal analysis. The durability of the design under stresses is checked by utilizing FEA techniques to investigate the mathematical modeling, structural, and modal analysis of the design. The research evaluates the design of the machine that reduces the cost by up to 65%. Its applications can be found in the polymer, agricultural, and construction industries.

Mechanical-Research-111; Experimental Investigation of Tensile Behaviour for Hybrid Composites: Effects of Hole and Stacking Sequences

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ABSTRACT

Hybrid composites of synthetic fibers are widely used in many industrial applications due to their specific mechanical properties and low density. This research compared the tensile strength (σts) of simple glass and jute fiber hybrid laminates with different stacking sequences and holes in the middle using epoxy YD-128. Different sequences of five jute and glass fiber laminate layers created by controlled hand layup are evaluated. Hybrid composite sample tensile characteristics were examined in compliance with ASTM standard D3039. The results were validated with simulated results using Abaqus software. The experimental and numerical results indicated that Sample W (Glass-Jute-Jute-Glass-Glass without central hole) has the highest σts of 108.8 MPa and has 15.9%, 49.5%, and 55.1% higher σts compared to Sample X (Glass-Jute-Jute-Glass-Glass with central hole), Sample Y (Jute-Glass-Glass-Jute-Jute without central hole), and Sample Z (Jute-Glass-Glass-Jute-Jute with central hole). The σts of Sample Z has the lowest value of 48.80 MPa. Sample X has 66.4% higher σts compared to Sample Y and Sample Y has 12.7% higher strength compared to Sample Z. It is concluded that the improper and non-uniform distribution of epoxy between the layers for different stacking sequences and hole in the hybrid composite, decreases the σts. The morphology of fractured edges of hybrid composites revealed that the failure was matrix failure for all the samples of hybrid laminates.

Energy Research-113; Investigation of heat exchange performance with stainless steel double-walled pipe of power plant

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ABSTRACT

Heat exchangers are essential components across various industries, and many types are widely utilized. Operating these devices at high temperatures often requires a balance between maximum strength and long-term corrosion resistance. The use of traditional single-walled pipes leads to undesirable changes in tube characteristics or operational conditions. A viable solution to overcome these challenges is the implementation of double-walled pipes, which enhance structural integrity and reduce the risk of crack propagation. In this study, the tensile method is employed to fabricate double-walled pipes, each with a wall thickness of 1 mm. Additionally, a phase-sensitive transient thermal method is applied to evaluate the heat exchange performance. The results indicate that the obtain thermal contact conductance value is 1.33×10^3 W/m²K at contact pressure of 15 MPa, while the thermal conductivity values remain approximately constant at 14.43 W/mK. Double-walled pipes are used in industries such as chemical processing, power generation, oil refining, pharmaceuticals, food production, and HVAC systems to efficiently manage and transfer heat.

Mechanical Research-114; Structural and Thermal Numerical Investigation of Multiple Configurations of Super Insulated Cryogenic pipe for Liquid Nitrogen

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ABSTRACT

Vacuum-insulated cryogenic pipes play a critical role in industrial applications for the transportation of liquid nitrogen (LN2). To maintain the temperature of the cryogenic fluid, effective thermal insulation and careful selection of pipe material are crucial. Failure to do so can result in the vaporization of LN2. Extremely low temperature of LN2 (-196°C) can cause material brittleness and loss of tensile strength, resulting in pipe cracking, corrosion, bending, issues. Even a tiny LN2 leakage onto the pipe's surface can lead to frost or ice accumulation, which can cause structural failure. The objective of this study is to develop a model of super-insulated cryogenic pipe that prevents thermal losses and structural failure of cryogenic pipes. In the present work, initially, identification of the most appropriate materials for the cryogenic pipe, i.e. ASTM A312 SS304 and aluminized Mylar for insulation is made. Then, a cryogenic pipe of 1 meter length is designed by analytical modelling using the relevant governing equations. A 3D model is developed, followed. Afterward, detailed structural and thermal simulations are performed in ANSYS-Fluent to analyze the Performance of the multiple configurations (20, 40, 60 and 80 layers of insulation) of super-insulated cryogenic pipe in terms of structural and thermal behaviors under wide range of operating conditions. Through theoretical and numerical simulations, it has been determined that the ideal thickness for achieving minimal heat loss of LN2 is 70 layers of Aluminized Mylar. It's worth noting that increasing the layer thickness beyond this point does not significantly improve thermal performance. It is concluded that the use of effective thermal insulation and Vacuum in these pipes, successfully addresses the challenges of heat gain from the environment, structural failure due to material brittleness, and frost or ice accumulation on the surface of pipes

Mechanical Research 115; Design and Development of Solar Assisted Hybrid Bicycle

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ABSTRACT

Fossil fuel transportation is the most common type of transportation around the globe. Transportation in the developed countries consumes over one-third of all worldwide transportation energy and is a major source of the emission of pollutants like CO2 which plays a great role in environmental pollution. To overcome the sustainability issue, a solar hybrid bicycle design is proposed as an alternative mode of transportation to address the ever-growing environmental pollution by minimizing CO2 emissions as well as cost reduction. Hybrid Bicycle consists of a dual running mechanism such as solar energy and paddles. A BLDC motor is run with 12-volt dual batteries connected in series charged by a solar panel. In order to propel the Bicycle without physical human effort a 250-watt Brush Less DC motor is used. The motor is fitted in the rear wheel and relates to the help of a Chain Drive System. The design adopted in this study is to fit the panel as a roof of the vehicle due to the reasons that the load is equally distributed on the cycle, the roof is adjustable not just for a heighted person but also to avail maximum light intensity. The novelty of this research is that studies on e-bicycle existed but limited research on solar-powered e-bicycles and their influence on society, environment and cost were carried out. The analysis revealed that a solar e-bicycle is used as a sustainable way of transportation by meeting the requirements of a local peoples with its greater occupancy rate, speed, and travel distance

