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Abstract Booklet

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School of Mechanical and Materials Engineering

Indian Institute of Technology Mandi

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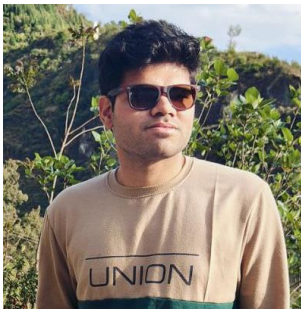

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Invited Speakers

Speaker: Prof. Bhanu Kumar Mishra

Affiliation: Department of Mechanical and Industrial Engineering, IIT Roorkee, India
Title: Composite Materials: Historical Evolution, Current Trends and Future Directions
Abstract
The origin of composite materials can be traced back to ancient uses of natural fibers and resins. Composite materials have undergone transformative advancements that significantly enhance their properties and broaden their application range. Historical milestones, such as the development of reinforced concrete in the 19th century and fiber-reinforced plastics (FRP) in the mid-20th century, laid the groundwork for the modern composites, we use today. Recent advancements focus on high-performance composites, including nanocomposites, bio-composites, and smart composites, which exhibit superior strength, durability, and functionality. These materials are now integral to various industries, from aerospace and automotive to renewable energy and biomedical engineering. In the aerospace sector, composites are used to reduce weight and improve fuel efficiency, while in automotive applications, they enhance crashworthiness and fuel economy. The renewable energy industry benefits from composites in the manufacturing of wind turbine blades and solar panel supports, owing to their high strength-to-weight ratio and durability. Biomedical applications leverage biocompatible composites for prosthetics and implants, leading to better outcomes. Evaluating the life and performance of composite components involves sophisticated tools and numerical techniques. Finite Element Analysis (FEA) is pivotal in simulating mechanical behavior and predicting failure modes. Non-destructive testing (NDT) methods, including ultrasonic testing, X-ray radiography, and thermography, are essential for assessing the structural integrity of composites. Lifecycle assessment (LCA) techniques are also employed to evaluate the environmental impact and sustainability of composite materials. These advanced methodologies ensure the reliability and longevity of composite components, fostering continuous innovation and expanding their use across various engineering fields. This presentation will delve into the historical evolution, recent advancements, and diverse applications of composite materials, highlighting the critical tools and techniques used to ensure their performance and durability in modern engineering applications.

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Speaker: Prof. Apurbba Kumar Sharma

Affiliation: Professor, Mechanical and Industrial Engineering and Joint Professor in the Department of Design, Indian Institute of Technology Roorkee, Roorkee – 247 667, India.

Title: Microwave assisted treatment of natural fibers for fabrication of sustainable Sisal/HDPE composites: A resource efficient approach
Abstract
Composites made of natural fibers and polymers are receiving increased attention owing to growing efforts for sustainable product development. Natural fibers and recyclable polymers are among the preferred alternatives for manufacturing sustainable products. Consequently, natural fiber-reinforced composites (NFRCs) are in high demand due to their easy availability, low production cost, less weight, and low environmental impact. However low mechanical properties and fiber-matrix interfacial bonding have limited their application spectrum. The current research explores the effectiveness of microwave-assisted pre-treatment of natural (sisal) fibers in combination with alkali solution on the properties of the composites. Single fiber test was performed to determine the tensile strength of the fibers

before and after treatment. Scanning electron microscope (SEM) images showed the effectiveness of the treatment in terms of enhanced surface area as confirmed by the rough surface texture of the fiber. The research also focused on utilizing microwave-assisted molding (MAM) method to rapidly fabricate Sisal/HDPE composites utilizing the microwave-assisted alkali treated (MAAT) fibers. The weight fraction of sisal fiber was fixed at 10% by weight. Tensile, flexural, XRD, and TGA tests were performed on the fabricated composites. The vector network analyzer (VNA) was used to determine the dielectric constant of the sisal fibers. It was observed that the MAAT sisal fibers at moderate power level had shown superior performance in terms of enhanced mechanical properties of the developed composites. The interfacial bonding between the MAAT sisal fibers and the HDPE matrix was improved due to microwave processing as observed from the fractography of tensile specimens. Results suggested the potential of microwave processing as a time-efficient and energy-saving technique while compared to conventional processing methods.

Keywords: Microwave processing; Sustainable composites; Natural fiber; Mechanical properties.

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Speaker: Prof. Inderdeep Singh

Affiliation: Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee – 247 667,

Title: Good Quality Joints in Composite Materials: A Myth or Reality

Abstract

Composite materials are now being used in a diverse spectrum of applications, ranging from sports goods to medical implants. Designers are exploring multi-functional products with innovations in materials and forms. As the product complexity increases, the need for ensuring good quality and cost-effective manufacturing also increases multifold. A wide range of processes have been conceptualized, investigated, developed and commercialized for processing of composite materials. However, the joining strategies for multi-phase/heterogeneous/anisotropic materials have always excited engineers and scientists. The composite materials are tailorable and so does the manufacturing routes/strategies. The judicious selection of a manufacturing process followed by an optimal joining technique for a specific application set presents the engineers with a plethora of questions. A general perception that joints are the weakest link in any structure needs to be explored in detail. The joint performance of the fabricated joints needs to be investigated under different loading environments. The talk with focus on the challenges associated with the fabrication of joints in composite materials and will address the specific techniques developed /being investigated at IIT Roorkee.

Keywords: Composite materials, applications, processing, joining, joint performance.

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Speaker: Prof. Indra Vir Singh

Affiliation: Department of Mechanical and Industrial Engineering, IIT Roorkee, India

Title: A Numerical Framework based on CDM and CZM to Estimate the Fatigue Life of Laminated Composites

Abstract
In recent years, the application of laminated composites in aircraft industry is significantly increased due to their superior mechanical properties. Aircraft structures experience degradation in mechanical properties due to cyclic stresses. This fatigue damage results in the degradation of the strength and stiffness of the composite structures, necessitating a precise evaluation of fatigue damage progression. Consequently, the development of a numerical framework has become crucial to ensure structural integrity and assess the fatigue-progressive damage.

The primary goal of this work is to determine the influence of the actual loading conditions on the fatigue performance. To achieve this, both experimental and numerical studies have been performed. The fatigue behavior of laminated composites has been investigated experimentally to model the material's cyclic behavior. Based on the experimental data, a numerical framework is developed for the fatigue life prediction of composite materials. The developed framework combines the continuum damage mechanics (CDM) and the cohesive zone model (CZM) to capture the intra-laminar and the interlaminar damage response accurately. Damage evolution at different stages under the influence of fatigue load is monitored in real time using an infrared thermography (IRT) setup. This experimental data is then compared with damage evolution obtained from the numerical framework to validate the model's accuracy and robustness. The fully developed framework aims to predict the remaining fatigue life of the component based on previously accumulated damage in service which is quantified from the image segmentation using IRT. This work enhances our comprehension and ability to anticipate fatigue performance of the composites. It establishes a reliable basis for designing the laminated composite structures used in critical applications.