Energy Research-118; Prioritizing Energy Efficiency in Pakistani SMEs: A Techno-Economic Analysis using EUAC and Payback Period

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ABSTRACT

Global energy consumption is surging, exerting immense pressure on resources and the environment., especially in developing countries like Pakistan, where approximately 4.4 million Small and Medium-sized Enterprises (SMEs) contribute over 20% of the nation's energy use. Despite their economic importance, this research developed a techno-economic framework tailored for Pakistani SMEs, which often lack optimization due to resource limitations and unique challenges, focusing on a representative compressor room. Utilizing Self-Assessment Tool and energy audit guidelines, a thorough analysis of energy consumption patterns defined a baseline of USD 211 thousand. Key energy performance indicators (EnPIs) and potential strategies were evaluated through Reliability-Centered Maintenance (RCM), Equivalent Uniform Annual Cost (EUAC), and Payback Period analyses to assess their financial viability. Results revealed significant disparities in annual energy consumption among compressors, with electricity accounting for USD 187,000 and water for USD 24,000. Major opportunities for savings of 32% include reducing compressed air leakages and optimizing system pressure. The use of nozzles for machining processes, where high-pressure is used, emerged as the most affordable and technically feasible strategy, offering savings of

USD 46 thousand with the shortest payback period. Implementation of water recycling unit emerged as a critical environmental measure, promising annual savings of around 70% with 1 year payback period. Unidentified compressed air leakages, though requiring a high initial investment, offer long-term savings with 4 years payback period. The findings validate the financial viability of the proposed model, demonstrating that selected EnPIs can achieve cumulative annual savings of USD 130 thousand and an equivalent reduction in carbon footprint. This study highlights the necessity of a structured approach to energy management in Pakistani SMEs, stressing advanced technological solutions and rigorous maintenance practices. By prioritizing EnPIs based on the techno-economic framework used, SMEs can significantly reduce energy consumption and operating costs, enhancing their sustainability and competitiveness.

Mechatronics Research-119; Wearable Data Acquisition System for Biomechanical Analysis

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ABSTRACT

Gait is the essential function for humans, reflecting physical and cognitive status. This research aims to revolutionize clinical gait analysis, prosthetic design assessment, and human motion evaluation using the Wearable Data Acquisition System (WeDAQ). The system collects multi-parameter data, is capable of real-time transmission, and can be tailored for 90% less in cost than the average price for a standard 3D motion analysis set up. The wearable sensor modules include Force Sensitive Resistors (FSR) FSR402, Surface Electromyography Measurement (sEMG) MyoWare AT-04-001 and Inertial Measurement Unit (IMU), MPU6050. The configuration is scalable to handle input specifications, consequently lowering the design footprint and increasing ease of wear. Healthcare facilities can get it via the Data Logger GUI and WIFI- Enabled ESP microcontrollers. During thorough validation of the data, a correlation coefficient (R) between WeDAQ and SHIMMER® occupied 0.949..

Mechanical Research-121; FEM Based Complex Multivariate Random Vibration Fatigue Life Prediction of a Tracked Vehicle Balance Arm Using Various Road Surface Profiles

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ABSTRACT

Probabilistic random vibration can speed up wear and tear on several components of the tracked vehicle, including the track system, drivetrain, and suspension. Extended exposure to high levels of vibration can cause structural damage to the vehicle frame and other critical components. Assessing random vibration in track vehicles requires a comprehensive approach that considers both the root causes and potential consequences of the vibrations. This Random vibration significantly influences the structural performance of balance arm which is key component of tracked vehicle. The current research article investigates the fatigue damage characteristics of a tracked vehicle balance arm considering the dynamic loads induced by traversing on smooth and rough terrain. The analysis focusses on assessing the damage and stress response Power spectral density (PSD) ground based excitation which is termed PSD-G acceleration. Quasi Static Finite Element Method based approach is used to simulate the operational conditions experienced by the balance arm. Through comprehensive numerical simulations, the fatigue damage accumulation patterns are examined, providing insights into the structure integrity and performance durability of the balance arm under varying operational scenarios. The obtained stress response PSD data and fatigue damage showed that the rough terrain response exhibits higher stresses in balance arm. The accumulated stresses in case of rough terrain may prompt to brittle failure at specific critical locations. This research contributes to the advancement to the design and

optimization strategies for tracked vehicle components enhancing their reliability and longevity in demanding operational environment.

Mechatronics Research-123; Simulation of Collaborative Controlled Collision Avoiding Robot

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ABSTRACT

Vehicle robots have become part of our daily life, from household tasks to military operations. Typically, these robots are controlled autonomously, semi-autonomously, or manually via remote control, but each method has limitations, including sensor failures, communication errors, and processing delays. To remove such issues, this study introduces a collaborative control method for vehicle robots that combines the strengths of tele-operated and fully autonomous systems to provide better navigation for the vehicle robot. A simulation environment is created using MATLAB® that contains multiple dynamic, circular shaped obstacles that move linearly and reflect off walls. The robot's position is specified by its x and y coordinates, and its trajectory is predicted based on its steering direction. Obstacles are detected at the robot's corners and edges. When a collision is anticipated, the collaborative control system activates to provide avoidance recommendations, selecting the safest option with minimal or no collision risk. If no obstacles are detected, the robot remains under manual control. The results show that the collaborative control system allows the vehicle robot to reach its destination faster and with fewer collisions compared to fully manual or autonomous modes. The proposed system significantly improves safety and operational efficiency while avoiding very few dynamic obstacles.

Mechanical Research-124; Performance Analysis of V-Trough Concentrators

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ABSTRACT

This research endeavor holds immense importance, particularly in regions like Pakistan, where the energy crisis presents formidable obstacles to both economic progress and daily existence. Our study explores the performance of monocrystalline solar panels with V-trough concentrators made of simple reflective mirrors. A comprehensive CAD model was simulated in Trace Pro for advanced ray tracing. The cooling system, designed with copper tubes arranged in a spiral pattern beneath the panel, enhances heat dissipation. Experiments measured surface temperature and electrical output under varying solar irradiance conditions. Results indicated that panels with V-trough concentrators experienced significantly higher surface temperatures, particularly during peak sunlight hours, resulting in an electrical output increased by up to 20% as compared to those without the trough. Theoretical efficiency was calculated at 92%, practical efficiency was 35% due to heat and other losses. Effective thermal management is essential to mitigate overheating risks and optimize overall system performance, highlighting the importance of balancing enhanced solar concentration benefits with thermal regulation.

Energy Research-125; Experimental Comparative Investigation of EGR and Water Injection for Lean and Rich Combustion in Turbocharged Diesel Engine

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ABSTRACT

Emission reduction in diesel engines is crucial due to their widespread use and environmental impact. Exhaust Gas Recirculation (EGR) and Water Injection (WI) are used for emission reduction. This study compares the efficacy of Low-Pressure Exhaust Gas Recirculation (LP-EGR) and Indirect Water Injection (IWI) in modifying combustion modes, focusing on lean and rich combustion using lambda values. A high-speed, turbocharged automotive diesel engine, fitted with an indirect water injection system, was tested under three distinct speed and loading (operating) conditions, with a total of 20 different rates of water injection and EGR for each condition. WI resulted in lambda value decreases of 5%, 3%, and 3% for respective operating conditions, while EGR showed more significant decreases of 43%, 27%, and 18%. Both methods showed lower reductions in lambda values at higher speeds, but EGR consistently led to richer combustion over the entire range of operating conditions. The study concluded that WI better maintains lean combustion, making it a more favorable option for sustaining leaner combustion modes in high-speed automotive diesel engines.

Materials Research-126; Experimental Investigation of Mechanical Properties of Biodegradable Polymer Composite for Artificial Orthopedic Implants

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ABSTRACT

Polylactic acid (PLA) is a biodegradable polymer material with mechanical properties similar to bone. However, its use is limited due to low biocompatibility and mechanical properties. To address this, tricalcium phosphate (TCP) can be used to improve biocompatibility, while metal oxide reinforcements can enhance mechanical properties. In this research, novel PLA/ZnO/TCP composites were developed using TCP and ZnO to improve biocompatibility and mechanical properties. The samples were prepared using solution casting. Mechanical and degradation studies were performed to investigate the performance of the composites. Ultimate tensile strength and Young's modulus of PLA-based nanocomposite membranes were determined using a Universal Testing Machine. The mechanical strength of PLA was increased upto 17.03% after adding 1 wt.% ZnO nanoparticles. Additionally, the biodegradation behavior of PLA was maintained by adding tricalcium phosphate (TCP). The improvement in mechanical properties and degradation behavior of composite membranes suggests their potential use in tissue engineering applications.

Material Research-131; Evaluating the Influence of SiC coating on Surface Characteristics of UHMWPE

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ABSTRACT

Ultra-high Molecular Weight Polyethylene (UHMWPE) is a highly versatile polymer known for its exceptional properties, however, its limited life as an implant material in biomedical applications necessitates surface modification to lessen wear debris formation. Silicon Carbide (SiC) is extensively employed as a coating material due to its exceptional corrosion resistance, resistance to significant temperature fluctuations, and effective wear resistance. This study aims to investigate surface properties of UHMWPE through application of SiC coating. Magnetron sputtering in RF mode was used to deposit thin film with thickness 500 nm on UHMWPE substrate. The surface characteristics, such as, surface roughness, uniformity, elemental composition, nano-hardness and adhesion of coated and uncoated samples were analyzed through Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDX), Nano Indentation and mechanical adhesion tests, respectively. The finding showed no significant difference in surface topography comparatively. Nano-indentation reveals that the hardness increases by 167%. The adhesion test also confirms that a strong adhesive film of class 4B was obtained. It was concluded that SiC exhibits good properties confirming magnetron sputtering as a reliable method that can result in enhanced life span of UHMWPE.

Mechanical Research-132; Comparison of Different Reverse Engineering Techniques used for the Fabrication of total Hip Joint System

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ABSTRACT

Reverse engineering analyses product design and structure to replicate it. This study compares 3D scanning and manual measurement techniques for replicating total hip joint systems (THJS) to optimize medical device design. Using an EinScan-SP 3D scanner, a THJS was scanned and processed with Geomagic Wrap and Geomagic Design X software to create 3D CAD models. Manual measurements were taken using vernier callipers and radial gauges. Results showed that manual measurement excels in consistency, identifying threads and adhering to standards, providing more accurate dimensions, while 3D scanning offers speed and better finishing. The choice of technique should align with project requirements, guiding medical device designers in selecting the most suitable method for precise replication.