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Speaker: Dr. Debdatta Ratna

Affiliation: Polymer Science and Technology Directorate, Naval Materials Research Laboratory, Shil Badlapur Road, Anandanagar P.O., Addl. Ambernath (E), Thane District, Maharastra - 421 506, India

Title: Toughened Polymer Matrix Composites for Industrial Applications

Abstract
Over the last three decades, the use of polymer matrix composites (PMCs), especially fibre-reinforced plastic (FRP) composites, has increased tremendously and this dramatic growth is showing every sign of the trend continuing in the future. The composites possess many useful properties like high specific stiffness and strength, dimensional stability, adequate electrical properties and excellent corrosion resistance. The implications are easy transportability, high payload for vehicle, low stress for rotating parts, high ranges for rockets and missiles, which make them attractive for both the civil and defense applications.

FRP industries are dominated by thermoset resins. This is because of their availability, relative ease of processing, lower cost of capital equipment for processing and low material cost. Since thermosetting resins are available in oligomeric or monomeric low-viscosity liquid forms, they have excellent flow properties to facilitate resin impregnation of fiber bundles and proper wetting of the fiber surface by the resin. They are characterized by a crosslinking reaction or curing, which converts those into a three-dimensional (3D) network form (insoluble, infusible). Because of the crosslinked structure, thermoset composites offer better creep properties and environmental stress cracking resistance compared to many

thermoplastics e.g. polycarbonate. However, thermosets composites are in general known to be highly susceptible to internal damage caused by a low velocity impact due inherent brittleness of thermoset resins. The various ways to improve damage tolerance of FRP composites along with the highlights of various civil and defence applications of such composites will be discussed in the present lecture.

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Speaker: Prof. Sanjay Mavinkere Rangappa

Affiliation: Natural Composites Research Group Lab, AED, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand.

Title: Natural fibers: An environmentally acceptable and sustainable green material for polymer composites

Abstract

Cognizance towards the development of biodegradable and sustainable materials has impacted in the use of more green materials which would be an effective solution in overcoming the global environmental crisis. In this regard, composites composed of various natural -based resources have been utilized by manufacturers for developing their products which have benefited in the minimization of carbon footprints and greenhouse gas emanations. Natural fibers possess several advantages such as low cost, easy processing, biodegradable, recyclable, and less health-hazardous problems when compared with synthetic fibers making them effective and efficient reinforcements in composite materials. Though having above mentioned merits the natural fibers are sometimes suspectable with hydrophobic matrices due to their hydrophilic nature, poor interfacial adhesion behavior, high moisture absorption, poor fire resistance, and low durability properties. The above issues are resolved through different physical and chemical treatments which will make the natural fibers become efficient reinforcing agents with hydrophobic matrices and helps in achieving high-performance composite materials.

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Speaker: Dr. Amit Kumar Gupta

Affiliation: Composites Research Centre, Research and Development Establishment (Engineers) Dighi, Pune - 411015

Title: Manufacturing of High Performance Composites for Defence Applications

Abstract

Development of advanced composite structures are increasing particularly in defence applications due to ever increasing demand of superior technological systems for performance enhancement aligned with multifunctional capabilities, low weight, cost efficiency etc.

Desirable properties associated with composites for structural applications includes low void content, high fiber loading, repeatability, consistency in properties etc. The important factor

in realising the full potential of composites is the choice of correct manufacturing process based on the application of the products. Resin Film Infusion, a composite manufacturing process provides an opportunity to realize the structures with desired properties along with an added capability of engineering the process to achieve multifunctional capabilities. This work presents development of high performance composite products for defence applications using Resin Film Infusion process.

Technical Sessions

Submission ID: 06

Failure pressure strength of wall loss defective pipelines repaired with composite fiber-reinforced polymer

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ABSTRACT

Wrapping a composite material around the defect region of metallic pipeline is well developed and practices to repair a corroded pipeline as per the design standard. A numerical model to predict the strength of composite repair system of defect pipeline using finite element (FE) analysis is presented. Two different repair strategies: defect cavity completely filled with resin and second case with 50% defect cavity filled with resin and remaining 50% with CFRP patch (shown in figure 1) is studied. A nonlinear explicit FE code with constitutive models for metallic steel and composite material to failure modelling is used. Numerical analysis of composite repair of wall loss defect metallic pipeline is carried out using ABAQUS v6 finite element software package to simulate. The composite laminate is modelled using 2D axisymmetric shell element. The composite failure and damage modelling are done using Hashin damage criterion. The steel pipe was modelled (elastic-plastic) based on the test data acquired from tensile test of steel pipe with yield stress of 386 MPa using solid 3D stress linear element.

Keywords: Composite material; Numerical modelling; Finite element; Steel pipelines; Failure strength.

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Submission ID: 08

Effect of Wing Attachment Bolts on the Drooping Phenomenon in CFRP Composite Aircraft Wing

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ABSTRACT

This research paper investigated the effect of wing attachment bolts on drooping in carbon fiber reinforced polymer (CFRP) composite aircraft wings. A comprehensive analysis of an aircraft wing model featuring a NACA 4412 airfoil design with internal ribs examined stationary and flight conditions. At present, the wing spans are, in general, attached through simple bolt connections. The study analyzed the influence of varying tapering angles and the number of bolts on wing drooping.

Initially, aluminum Alloy was chosen as the wing material, and frictional connections were made to represent structural interactions. Emphasizing wing drooping during stationary and flight phases, a FEM-based computational model has been developed to investigate the total deformation due to drooping and variation with flight attack angles. The developed FEM model is tested against the mesh independency and further optimal mesh size was determined for numerical results. Comparative analyses between aluminum alloy and CFRP composite materials are conducted to assess performance differences. The research aimed to identify the optimal configuration for the mechanical fasteners; minimizing transverse and total deformation and weight while enhancing fuel efficiency and aircraft performance. The advantages of employing CFRP for outer wing sections, such as superior strength-to-weight ratios, stiffness, fatigue resistance, and corrosion resistance, are highlighted. The findings provided valuable insights into the use of wing attachment bolts in CFRP composite aircraft wings and their impact on drooping. Integrating composite materials and optimal bolt configurations held significant potential for revolutionizing aviation design and achieving reliable, fuel-efficient, and eco-friendly flights.

Keywords: Wing drooping; FEM; Aircraft wing; CFRP composite.

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Submission ID: 10

Retention of Mechanical Properties of Carbon/Fiber Epoxy Vitrimer Composite Material: Towards Recyclable and Reusable Carbon Fiber

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ABSTRACT

Development of recycling and reusable route for carbon fiber reinforced polymer composite have been driven by environmental, sustainable, and economic factors. Degradation of epoxy resin is a difficult task due to the permanent covalent cross-linking structure, which hinders the segregation of the carbon fiber and the reuse of it. To address this challenge, in this research work, recyclable and degradable epoxy vitrimer with carbon fiber composite is studied. The main study is to investigate the applicability of recycled carbon fiber for primary and secondary applications in various structures. The vitrimer employed in this study is based on bio-base curing agents citric acid (CA) and cashew nut shell liquid (CNSL) combined with DGEBA (diglycidyl ether of bisphenol A)/Epoxy. Thermal characterization and Fourier transform infrared (FTIR) spectroscopy are used for the analysis. Results of FTIR show the successful curing of vitrimer by esterification and etherification reaction. The flexural test of vitrimer base carbon fiber composite also shows a flexural strength of 582.76 MPa and flexural modulus of 34.53 GPa, which is comparable to the epoxy-based carbon fiber composite. The carbon fiber composite constructed of vitrimer is recovered by dissolving it in DMF (dimethyl formaldehyde). This finding suggests that the developed EP/CA/CNSL vitrimers hold great potential as a sustainable alternative to traditional epoxy composites in various applications. This study opens the way for the preparation of high-performance epoxy resin and the effective recycling of carbon fiber.