Material Research-133; Crosslinking of UHMWPE: A Path to superior wear resistance in Total Joint Replacement

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ABSTRACT

Ultra-high molecular Weight Polyethylene (UHMWPE) is a material of choice used in Total Joint replacement (TJR) as a bearing surface. UHMWPE suffers from wear leading to osteolysis (artificial joint failure), which is coped with crosslinking to improve its wear resistance. Antioxidants are added in UHMWPE to take care of oxidation embrittlement caused by crosslinking. In this research paper a well-known antioxidant vitamin E (VE) and different crosslinking techniques are used for crosslinking of UHMWPE and VE-UHMWP to reduce wear related osteolysis and oxidation embrittlement in TJR. This research aims to evaluate and compare the impacts of different crosslinking techniques on the different properties of control UHMWPE and VE-UHMWPE. Crosslinking can be performed through different techniques such as radiation crosslinking and chemical crosslinking both bulk chemical crosslinking and surface chemical crosslinking through Dicumyl Peroxide (DCP) as a crosslinking initiator is analyzed.

Material Research- 134; Estimation of Creep Behaviour of CFRP Composite under Hoop Stress through ASTM D2290 and Accelerated Testing Methodology

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ABSTRACT

Polymer composites are used in almost every industry from automotive, aerospace, sports and defense industries. Like other materials, composites also undergo creep. Finding the creep behavior of composites is crucial because unlike other defects, we cannot see if the material is undergoing creep as the strains are very small. After reaching a certain limit, the strain maximizes, and the material fails catastrophically. The goal of this research was to review the previous work done on the creep behavior and perform experiments to conduct our research on the basis of which we can estimate the creep behavior of the CFRP composite. For the experimental setup, we used the ASTM D2290 standard which is used for hoop tensile tests and Accelerated Testing Methodology which is used for creep testing at elevated temperatures. The pre-stressed samples were then placed in the thermal chamber at 80°C for 40 days. The strain data at different time periods at 80°C temperature from the experiments were used to obtain the creep behavior of the composite. The knowledge gained about the creep behavior of the CFRP composites through the experimentation can be applied by the mentioned industries in their products

Mechanical-Research-141; Improvement in Shear properties of Fused Filament Fabrication printed polymers through process parameters optimization

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ABSTRACT

Unmanned Underwater Vehicles (UUVs) play a critical role in underwater warfare and exploration, traditionally relying on steel or aluminum pressure hulls. This project compares two pressure hull designs, one constructed from steel HY100 and the other from carbon fiber-reinforced epoxy composites. While steel offers high stiffness for deep-water operations, it presents a problematic magnetic signature. In contrast, aluminum is less suited for significant depths, and composite materials emerge as a superior alternative, featuring non-magnetic properties, high stiffness-to-weight ratios, and low density. The pressure hulls, both with identical dimensions (300 mm diameter, 1000 mm length) and designed without dished ends, feature internal rectangular ring stiffeners. Under 3 MPa external pressure (simulating 300 meters depth), ANSYS simulations assessed their structural performance and buckling behavior. Results showed the composite hull, though significantly lighter than the steel version, had comparable or superior buckling resistance, allowing for greater operational depths and improved stress distribution under pressure. Despite the potential trade-offs in durability and maintenance particularly regarding impact damage and delamination. This Project highlights the advantages of using carbon fiber-reinforced epoxy composites for UUV applications. The findings underscore the viability of composites in enhancing the performance and capabilities of underwater vehicles.

Mechanical Research-142; Finite element analysis of synthetic and natural fiber composites with different stacking sequences to improve mechanical properties

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ABSTRACT

Natural fiber composites offer eco-friendly alternatives to traditional synthetic materials, addressing the growing need for sustainable and renewable solutions in various industries. The use of Finite Element Analysis (FEA) is crucial as it allows engineers to predict the properties of the composites in a cost-effective way. Flax Epoxy composites are compared with synthetic fiber composite using FEA with ANSYS software, adhering to ASTM standards for specimen dimensions specific to each test. Various stacking sequences are compared for mechanical properties. Additionally, comparisons were made for specimens with and without holes. In terms of tensile failure stress for specimens without holes, flax epoxy exhibited superior performance compared to glass epoxy, showing an improvement of 8.4% and 17.05% in the $[\pm45_2]$s and $[\pm60_2]$s stacking sequences, respectively. Similarly, for specimens with holes, flax epoxy composites outperformed glass epoxy composites in terms of tensile strength across several stacking sequences except for [0]s and [90]s. Additionally, in compression tests, flax epoxy consistently experienced higher minimum principal stresses than glass epoxy, regardless of the presence of holes.

Mechanical Research-144; Enhancing Mint Yield through IoT-Integrated Vertical Hydroponic Systems: A Sustainable Solution for Future Agriculture

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ABSTRACT

The purpose of this study is to highlight the challenges inherent in traditional irrigation systems, such as lower yields, higher resource consumption, extensive land requirements, and lengthy growth cycles. Moreover, traditional methods put constraints due to environmental factors and are more likely to be attacked by the pests. The proposed system is a hydroponic system, which can maximize mint yield in a confined indoor space utilizing less resources. This study provides insights and shows the advantage of hydroponic systems over traditional agriculture by providing validation on how vertical plant cultivation can achieve three times the growth over conventional methods. The hydroponic structure is designed with optimal vertical dimensions, ensuring adequate sunlight exposure and spatial growth for mint plants. Given the increasing population and decreasing agricultural land, hydroponics presents a sustainable method for future food production. This research also incorporates an Internet of Things (IoT) based data collection system, using an Arduino Uno microcontroller to monitor and control environmental conditions and nutrient delivery in real-time. The system includes sensors for light intensity, temperature, humidity, and nutrient solution quality. An automated control system maintains optimal growing conditions, enhancing growth efficiency by 50%. Experiments conducted at HITEC University Taxila with a vertical hydroponic setup demonstrated that mint could be successfully grown with controlled pH and nutrient levels, achieving full growth in 24 days. The findings suggest that hydroponics is a viable alternative for urban and barren land agriculture, offering a high yield from a small area, though initial setup costs are higher compared to traditional methods.

Materials Research-150; Assessment of Erosive Wear Resistance Characteristics of 3d Printed Polymers Agitator Blade

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ABSTRACT

Erosion, the wearing away of material, is quite common in 3D-printed PLA plastic specimens and can be classified into various types, including abrasive, chemical, microbial, and hydrolytic erosion. Given the extensive use of 3D-printed materials in daily applications, understanding this process holds significant importance. In this experiment, the erosion of a 3D-printed PLA plastic agitator blade, mounted on a slurry pot erosion test rig and spun in a slurry solution, was investigated. The slurry mixture, containing water, sand, and other particles, is the primary cause of erosion in PLA specimens. Microscopic analysis

after the experiment revealed varying erosion rates across different points on the blade. The maximum erosion occurred at the center of each blade, likely due to factors such as velocity distribution. Although tangential velocity increases with distance from the center, turbulence and secondary flow patterns may cause higher velocities at the blade's center, increasing erosion. Additionally, as the blade spins, material is thrown outward, but the highest erosion remains at the center. Furthermore, 3D printing properties significantly influence the specimen's erosion. Improper printing or asymmetrical blade dimensions can exacerbate wear. Lastly, the size of particles in the slurry affects the surface erosion. Heavier particles, which have greater momentum, often strike the blade's center with greater force, rather than the outer edges, causing increased erosion

Mechanical Research-151; Experimental identification of Campbell diagram of a flexible rotor supported by active magnetic bearings

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ABSTRACT

Resonances of a rotor system could lead to dangerous vibrations or even mechanical failure. To identify these resonance frequencies, a Campbell diagram is usually employed which visualizes the relationship between the discrete natural frequencies and the excitation frequency. This diagram helps identify rotor response frequencies resulting from typical excitation mechanisms like unbalance or alignment issues of the rotor. The experimental identification of the Campbell diagram of a flexible rotor supported by two active magnetic bearings is performed in the current study. An additional excitation is introduced in the active bearings during the rotation of the rotor in order to measure the speed-dependent natural frequencies. These frequencies are then collected and combined in the final Campbell diagram. The process is implemented in a rotor test rig. The results are benchmarked against the system response during run-up and run-down. The results show the lack of variation of the natural frequencies of the rotor plotted at different rotational speeds which is as expected. Due to simple configuration of the flexible rotor, there is not many variations in the natural frequencies. The maximum difference in natural frequency is 1.1% (2nd mode) from the perspective of stationary position of rotor. This approach helps analyze flexible rotor systems in operation.

Mechanical Research-155; A Study on Flow Induced Vibrations Behaviour of Finned Tube Heat Exchanger: An Experimental Approach

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ABSTRACT

Finned and tube heat exchangers are used in a wide range of industrial applications such as power plants, sewage treatment facilities, petrochemical and chemical factories, and cooling and heating systems for space. Flow-induced vibration occurs through a variety of mechanisms. In this study, the vibrational behavior of finned tube due to fluid elastic instability of flow induced vibration has been carried out on water tunnel. The fabrication of tune bundle with specifications of 8 plain tubes and 7 finned tubes with flexible finned tube at third row with P/D ratio of 1.33. Moreover, another case was tested with one finned tube and the remaining 14 plain tubes in parallel triangular arrangement with angle of 45. These cases were tested on water tunnels with velocity range from 0.1 to 0.28 m/s with the help of accelerometer. In addition to this, vibrational behavior of finned tube was also investigated through this tunnel. Moreover, vibrational signal was analyzed through nodal software and SIGVIEW software. The findings showed that the behavior for case-1 was more complex as compared to case-ii. The flow elastic instability phenomenon found more prominent in case-2 as compared to case-i.it is noted that behavior of case-i has shown delayed instability threshold of fluid elastic stability as compared to case-ii. In this range, damping is found to be 0.117 to 0.47 which will result in the value of logarithmic value from 0.0071 to 0.029. As flow velocity was very low, the vibrations can be measured using the accelerometer.

Energy Research-161; Evaluating Capillary Pressure and Relative Permeability Models for Enhanced Reservoir Management

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ABSTRACT

Accurate characterization of petrophysical properties is essential for optimizing hydrocarbon extraction for reservoir management. Capillary pressure and relative permeability are key factors that influence fluid distribution and flow within reservoirs. This study investigated the implications of these properties on reservoir simulations, focusing on the Brooks-Corey and Van Genuchten models. Significant variations between these models, particularly near the endpoint saturation, can lead to inaccurate predictions and inefficient recovery strategies. This research refines these models by integrating real field data, enhancing their practical applications. The methodology involved data analysis, model testing, and comparison of predictions with field results. By generating capillary pressure and relative permeability curves, the study evaluated the recovery efficiencies and explored the effects of endpoint saturation variations. The results indicate substantial differences between the models, especially at saturation endpoints, necessitating careful history matching with field data. This study underscores the importance of incorporating geological heterogeneity in modelling for more accurate forecasts. Advanced models that consider geological features are required to optimize hydrocarbon recovery. Improving these models can enhance reservoir management strategies, align with global energy demands and sustainability goals, and improve the petroleum industry's strategic planning.