Keywords: Recycling; Vitrimer; Reusable; Carbon fiber.

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Submission ID: 12

Experimental Validation of Permeable Composite Conical Shell for Combined External Pressure and Axial Load

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ABSTRACT

Design of composite conical shells requires experimental validation of the design before its use. Design of experimental set-up for qualification of composite shells subjected to external pressure and axial loads is a challenging task in itself. A nonpermeable rubber sleeve is proposed to be used on the conical shell for applying hydraulic pressure on it simulating the external pressure loads. A pressure chamber encompassing the set-up with a provision for the axial compressive load is fabricated with necessary factor of safety. Scheme for arresting the hydraulic fluid from entering through the sleeve has been arrived through a clamp ring attached to the adjacent dummy section. Dummy section simulators are designed to avoid local load on the composite shell. Provision for measurement of strains of the shell is implemented from the inner surface of the composite shell. Simultaneous application of external hydraulic pressure and axial compressive load has successfully been achieved without any leak through the shell. Functionality of the sleeve concept has been successfully demonstrated for conical shell structure.

Keywords: Conical shell; External pressure; Experiment, Permeable; Composite.

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Submission ID: 17

Review of Nanocarbon Tubes and Nanomaterials in Civil Engineering Industry

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ABSTRACT

Nanocarbon tubes and Nanomaterials will be the gamechanger in the civil engineering industry in the coming days due to environmentally friendly and sustainable innovative design options to reduce the carbon emissions of producing cement by burning coal. The application in not limited to the field of Civil Engineering but in many more like Automobiles, Transmissions, Solar Energy, Wind Energy, Fiber light weight bodies of war tanks, Ship

Buildings, Medical fields, Mechanical and Electrical industries and many more. Nanomaterials are having added advantages due to light weight in reducing the foundation loads by reducing the supervenient of the bridge super structures, cable diameter in cable stayed bridges, ground improvement techniques, prevention of leakages, preventions of cracks, preventions of corrosion in reinforced concrete elements and useful materials for repairs and renovations. This paper represents the research and studies carried out all over the world for the sustainable and optimal use of Nano materials namely nanocarbon tubes, nanocarbon powder, nanocarbon materials, nanofibers, Nano silica, titanium dioxide which provides the improvement of the strength of concrete and cement paste and reducing the cracks development with prevention of corrosion of rebars. This paper will help future researchers to get the most recent work done in nanotechnology in various parts of the globe.

Keywords: Nanocarbon tubes; Nanomaterials; Titanium dioxide.

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Submission ID: 18

Effect of MWCNT on Basalt Fibre-Reinforced Polymer composite at elevated temperatures

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ABSTRACT

Basalt fibres, naturally obtained from volcanic rocks have emerged as a promising reinforcement in the field of composite materials due to their excellent thermo-mechanical properties and environment-friendly applications. However, the strength of basalt fibre-reinforced polymer composite at elevated temperatures needs to be further researched. This research aims to investigate the behaviour of basalt fibres with a primary focus on Flexural Strength and Inter Laminar Shear Strength according to ASTM D790-10 and ASTM D2344 standards respectively at elevated temperatures. Symmetric laminates of Basalt epoxy composite and basalt epoxy composite with MWCNT as secondary reinforcement were made using autoclave fabrication methods followed by thermal conditioning at elevated temperatures. The results showed that interlaminar shear stress and flexural strength were improved after the introduction of MWCNT in the basalt epoxy composite. Introducing nano-fillers shows potential for improvement in the mechanical properties of basalt epoxy composites. These secondarily reinforced basalt epoxy composites due to their better mechanical properties at elevated temperatures can serve as a viable replacement for the more common glass fibre epoxy resin composites for specific applications and cost considerations.

Keywords: Symmetric, Flexural strength; Inter laminar Shear strength; Elevated temperature; MWCNT.

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Submission ID: 20

Nonlinear Performances of Laminated Composite Skewed Cylindrical Shells Under Hygrothermal Environment with Imperfection

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ABSTRACT

Basalt fibres, naturally obtained from volcanic rocks have emerged as a promising reinforcement in the field of composite materials due to their excellent thermo-mechanical properties and environment-friendly applications. However, the strength of basalt fibre-reinforced polymer composite at elevated temperatures needs to be further researched. This research aims to investigate the behaviour of basalt fibres with a primary focus on Flexural Strength and Inter Laminar Shear Strength according to ASTM D790-10 and ASTM D2344 standards respectively at elevated temperatures. Symmetric laminates of Basalt epoxy composite and basalt epoxy composite with MWCNT as secondary reinforcement were made using autoclave fabrication methods followed by thermal conditioning at elevated temperatures. The results showed that interlaminar shear stress and flexural strength were improved after the introduction of MWCNT in the basalt epoxy composite. Introducing nano-fillers shows potential for improvement in the mechanical properties of basalt epoxy composites. These secondarily reinforced basalt epoxy composites due to their better mechanical properties at elevated temperatures can serve as a viable replacement for the more common glass fibre epoxy resin composites for specific applications and cost considerations.

Keywords: Finite element method; Laminated composite; Hygrothermal loading; Skewed cylindrical shell; Geometric nonlinearity.

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Submission ID: 21

Numerical Modeling of Damage Behavior in Unidirectional Carbon/Carbon Composites

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ABSTRACT

Carbon/carbon (C/C) composites are frequently employed in aerospace applications because of their superior mechanical properties even at high temperatures. This study proposes a progressive damage development model for unidirectional C/C composites. C/C composite consists of carbon fibers and pyrolytic carbon matrix. A Representative Volume Element

(RVE) incorporating the microstructural features is generated based on the Scanning Electron Microscopy (SEM) images of the C/C composite samples. The composite constituents, namely carbon fiber and pyrolytic carbon matrix, are modeled explicitly inside the RVE, and failure criteria are provided for the individual constituents. The damage model used in this study comprises damage initiation and evolution criteria. The carbon fibers are inserted inside the RVE using the Random Sequential Adsorption algorithm (RSA). The carbon fiber is modeled as a transversely isotropic material, and the damage initiation is based on the maximum stress criteria. The carbon matrix is considered as an isotropic material, and damage initiation inside the carbon matrix is based on modified von Mises stress criteria. The damage evolution criteria, which depend on the fracture energy of the material, are used to predict the post-peak behavior of the components following the onset of damage. The non-linear damage behavior of unidirectional C/C composite is studied under axial tensile loading conditions.

Keywords: Carbon/carbon composites; Representative volume element; Random sequential adsorption algorithm; maximum stress criteria; von Mises stress criteria.