Energy Research-162; Investigating Public Opinion to Overcome Energy Policy Hurdles in Pakistan

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ABSTRACT

Energy policies in Pakistan are critical for addressing the country's severe energy crisis; however, their effective implementation faces significant challenges. The reliance on fossil fuels, inadequate infrastructure, and policy mismanagement have led to persistent energy deficits. Key obstacles include the scarcity of renewable energy sources, widespread corruption, and political instability, all of which exacerbate energy shortfalls. This study utilized a comprehensive survey methodology to capture public opinion and engage various consumer sectors to identify preferences for affordable energy and flat-rate billing.

Our analysis indicates that a strategic shift towards renewable energy could mitigate this crisis, providing a cost-effective and sustainable solution. This study advocates policy revisions that emphasize transparent governance, infrastructure improvements, and public awareness campaigns. By incorporating consumer feedback into policy formulation and addressing systemic issues, Pakistan can enhance energy security and economic stability. The findings offer actionable recommendations for policymakers, suggesting targeted investments in renewable energy and robust regulatory frameworks to overcome existing challenges, thus paving the way for a more resilient and sustainable energy future. Additionally, this study underscores the importance of addressing corruption and political instability, which are critical to the success of any energy policy reform. These results highlight that consumer involvement and transparency are crucial for achieving public trust and cooperation. Pakistan can transition toward a more sustainable and reliable energy system through a comprehensive approach that includes technological advancements, regulatory support, and active public engagement.

Mechatronics Research-167; Enhancing the Accuracy of SSVEP Target Frequency Detection: A User-Friendly Approach

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ABSTRACT

The steady-state visual evoked potential (SSVEP) is a brain signal induced by flickering visual stimuli, which usually originates in the occipital region. SSVEP detection methods often employ multichannel setups, which, despite their effectiveness, can be complex and uncomfortable. On the other hand, single-channel setups offer a simpler and more comfortable alternative, although achieving high accuracy can be challenging. To this end, this paper proposes an effective and robust single channel SSVEP-based method that relies on the improved complete ensemble empirical mode decomposition with adaptive noise (ICEEMDAN) method as a preprocessor. The ICEEMDAN decomposes the signal into various modes known as intrinsic mode functions (IMF). To accurately detect target frequencies, we utilize the Pearson correlation coefficient to select the most relevant IMFs. Our evaluation using the publicly available AVI-SSVEP dataset demonstrated the method's effectiveness, achieving an average accuracy of 91.97% and an information transfer rate of 62.98 bits per min, outperforming several existing methods. This robust single-channel approach enhances user comfort, making it a user-friendly choice. Additionally, it is adaptable to a variety of applications, including human-robot collaboration and controlling wheelchairs.

Mechatronics Research-172; Balanced Model Order Reduction Technique for Nonlinear Systems in Limited Frequency Interval

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ABSTRACT

In this paper, improved balanced curtailment method for the time-frequency limited model order reduction (MOR) of nonlinear systems has been incorporated. Balanced curtailment technique for nonlinear systems produces large state relative errors that cause nonlinearities in reduced order model (ROM) as well as unique transformation matrix is not obtained. To cater for large relative state errors, reconstruction of states for system outputs is performed. To reduce the nonlinearities and increase the robustness, static variable transformation is applied before the reduction process. Then the limited hiatus Gramians and respective Lyapunov equations are presented to cater for time or frequency or both time/frequency limited ROM performance optimization as per requirement. The presented development is tested on distillation column case study and results are compared over several limited time-frequency hiatuses. Based on results, the approach can be well effective for applications of nonlinear systems over finite hiatuses.

Energy research-173; Analysis of Vertical Axis Wind Turbine Utilizing Dissimilar Airfoil Blade Combination

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ABSTRACT

Vertical Axis Wind Turbine (VAWT) is widely being used nowadays due to its capability of operating through the wind on any side, low maintenance, and simple blade design. Computational techniques have increased technological advancement related to VAWT. This study introduces a new design of four bladed VAWT as an augmentation to previous models. In this study VAWT with fix pitch blades were used for assessing performance dependent on power and torque coefficients using numerical simulations and effect of design on self-starting capability was also analyzed. Flow behavior and efficiency of four-bladed VAWT were predicted using RANS turbulence modeling by selecting transient flow conditions with STD k-ω approach. Different cambered blade combinations were studied to predict the optimum combination for four bladed wind turbines while maintaining solidity and extracting data after twelve rotations for each turbine combination. Results demonstrated a 32% increase in performance when NACA 3421 and NACA 4421 airfoils were employed as a hybrid airfoil based VAWT

Mechanical Research-176; Topology Optimization of Bell Crank Lever using FEA

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ABSTRACT

Topology optimization has emerged as a critical tool in the quickly developing field of engineering, helping to achieve high-performance, economical, and sustainable solutions. In lean manufacturing, when maximizing efficiency and lowering material usage are critical, this procedure is very important. Our research effort focuses on optimizing the mass of a 90-degree bell crank, a pivotal lever that is used to shift the direction of force in industrial, automotive, and aerospace applications. Bell cranks are traditionally over-engineered and can contain redundant material, which introduces additional weight and inefficiency. Using the technique of topology optimization with attention on mass reduction, we are able to significantly lower the weight of the bell crank without compromising its structural integrity or performance. In the present study, we mostly emphasize mass topology optimization, nonetheless there are other types as well, like compliance minimization and stress optimization.