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Submission ID: 23

Seismic Performance Based Assessment of Concrete Bridge Piers Reinforced with Fe-Based SMA Bars

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ABSTRACT

Infrastructure projects are considered as one of the major backbone of country's economic growth and utmost care and priority is necessary to protect these structures from damages due to earthquakes. The development of smart materials is effective in improving the performance of these structures when subjected to severe damages due to earthquakes. Shape memory alloys are one such smart alloy which is proved as a promising material because of its unique property of returning back to their original undeformed shape even after undergoing large deformation. The shape memory effect and pesudoelastic properties of shape memory alloys are deployed in numerous civil engineering applications. Ni-Ti being the most extensively used SMA, it is very costly material and hence Ferrous based alloys are getting more attraction in recent years due its cost effectiveness, better corrosion resistance and easy manufacturing process. Some notable features of Fe-SMA are High tensile strength, Excellent shape recovery stress (i.e. prestress), high elastic stiffness, and excellent low-cycle fatigue (LCF) resistance. This paper focuses on Fe based SMA to be applied as a reinforcement bar in bridge piers for better seismic resistance. A few researches are already made in utilizing this Fe based SMA, mainly Fe-Mn-Si in retrofitting and strengthening of RC structures, but only a handful of researches are being made in applying this material in new structures. Hence this alloy if used as a rebar in bridge piers, in combination with conventional steel it can be effective in controlling damages due to earthquakes. This paper also highlights the application and FEM analysis of Ferrous based shape memory alloy and comparison of properties with Ni-Ti alloys, to be effectively used as an alternative to Ni-Ti bars in bridges. Material modeling of this material is also done through FEM, which can be used to validate the results

post experimental work.

Keywords: Shape memory alloy; Fe based SMA; Shape memory effect; Bridge piers; Low cycle fatigue.

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Submission ID: 24

Effect of Interfacial VACNT on the Transverse Deformation of Antisymmetric Angle-ply Composite Laminates

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ABSTRACT

Composite laminates usually exhibit poor mechanical properties in the transverse direction. To overcome this issue, vertically aligned carbon nanotubes (VACNT) are employed perpendicular to the planer direction as a reinforcing element at the interfaces of the composite laminae. The present study investigates the influence of VACNT on the overall effective properties of anti-symmetric angle-ply composite laminate, followed by the investigation of transverse deformation of the composite laminate subjected to a uniformly distributed load along thickness direction. This analysis is conducted via a two-step methodology. The initial phase involves the development of a numerical model for a thin layer of VACNT-reinforced material. This model is used to calculate the effective elastic constants by employing a three-dimensional micro-mechanics technique. The overall effective stiffness properties are calculated with and without applying VACNT reinforcement in the antisymmetric angle-ply composite laminate. The next step investigates the impact of different interfacial carbon nanotubes (CNT) on the transverse deformation of a simply supported composite plate by using a first-order shear deformation theory (FSDT) based finite element formulation. For validation purposes, the transverse deformation is determined for graphite epoxy antisymmetric angle-ply composite laminate without VACNT at the interfaces, and a good agreement is found when compared with the existing analytical solutions. Furthermore, the comparative study presented in the paper exhibits significant improvements in the transverse deformation of the VACNT-reinforced composite over the conventional graphite-epoxy antisymmetric angle-ply composite laminate.

Keywords: Vertically aligned carbon nanotube (VACNT); Finite element method (FEM); Laminated composite; Micro-mechanics; FSDT (first-order shear deformation theory).

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Submission ID: 31

Multi-level Modelling of Epoxy/MWCNT Composite and Experimental Validation

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ABSTRACT

Satellite communication requires earth-stationed parabolic Antenna reflectors. These reflectors are made of carbon fibre-reinforced Polymer (CFRP) composite with an increasing demand for improved reflectivity for RF signals and lightweight design. The lightweight and stiff structure demands ultra-high modulus carbon fibres, yielding a costlier antenna. In this study, a hybrid composite architecture of the antenna reflector is proposed, which will be achieved through a thorough investigation of cost versus stiffness/strength. The nanocomposite model is characterized by epoxy (Huntsman, 1564 grade) and MWCNT as the nanofillers and developed in ABAQUS. Based on the geometry of the nanofillers, the numerical model is stratified into three levels – micro-level (RVE of edge 12 μm), meso-level (RVE of edge 0.25 mm), and macro-level (or product scale) (Figure 1). The MWCNTs vary from 0.1wt% to 0.4wt% epoxy. They are modelled with the help of hollow beam elements, where the cross-section and area moment of inertia are as per the supplier's datasheet. Periodic boundary conditions and embedded element features are invoked to approach reality. The numerically obtained micro-level mechanical properties agreed with Halpin-Tsai equations within 10%. The macro-level model, which simulates the ASTM D3039 standard of a tensile specimen, is found to deviate by 2% from the literature (Figure 2). The model is robust to include any polymer-nanofiller system. It will further be explored to incorporate fibrous reinforcements and simulate a hybrid CFRP antenna reflector.

Keywords: Multiscale model; MWCNT; RVE; CFRP.

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Submission ID: 33

Study Microstructural Characteristic and Mechanical Behavior of Bimodal Hybrid Tio_{2np}-Sic_p/Al6082 Composites Fabricated by Stir Squeeze Casting

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ABSTRACT

Recent advancements in the field of composite materials have highlighted the significant advantages of using hybrid-reinforced advanced aluminium matrix composites over those reinforced with a single type of particle. In this study, bimodal hybrid composites based on

Al6082 alloy were fabricated by incorporating varying proportions of SiCp (Silicon Carbide Particles) and TiO2np (Titanium Dioxide Nanoparticles) using a modified stir-squeeze casting technique. Transmission Electron Microscopy (TEM) was employed to examine the morphological attributes of TiO2np particles. Furthermore, the microstructure of the resulting composites and fractured surfaces was examined by using Field Emission Scanning Electron Microscopy (FESEM). Energy Dispersive X-ray Spectroscopy (EDS) was employed to analyse the elemental composition, and phase analysis was conducted using X-ray Diffraction (XRD) techniques. The microstructural analysis revealed a crucial finding: the SiCp particles exhibited homogeneous dispersion within the matrix, notably up to a concentration of 3.5 wt.%. Beyond this threshold, clusters of SiCp were observed, negatively impacting the composite properties. The incorporation of 3.5 wt.% of SiCp and 0.25 wt.% of TiO2np resulted in the most significant enhancements in the mechanical properties of the Al6082 alloy. These improvements included a remarkable increase in yield strength, ultimate tensile strength, and compressive strength, measuring 202.13±1.21 MPa, 246.21±1.75 MPa, and 314.14 MPa, respectively, when compared to the as-cast Al6082 alloy.

Keywords: Hybrid composites; Stir-squeeze casting technique; Al6082; Microstructure; Mechanical properties.

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Submission ID: 34

Powder Metallurgy Processing of Al-HEA Composite: Microstructure and Mechanical Characteristics

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ABSTRACT

The current study explores the application of High Entropy Alloy (HEA) particles as reinforcements in an aluminium metal matrix, showcasing their potential utility in various mechanical, electrical, and electronic structural components. Successful synthesis of HEA particles was achieved through the mechanical alloying process. The composite was developed using the powder metallurgy route, which included cold pressing and sintering. The microstructures of the composite were investigated by FESEM coupled with EDS, and the mechanical properties were evaluated through room temperature hardness and compression tests. The experimental findings indicate a nearly even distribution and effective dispersion of HEA particles throughout the aluminium metal matrix. The results reveal that the incorporation of HEA particles into the aluminium matrix significantly improves the composite mechanical properties.

Keywords: High entropy alloy; Mechanical alloying; Aluminium composite; Sintering.

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Submission ID: 35

Investigation of Sandwich Plates Subjected to Low-Velocity Impact

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ABSTRACT

Composites, known for their excellent stiffness-to-weight and strength-to-weight ratios, are widely used in engineering. Among these, sandwich structures are renowned for their lightness, specific strength and stiffness, energy absorption, and resistance to various loads. These structures, subjected to diverse loads during service, including low-velocity impacts, prompt researchers to investigate their behavior under such conditions. In-house finite element codes have been developed within the MATLAB environment, incorporating the first-order shear deformation theory to consider transverse shear energy. The material is assumed to be an elastic with infinitesimal strains. A suitable indentation law during the loading and unloading state is taken from the literature. The plate is meshed with 9-noded quadrilateral elements, with the impactor being a spherical rigid body. The dynamic behavior of impact on laminates and sandwich plates is analyzed using Newmark time integration with constant acceleration. The results of contact force agree when compared to available literature. In ABAQUS, the effective material properties of corrugated core (CC) of sandwich plate are determined by applying periodic boundary conditions to its representative volume element (RVE). With the utilization of these homogenized effective material properties of CC, the impact study has been conducted on sandwich plate with face-sheets as laminates.

Keywords: Finite element methods, MATLAB; Laminate; Corrugated core; Newmark time integration.

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Submission ID: 36

Behaviour of Syntactic Foam under Triaxial Stress State for Infrastructure Applications

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ABSTRACT

Syntactic foam is a robust material that finds applications requiring high strength-to-weight ratios. It consists of hollow microspheres randomly dispersed in a high-strength resin matrix.

The extremely lightweight nature of the foam is due to the low density of the microspheres. Due to its low density, it can be used as a very effective core material in sandwich panels in composite bridge deck systems. The behaviour of the resin in the foam is sensitive to hydrostatic pressure, making the behaviour of the syntactic foam pressure sensitive. To account for the effect of hydrostatic pressure, it is necessary to adopt a pressure-dependent yield criterion such as the Drucker-Prager (DPYC) and Mohr-Coulomb (MCYC) yield criteria. The parameters used to define the failure criteria are calculated with the help of the friction angle and cohesion obtained from Mohr's circles under various lateral pressures through triaxial compression tests. A Hoek cell is used to apply lateral confinement pressure along with a deviatory pressure in the vertical direction to the specimen. The DPYC parameters are calculated for various volume fractions of hollow microspheres and the type of resin matrix. Furthermore, an equation is proposed to calculate the DPYC parameters, which are a function of the volume fraction and mechanical characteristics of the resin matrix.

Keywords: Syntactic foam; Microspheres; Drucker-Prager parameters; Triaxial test.

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Submission ID: 37

Polymer-Ceramic PVDF-TrFE-BSTO Composite Synthesis for Fabricating High Frequency Ultrasound Sensors

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ABSTRACT

This work demonstrates the fabrication of transducers using composite polymer-ceramic film consisting of PVDF-TrFE and BSTO(Ba0.8Sr0.2TiO3). The transducer is capable of both generating, receiving and detecting high frequency ultrasound signals. The composite film using PVDF-TrFE and BSTO shows better sensitivity compared to PVDF-TrFE sensor film alone. The composite film was fabricated using a dry and drop casting method and characterized the sensor film using FTIR spectroscopy to optimize the functionality. The central acoustic frequency of the fabricated transducer is found to be 39 MHz in pulse echo mode with a large bandwidth of more than 33 MHz i.e 84% of central frequency at -6 dB. The central frequency and its bandwidth are very high compared to commercially available ceramic based transducers. Due to its high frequency and large bandwidth, the transducer is suitable for high resolution ultrasound imaging, nondestructive testing and photoacoustic based high resolution microscopic macro-vascular imaging under various disease models.

Keywords: Ultrasound transducer; PVDF; BSTO; Composite polymer transducer; Ultrasound imaging; Biomedical imaging.

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Submission ID: 38

PVDF-Bi2O3 Composite Film Synthesis for Fabricating High Frequency Ultrasound Sensors

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ABSTRACT

We have demonstrated a cost effective way to fabricate ultrasound transducers using PVDF and Bi_2O_3 based polymer-ceramic composite. The nanofiller is widely used for enhancing the overall properties of the polymers. The composite sensor film was fabricated on the aluminum substrate using a drop casting method. FTIR spectroscopy data are analyzed to optimize the functionality of the composite sensor film. The central acoustic frequency of the fabricated transducer is found to be 14 MHz and bandwidth found to be 18 MHz i.e, 128% of central frequency at -6 dB. The photoacoustic signal is measured and found that the central frequency of the fabricated transducer is 13.5 MHz and bandwidth found to be 13 MHz i.e, 96.2% of central frequency at -6 dB. Due to its high frequency and large bandwidth, the transducer is suitable for nondestructive testing and photoacoustic imaging.

Keywords: Ultrasound transducer; PVDF; Bi_2O_3.

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Submission ID: 39

Maximizing Efficiency and Accuracy: Exploring the Role of Maxwell Elements in Viscoelastic Material Modelling

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ABSTRACT

Viscoelastic materials are crucial in various applications towards actuation, sensing, and energy harvesting, which demands accurate modelling for predicting real-time behavior. This study examines the pivotal aspect of computational efficiency and precision for the implementation of Maxwell elements in viscoelastic modeling. Maxwell elements, characterized by series connection of springs and dashpots, form fundamental components for representing time-dependent material behavior in dielectric elastomers (DE). The study explores computational efficiency and precision in various viscoelastic models in varying configurations of Maxwell elements. The analysis encompasses factors affecting computational efficiency, element count, arrangement (parallel/series), material attributes, etc.

Furthermore, it delves into the interaction among time step sizes and numerical integration methods to strike a balance between model precision and computational speed. Through extensive simulations, insights are uncovered regarding the optimization of Maxwell element utilization in viscoelastic models, aiming for enhanced computational efficiency and predictive accuracy. These findings offer valuable guidance applicable to researchers and manufacturers involved in DE modelling across diverse engineering domains. This research contributes to a deeper comprehension of the trade-offs between computational efficiency, modelling accuracy and Maxwell element count, thereby assisting in making informed decisions in the design and analysis of viscoelastic systems.

Keywords: Maxwell elements; Viscoelastic model; Efficiency; Accuracy.

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Submission ID: 40

Bird Strike on Hybrid Composite Coupon- Test/Analysis Correlation

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ABSTRACT

There are attempts to develop a hybrid (S glass-carbon) composite fan blade which can show excellent damage resistance under bird strike kind of loading. Some part of the carbon fiber composite blade is to be replaced with S-Glass and to achieve this, carbon -glass joints need to be optimized. The main technical challenge in this, is the robustness of the interface region between S-Glass and carbon plies. The interface region optimization in terms of ply layups and overlaps has been performed and a few promising cases of interlock configurations have been proposed in this context. As part of this interlock region structural evaluation task, representative composite coupons were made, and bird strike impact tests were performed. This article presents the bird strike analysis results of these interlock ply by ply coupons and the correlations of these analysis results with the actual bird strike test results performed on these coupons. Overall analysis to test results correlation has been satisfactory and detailed comparisons are shown in this article. The coupon level bird strike analysis methodology was enhanced by including the resin pockets that results in the interlocking regions. The understanding obtained from this work will be used as guideline for designing and validating the hybrid composite blade for aircraft engines.

Keywords: Composite fan blade; Interlock hybrid; Bird strike.