Mechatronics Research-177; Model Curtailment of Hybrid Time-Frequency Limited Interval Gramianns for Continuous Time Second Order-form Systems

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ABSTRACT

Modeling of dynamic systems is essential for analysis and design for physical systems and controllers. Different state space structures emerge during the modeling process. The order of these models is usually in thousand(s) or even more, that makes it practically impossible to analyze or implement such systems because of computational and storage imperatives. Model Order Reduction (MOR) techniques are designed for such systems that estimate large Scale System (LSS) with tiny models called Reduced Order Models (ROMs). Error of the ROM should be as small as possible, and the developed technique should be computationally efficient. Controllability and observability gramianns are computed for required time-frequency intervals. For generalized second orderly structured systems (SOSSs,) gramianns are fragmented into position and velocity snippets for structure retainment in ROM. The proposed development can be utilized for combined time-frequency limited interval-based MOR applications of continuous time SOSSs.

Mechatronics Research-178; Model Reduction of Combined Time-Frequency Limited Interval Gramianns for Discrete Second Order-form Systems

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ABSTRACT

Hybrid time-frequency scanty hiatus model order curtailment framework for second or-derly structured systems is discussed in this article. The second order structure is transmuted into first order generalized form that poses a constraint on retention of first and second order state pairs in reduced order model (ROM). For emphasis of ROM on simultaneous time and frequency hiatus, com-bined time-frequency limited gramianns and corresponding algebraic Lyapunov equations (ALEs) are construed. To retain second order structure in ROM, ALEs are solved for gramianns and then gramianns are fragmented into position and velocity portions. The position and velocity gramianns are equated with different combinations to obtain multiple second order equated curtailment algo-rithms that yield the ROM that not only preserve second order structure, but also ROM response perform near to perfection in required time and frequency interval. Testing on multiple models took place and successful validation of results was achieved.

Mechatronics Research-179; Intelligent System for Real-time Health Monitoring of Power MOSFETs

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ABSTRACT

As Power MOSFETS plays a significant role in the industrial manufacturing process, it is of immense value to study the failure modes of these MOSFETS. A typical MOSFET failure condition is caused by a short circuit between the source and drain. In addition, excessive current and excessive power dissipation are causes of MOSFET failure. The focus of this research was to create an intelligent data-driven system that uses Prognosis, Neural Networks, and Machine Learning Models to forecast the Remaining Useful Life (RUL) of power MOSFETs. After executing the train and test models on LSTM using a learning rate of 0.001, 50 epochs, and the ReLu activation function, it was discovered that the MAE and model loss decreased substantially. A modest hardware setup was developed later for real-time testing of trained and tested LSTM models. After implementing data driven techniques, real-time testing was done under accelerated aging at 70◦ C. After 3 minutes of intensive accelerated aging, the MOSFET had 34.706 minutes of RUL. Future work will focus on developing a benchmarking circuit capable of operating under a wide range of temperature-controlled conditions. This will allow us to compare the activation energy derived from current models with that of the proposed model.

Materials Research-180; Superelasticity of mesoscopically porous Ni-Fe-Ga shape memory alloy foam with 69% porosity

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ABSTRACT

Superelasticity (SE) is mainly concerned with the stress-induced martensitic transitions (MT) under the application or removal of uniaxial mechanical stresses which is utilized in actuators, sensors and solid-state cooling devices based on electrocaloric effect. However, the intrinsic hysteresis of bulk shape memory alloys (SMAs) rigorously suppresses their applications in several crucial areas. Here, we report the superelastic properties in mesoscopically porous Ni-Fe-Ga SMA foams with 69% porosity, which exhibit less hysteretic superelastic response compared to their bulk counterparts. Ni-Fe-Ga SMA foam was initially prepared via replication casting with NaAlO2 as pore carrier. Subsequently, the high porosity foam of 69% was obtained by chemical etching under several acid baths. Differential scanning calorimeter (DSC) tests revealed that the high temperature austenite finish temperature existed at room temperature in the annealed foam specimen. Compressive tests confirmed that a completely reversible superelastic response with 2.1% superelastic strain was achieved at 290 K. In addition, the specimen exhibited a perfect superelasticity in a broad temperature range of 288-303 K. The small hysteresis 7 MPa at room temperature was conducive to stable multiple martensitic transitions, which extended the fatigue life. Thus, the depreciation of grain boundary defects/constraints in high porosity Ni-Fe-Ga SMA foams breaks new ground for exploiting elastic strain engineering and the development of relevant porous materials by crafting the materials architecture.

Mechanical Research-181; Optimization Analysis of Innovative Counter Flow Spiral Absorber Tubes for Thermal Management of Photovoltaic Modules.

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ABSTRACT

Effective thermal management is crucial for optimizing performance and extending the lifespan of photovoltaic (PV) modules. This study introduces a novel design incorporating a counter-flow spiral mechanism for fluid movement and Nano Phase Change Materials (PCM) to ensure consistent temperature distribution across PV cells. Investigation reveals that increasing the flow rate from 0.48 l/min to 2.4 l/min and the tube diameter from 10 mm to 15 mm enhances electrical efficiency up to 13.6% and reduces module temperature by 8.2 degrees Celsius. Additionally, utilizing a PCM with an optimal thickness of 25 mm proves essential for effective heat retention, thereby improving thermal management. This innovative design not only maintains uniform temperature across the modules but also substantially increases both electrical and thermal efficiencies by 3.2% and 22.5%, respectively. These advancements suggest that such a design can significantly enhance the efficiency and sustainability of solar energy systems.