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Submission ID: 41

Natural Frequency Behavior of Composite Laminated Plates with an Extended Finite Element Approach

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ABSTRACT

This study employs an extended finite element method (XFEM) for free vibration analysis of laminated cracked plates, which is based on higher order shear deformation theory (HSDT) plate theory. The laminate plate typically undergoes vibration during service conditions under transverse shear loading. The cracks present in the structure affect the vibrational property. XFEM formulation has been developed based on HSDT theory for composite laminate plates to analyze this vibrational property. To check the performance and accuracy of the developed formulation, an extensive analysis is conducted in which the plate's natural frequency is analyzed with different boundary conditions and crack sizes. The numerical results clearly show that different boundary conditions and crack sizes significantly affect the natural frequency of laminated plates.

Keywords: Free vibration; Composite laminate plate; XFEM.

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Submission ID: 42

Deformation Characteristics of Hyperelastic Material in the Presence of A Crack By Three-Way Synchronized Measurements of Load, Strain and Optical Imaging

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ABSTRACT

Due to large deformations, strain measurement in hyperelastic soft material has always been challenging. While extensometers cannot be mounted due to the material's large compliance, it is challenging to employ non-contact strain measurement techniques due to its highly nonlinear strain characteristics. Besides, synchronizing load cell data with the strains, especially when they are measured by optical methods, adds to the experimental complexity. In this investigation, the deformation characteristics of vulcanized natural rubber reinforced with varying carbon black contents are investigated. Three-way synchronization between the load, strain and optical image is realized using a load cell, strain gauge rosette and charge couple device (CCD) camera. The Digital Image Correlation (DIC) technique is employed for non-contact strain measurement. The accuracy of the optically measured strain is first

ascertained by comparing it with the synchronized strain gauge data. A separate quasi-static uniaxial tension test is performed on an epoxy calibration sample for this validation. The National Instruments (NI) data acquisition (DAQ) modules and the LabVIEW software are used for the measurements. Next, the vulcanizate specimens are subjected to uniaxial tension tests, up to 70% nominal strain. The load cell synchronized optical images are processed through DIC to evaluate the material's strain distribution. The stress vs. stretch data is plotted, and the effect of carbon black content on the material's mechanical characteristics is assessed. Experiments are also conducted on single-edge notch tension (SENT) specimens of the vulcanizates to exhibit the robustness of the developed synchronized measurement technique in evaluating the strain field near the crack tip.

Keywords: Load-strain synchronization; LabVIEW; Digital image correlation (DIC); Hyperelastic material; Single edge notch tension (SENT).

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Submission ID: 43

Advancements in Additive Manufacturing: A Focus on Fabrication and Characterization of T700 Carbon Fiber Composites

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ABSTRACT

This research paper focuses on the use of additive manufacturing techniques to create T700 carbon fiber composites using epoxy resin. Additive manufacturing, has emerged as a promising method for fabricating various materials, including composites. The study aims to investigate the feasibility and effectiveness of using additive manufacturing techniques to produce T700 continuous carbon fiber composites using infused fiber. This technology has shown great potential in the field of composite materials, as it allows for the precise control of fiber alignment and resin distribution, resulting in enhanced mechanical properties and improved performance of the composites. Here we report the effect of different manufacturing parameters, such as laying technique, on the final properties of the composites manufactured using 3D printing. The study will examine the microstructure and mechanical properties of the manufactured composites through various characterization techniques, such as scanning electron microscopy and mechanical testing. By considering the variability in the properties of T700 carbon/epoxy composites fabricated by different researchers, this research paper aims to provide a comprehensive analysis of the mechanical properties of T700 carbon fiber

composites. This process development will contribute to the understanding of the potential applications and limitations of additive manufacturing for continuous carbon fiber composites. Moreover, the findings of this research could provide valuable insights for industries looking to incorporate carbon fiber composites into their products, as well as inform future research and development in the field of additive manufacturing of continuous carbon fiber composites.

Keywords: Additive manufacturing; T700 carbon fiber composites; Epoxy resin; Laminates fabrication; Mechanical properties.

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Submission ID: 46

Stress Distribution and Failure Pattern of Stair Wise Staggered Composites

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ABSTRACT

Modern engineering applications require materials with exceptional and distinctive mechanical properties. Biological composites possess excellent mechanical properties due to their hierarchical and staggered structure. A stair wise staggered arrangement is an idealized structure based on biological composites such as bone and nacre. Here, the platelets are arranged in a stair wise manner, in which the platelets in the succeeding rows are offset by a certain distance, for a specified number of rows, which is referred to as the period (n) of the model. In bio inspired stair wise staggered composites randomness could exist in their microstructural building elements and interface properties due to flaws in manufacturing. The influence of microstructural randomness has to be looked into since these variations could significantly affect the mechanical properties of bio inspired composites. Although researchers have extensively explored the influence of microstructural randomness in regular staggered brick and mortar (BaM) composites, there remains a gap in the literature regarding its impact in stair wise staggered BaM composites. The present study examines the influence of random platelet aspect ratio in the mechanical properties of stair wise staggered composites. 2D finite element models with stair wise staggered arrangement are made assuming the platelets to be elastic. The interface delamination is modelled using cohesive zone material model (CZM) in which fracture mechanism is brought into use by following traction separation relation at the interface. The models are used to find the variations in stress distribution and failure pattern when randomness in the platelet aspect ratio is considered. The results show that randomness in platelet aspect ratio affects the stress distribution and failure pattern of stair wise staggered composites.

Keywords: Nacre, Bio inspired; Microstructural randomness; Cohesive zone; Material mode.

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Submission ID: 47

Probability-Based Analysis of Mg-based Aircraft Fuselage Section by using Drop Test

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ABSTRACT

In aviation safety design, crashworthiness (crash-resistant) accidents are major concern. To overcome this concern, the protection of fuselage structure plays a key role by absorbing its energy. Current probabilistic research focuses on fuselage structure by considering stress-strain parameters through the drop test phenomenon. This study was performed by investigating airframe fall position through (varying) fuselage fall angle in vertical position. The replica design of the fuselage is modeled in Solid Work software and then for simulation, fuselage model imported in Abacus software for drop test analysis. Simulated results show structural deformation when in contact with the rigid ground. However, due to impact (internal and strain) energies, high structural deformation has been observed under different collision load conditions. The collision condition evaluates with the variation for 4-6 seconds up to a maximum limit of 10 seconds. An optimized best stress-strain result is observed at a 15° angle in a vertical position under the stress of 480 MPa for struts, 401 MPa for the skin, and 482 MPa for the cargo frame sections.

Keywords: Airplane, Fuselage; Solid-works; Abacus; FE modelling.

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Submission ID: 53

Design and Development of CFRP reflector for 4.6 m diameter Ship Borne Terminal (SBT) antenna

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ABSTRACT

In aviation safety design, crashworthiness (crash-resistant) accidents are major concern. To overcome this concern, the protection of fuselage structure plays a key role by absorbing its energy. Current probabilistic research focuses on fuselage structure by considering stress-strain parameters through the drop test phenomenon. This study was performed by investigating airframe fall position through (varying) fuselage fall angle in vertical position. The replica design of the fuselage is modeled in Solid Work software and then for simulation, fuselage model imported in Abacus software for drop test analysis. Simulated results show structural deformation when in contact with the rigid ground. However, due to impact

(internal and strain) energies, high structural deformation has been observed under different collision load conditions. The collision condition evaluates with the variation for 4-6 seconds up to a maximum limit of 10 seconds. An optimized best stress-strain result is observed at a 15° angle in a vertical position under the stress of 480 MPa for struts, 401 MPa for the skin, and 482 MPa for the cargo frame sections.

Keywords: CFRP; Ship borne terminal; Axially Displaced ellipsoid; Surface accuracy.

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Submission ID: 54

Manufacturing of Light-Weight Metallic Components Using Extrusion-Based Metal Additive Manufacturing

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ABSTRACT

Light-weight structures are in massive demand in automotive, biomedical implants, and aerospace industries. Usually, these industries use components with complicated shapes and manufacturing difficulties. The challenges can be addressed with the implementation of metal additive manufacturing (AM) processes like laser powder bed fusion (LPBF) and direct energy deposition (DED). To manufacture light-weight components, the outer shell should be fully solid and semisolid within, due to which manufacturing of these type components becomes even more complicated. To manufacture a light-weight metal component, infill patterns may be utilized by reduce the material usage. However existing metal AM processes entrap powder inside the cavity, which makes the components bulky and overweight. However, these components can be easily manufactured using extrusion-based metal AM, which does not involve loose powder while printing components. Current work discusses AM of light-weight components using extrusion based metal AM using Gyroid and Concentric infills with 20 % infill. The AM components' tensile, flexural behavior, and microstructural characterization were studied using the universal testing machine and scanning electron microscope.

Keywords: Light-weight structures; Extrusion-based additive manufacturing; Sintering; Debinding.

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Submission ID: 56

Investigations on surface damage due to water jet erosion of glass fiber reinforced polymer composites

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ABSTRACT

In this study, a water jet erosion test setup was used to evaluate the erosion resistance of glass fiber-reinforced polymer (GFRP) composites. The erosion tests were conducted using GFRP composite coupons of size 40 mm × 40 mm × 4 mm. The erosion test parameters included jet impact angles of 30°, 45°, and 90° and test durations of 120 min, 240 min, and 360 min. Fresh water and 3% NaCl saline water solutions were used as erodent medium in the present study. The test results were obtained as mass loss and mass gain. The eroded GFRP surface was analyzed using scanning electron microscopy (SEM). The dominant erosion mechanism was ductile-brittle erosion, which was evident from the presence of matrix deformation and fiber breakage in the eroded coupons.

Keywords: Liquid impact erosion; Surface topography; Polymer matrix composite.

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Submission ID: 57

Effect of Microwave Heat Treatment on Mechanical Properties of Carbon Fiber Reinforced PEEK Composites Developed using Compression Molding

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ABSTRACT

The current study investigates the novel approach to enhance the mechanical properties of carbon fiber-based polyetheretherketone (PEEK). Microwave heating is cost-effective and short cycle time process to improve the mechanical behaviour of composites. The composites were manufactured using compression molding by optimizing the process parameter such as ramping temperature, holding temperature, pressure variation at different stages and time availability at each stage. Followed by novel microwave heat treatment of composites for 180 W, 360 W, 540 W, 720 W,and 900 W for different time durations. Although, the mechanical properties of developed samples using compression molding are superior to other manufacturing processes still mechanical properties can be further improved by post-processing using microwave heating at different powers and exposure times. Post-processing of developed composites improved the mechanical behavior by improving the adhesion between fiber and matrix as targeted heating by microwave caused local melting at the interphase between carbon fiber and PEEK thermoplastic. This localized heating leads to proper wetting of fiber and improved interfacial bonding between fibers and composites. The effect of microwave heating on developed samples were evaluated by mechanical testing like tensile, flexural, impact, inter-laminar shear strength (ILSS), and shore-hardness tests. These

results were analyzed and overall mechanical behavior improved using novel heat treatment techniques on the PEEK-based composites. Furthermore, the morphological study will be done using a scanning electron microscope which provides the microscopic changes induced by microwave heating. The current study presents the promising future for microwave heating of PEEK-based composites for optimizing the mechanical behavior of carbon fiber and PEEK-based composites which are generally treated as brittle material and find limited structural applications.

Keywords: Microwave heat treatment; Polyetheretherketone; Compression molding; Mechanical behavior.

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Submission ID: 59

Free Vibration Analysis of Variable Stiffness Laminated Composite Plates with Embedded Delamination

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ABSTRACT

A finite element formulation based on a first-order shear deformation theory is used to study the free vibration response of variable stiffness composite laminated (VSCL) plates with delamination. The fibre orientation in the VSCL is varied along the length of the plate and the fibre path is defined by two angles at the center and edge of the panel. The finite element dynamic equations are obtained using eight noded iso-parametric elements. The point continuity method is used here to satisfy the continuity conditions at the delamination front. The present results are compared for constant stiffness composite laminated (CSCL) plates available in the literature. Furthermore, a comparison is made for constant stiffness composite plates and variable stiffness composite plates having delamination. The effect of change in delamination size and position on the natural frequency is investigated for the first time using variable stiffness composite plate.

Keywords: Delamination; Free vibration; Variable stiffness composite laminate; Finite element method.

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Submission ID: 60

Experimental Study on the Influence of Aspect Ratio and Pulse Shaper on the Dynamic Behavior of Epoxy Polymer

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ABSTRACT

Understanding the epoxy polymer's dynamic behavior and its relationship with strain rate and specimen geometry is crucial for analyzing and designing polymer matrix composites (PMCs) under dynamic loads. The current study involved conducting high strain rate studies on EPOFINE®-1564, a liquid epoxy resin made of Bisphenol A Diglycidyl ether (DGEBA), using the Split Hopkinson Pressure Bar (SHPB). The pulse-shaper method is utilized to generate an incident pulse with a longer rise time compared to the duration needed for the specimen to attain stress equilibrium. This study aims to examine the influence of three pulse shapers - cotton gauze bandage, copper, and epoxy - on dynamic stress equilibrium, and constant strain rate. Additionally, the behavior of epoxy polymer is investigated at dynamic strain rates for varying aspect ratios (l/d) of 0.4, 0.5, and 0.75. The results demonstrated that the specimens stress-strain behavior and the strain amplitudes seen in the incident, reflected, and transmitted pulses were significantly influenced by the strain rate and aspect ratio (l/d). Peak stress values increased with an increase in l/d ratios and strain rates.

Keywords: Split Hopkinson pressure bar; Aspect ratio; Pulse shaper; DGEBA epoxy resin.

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Submission ID: 61

Experimental and Modelling Studies on the Dynamic Behaviour of Epoxy under Compressive Loading

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ABSTRACT

Epoxy, frequently utilized as a matrix material in diverse composite applications, demonstrates distinctive mechanical characteristics when subjected to dynamic loading conditions. This article endeavors to explore and comprehend the influence of high strain rates on epoxy polymer. High strain rate experiments were conducted on EPOFINE®-1564, a Bisphenol-A-based liquid epoxy resin for the strain rates between 1400 to 2800 s-1 utilizing Split Hopkinson Pressure bar (SHPB) under compressive loading. The results indicated an increase in mechanical properties, including strength and elastic modulus, with rise in strain rate. Additionally, an analytical methodology incorporating the variable rate power law is described for epoxy resin to assess the compressive strength at high strain rate loading. This analytical approach is applied to evaluate the compressive stress-strain characteristics under high strain rates up to 5000 s^{-1}.

Keywords: Epoxy resin; Split Hopkinson Pressure Bar; High strain rate; Power law.