Material Review-182; Corrosion Inhibition through Biofilms: A Comprehensive Review

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ABSTRACT

Corrosion causes a massive loss of money, energy and products. The prevalent corrosion control systems currently in use have the drawbacks of being sometimes ineffective, expensive, and sensitive to the environment. Research indicates that a variety of environmental factors contribute to the promotion of material corrosion. The latest developments in the use of biofilms to control corrosion in various materials are compiled in this review study. Among the various methods are artificial biofilms, layer-by-layer techniques, nano-coatings, vibrio species, polymer compounds, and so on. The primary viewpoint for each of these treatments is that they are eco-friendly. In addition to offering corrosion protection, these processes and the materials or microbial biofilms also lessen the requirement for hazardous products and chemicals. Utilizing organic materials, natural materials, or inhibitor biofilms provides a non-toxic and biodegradable solution to corrosion. In general, effective use of this viewpoint can aid in advancements in the fields of biofilm biology and corrosion engineering research.

Materials Review-183; Recent Advances in Energy Materials for Sustainable Energy Materials

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ABSTRACT

In pursuing global sustainability and the goals set by the Paris Agreement, which aims to limit global warming to below 2 degrees Celsius till the end of this century, advancements in energy materials have become critical for ensuring clean and sustainable energy solutions. This review discusses recent advancements within the domain of energy material research, focusing on different applications in energy storage, conversion, generation, and green synthesis of energy materials. Key aspects include lithium-ion batteries, supercapacitors, and hydrogen storage systems, whose functions have been focused on improving energy efficiency, storage capacity, power density, and environmental sustainability. Among these, lithium-ion batteries are particularly notable because of their good scalability and high energy density for extended applications like those in electric vehicles and grid storage by treating them with advanced cathode materials like Ni-rich layered oxides to improve fast-charging capabilities and energy density. Supercapacitors possess great cyclic stability, quick charging capability, and have shown enhanced performance through innovations in electrode materials and electrolytes. Hydrogen storage not only addresses the intermittent of renewable energy sources but also explores innovative methods such as chemical hydrogen storage to improve energy density, safety, and application efficiency. Furthermore, green synthesis techniques, utilizing microbes, fungi, and algae, have emerged as a sustainable alternative for producing nanomaterials. These methods reduce energy consumption by 30% and minimize environmental impact, offering significant advantages over conventional chemical processes. Research in optimizing these materials for greater scalability, faster charge times, and improved storage efficiency promises to reduce the reliance on fossil fuels and achieve global sustainability goals.

Mechanical-Research-185; Eco-Transient Revolution: Design and Fabrication of Three Wheeled Reverse Trike Vehicles

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ABSTRACT

This paper delves into the domain of three-wheeled reverse trike vehicles, emphasizing advancements in safety features, suspension systems, and lightweight body design. The primary objective is to enhance safety, optimize suspension performance, and incorporate cutting-edge lightweight materials. This research contributes to Sustainable Development Goals by promoting energy-efficient transportation solutions through innovative designs and eco-friendly materials. It also advances Energy Economics and Modelling, aiming for a sustainable future in transport. By integrating these elements, the study seeks to reduce carbon emissions, support the transition to a low-carbon economy, and provide a comprehensive framework for developing safer, more efficient, and environmentally friendly three-wheeled reverse trike vehicles.

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Energy Research-186; Numerical Analysis and Performance Optimization of Multi-Stage Regenerative Heat and Mass Exchanger

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ABSTRACT

The Maisotsenko cycle (M-cycle) revolutionizes the concept of indirect evaporative cooling by achieving sub-wet-bulb temperatures without moisture addition or harmful refrigerants, outperforming conventional vapor compression systems in efficiency and environmental impact. The integration of M-cycle with solid desiccant cooling system is numerically investigated in this research. It further optimizes the perforated, regenerative, multi-stage M-cycle through a novel analytical model integrating Python with TRNSYS. The optimization reduced the unmet cooling from 63.17 kW to 33.4 kW in summer, enhanced thermal performance indicators (dew point and wet-bulb effectiveness), and enhanced seasonal cooling capacity from 7685 kW to 8294 kW. The thermal comfort indicator predicted percentage of dissatisfied (PPD) was 15.87% for the base case on average, which reduced to 9.03% after optimization. These results demonstrate that the optimized SDMC can achieve higher performance and improved thermal comfort, establishing it as a sustainable alternative for traditional cooling in hot and humid climates.

Mechanical-Research-187; Unmanned Under Water Vehicle (UUV) Pressure Hull Design using Composite Materials

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ABSTRACT

Unmanned Underwater Vehicles (UUVs) play a critical role in underwater warfare and exploration, traditionally relying on steel or aluminum pressure hulls. This project compares two pressure hull designs, one constructed from steel HY100 and the other from carbon fiber-reinforced epoxy composites. While steel offers high stiffness for deep-water operations, it presents a problematic magnetic signature. In contrast, aluminum is less suited for significant depths, and composite materials emerge as a superior alternative, featuring non-magnetic properties, high stiffness-to-weight ratios, and low density. The pressure hulls, both with identical dimensions (300 mm diameter, 1000 mm length) and designed without dished ends, feature internal rectangular ring stiffeners. Under 3 MPa external pressure (simulating 300 meters depth), ANSYS simulations assessed their structural performance and buckling behavior. Results showed the composite hull, though significantly lighter than the steel version, had comparable or superior buckling resistance, allowing for greater operational depths and improved stress distribution under pressure. Despite the potential trade-offs in durability and maintenance particularly regarding impact damage and delamination. This Project highlights the advantages of using carbon fiber-reinforced epoxy composites for UUV applications. The findings underscore the viability of composites in enhancing the performance and capabilities of und

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