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Submission ID: 62

Delamination Behaviour of CFRP Laminated Composites using Cohesive Zone Modelling: A Numerical study

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ABSTRACT

The present work examines the quasi-static delamination behaviour of CFRP laminated composites under various delamination modes. The simulation is conducted under mode I, mode II, and mixed-mode (I/II) loadings using the double cantilever beam (DCB), end-notched flexure (ENF), and mixed-mode bending (MMB) specimen configurations, respectively. For each configuration, the cohesive zone model is used to do finite element modelling of the specimens. The quasi-static behaviour of delamination is simulated using a bi-linear cohesive model. A study is conducted on the variable SDEG (scalar stiffness degradation) to assess damage evolution. Additionally, the influence of interfacial strengths on delamination propagation for various modes of loading is also studied. It is noted that the resulting numerical forecasts are in close agreement with the reported data in the literature. The beginning of the process of delamination was slightly delayed at lower interfacial strength values due to the progressive decrease of stiffness in the elastic loading regime following the expansion of cracks.

Keywords: CFRP; Quasi-static delamination; DCB; ENF; MMB.

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Submission ID: 63

Effect of Cryorolling on Microstructure and Mechanical Properties of 8011 Aluminium Alloys

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ABSTRACT

In this study, cryorolled annealed and cold rolled annealed sheets of the AA8011 alloy were fabricated. The microstructure and mechanical characteristics of both sheets were compared. One of the crucial severe deformation processes to create sheets with great strength is cryorolling. This aluminium alloy was cryorolled in several passes to a final thickness of 1 mm from three-millimeter-thick sheets. According to research on the impact of annealing temperature and duration on hardness, a quick

annealing at 200°C for 45 minutes following cryorolling process would produce a good balance of strength and ductility. Microstructure analysis revealed that the bimodal grain structure of the cryorolled and brief annealed samples is what gives them greater mechanical performance than cold rolled sheets.

Keywords: Aluminium alloys; Cold rolling; Cryorolling; Microstructure; Mechanical properties.

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Submission ID: 64

Parametric Optimization of Microwave-Drilled Holes in Kenaf-Reinforced Polypropylene Composite using Response Surface Methodology (RSM)

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ABSTRACT

Kenaf-reinforced polypropylene composites (KRPCs) own numerous useful attributes, such as electrical and chemical resistance, toughness, and heat and fatigue resistance. Owing to these attributes, the KRPCs find their applications in packing material, mobile cases, insulations, bags, soilless potting mixes, etc. After the primary manufacturing, the KRPCs are fastened with one another using bolts and/or rivets during assembly. Superior quality holes are desired in KRPC parts for fastening. Conventionally drilling the KRPCs results in some severe drilling-induced damages, such as delamination, fiber pull-out, micro-cracking, and fiber burning. These damages are the result of harsh tool and work interface. Such damages adversely affect the residual strength of KRPCs and therefore, mitigate the durability of fastenings. However, non-conventional drilling techniques can be very effective in producing good quality holes owing to the absence of rigorous tool and work contact. Microwave drilling is one such novel technique that utilizes the energy of microwaves at 2.45 GHz to generate high-temperature plasma which removes the material. Therefore, the present work reports the microwave drilling of KRPCs at different levels of microwave power and feed rate. Prominent hole characteristics, namely circularity and overcut at the entrance of drilled holes will be studied and the parametric optimization will take place using response surface methodology.

Keywords: Kenaf-reinforced polypropylene; Microwave drilling; RSM; Circularity; Overcut.

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Submission ID: 65

The Effect of Molarity of Ferrocene Solution on the Carbon Nanotubes Growth Over the Carbon Fiber Surface using Microwave Irradiation

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ABSTRACT

Carbon fiber reinforced polymer (CFRP) composite has gained the interest of researchers worldwide due to its exceptional mechanical properties like high specific modulus, high strength-to-weight ratio compared to conventional materials like steel, iron, etc. The CFRP composites have been extensively used in the automobile, aerospace, and energy sectors in the manufacturing of different components. Despite being a strategic material, the CFRP has many drawbacks and limitations. The CFRP is often prone to fiber/matrix debonding, delamination due to its limited damage resistance capabilities and inert surface of the carbon fiber (CF). Reinforcing nano-material between the subsequent CF layers is one of the techniques to improve the interfacial bonding between the CF and matrix. The carbon nanotubes (CNTs) were considered to be the most appropriate nano-material for reinforcing. The CNTs possess mechanical properties like high elastic modulus, high tensile strength, low density, and a high aspect ratio. Researchers have reported many methods, like direct CNT growth by chemical vapor deposition (CVD), chemically grafting CNTs, and spray coating CNTs over the surface of the CF. These CNT grafting or attaching techniques were expensive, complex, time-consuming, and led to agglomeration of the CNTs. Recently, microwave heating has been popularly used in surface engineering. The selective and volumetric heating in the microwave provides rapid heating of the specimen. In the present research work, the CNTs will be directly grown on the CF surface using microwave irradiation. The CNTs will be grown with the help of 0.1 M, 0.2 M, 0.3 M, 0.4 M and 0.5 M, respectively ferrocene solution. The CNT-grown CF will be characterized using field emission scanning electron microscopy (FESEM) to investigate how dense the CNT forest has grown at different molarity of the ferrocene solution. The CNT-grown CF will be subjected to atomic force microscopy (AFM) to analyse the change in surface roughness of the CF after CNT growth at different molarity of the ferrocene solution.

Keywords: Carbon fiber; Microwave irradiation; Carbon nanotubes; Molarity; Ferrocene.

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Submission ID: 66

A Comprehensive Study on Mechanical Properties of Carbon Fiber Reinforced Plastics with Graphene Nano Platelets at Varied Compositions

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ABSTRACT

The research addresses the increasing demand for advanced materials, particularly in critical sectors like automotive, aerospace, naval, and defense industries, where the necessity for lightweight and high-performance materials is essential. The efficiency of CFRP depends on the meticulous selection of additives with its defined composition in the matrix. The study involves the fabrication of Carbon Fiber Reinforced Plastics (CFRP) composites using the Vacuum Assisted Resin Infusion Microwave Curing (VARIMC) method, incorporating varied weight percentages of graphene nanoplatelets (GNP)

ranging from 0 wt% to 2.0 wt%. The uniform distribution of graphene nanoplatelets (GNP) in epoxy matrix was achieved by its continuous stirring for 2 hrs using magnetic stirrer. The study investigates the mechanical properties, such as ultimate tensile strength, yield strength, impact strength, hardness, and Scanning Electron Microscopy (SEM) characteristics with the examination of obtained results. This research provides valuable insights contributing to the optimization of composite materials for enhanced performance across varied technological domains.

Keywords: CFRP; Graphene Nano-Platelets (GNP); Mechanical properties.

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Submission ID: 67

Vibration Characteristics of Functionally Graded Porous Beam Embedded in Elastic Foundations using Refined Higher Order Shear Deformation Theory and Boundary Characteristics Orthogonal Polynomial

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ABSTRACT

The present study is focused on the free vibration of a Functionally Graded (FG) beam with uniform porosity distribution along its thickness by utilizing the Boundary Characteristics Orthogonal Polynomial (BCOP) based Rayleigh-Ritz method and Navier's technique. The power-law exponent model has been used to vary the material properties such as Young's modulus, mass density, and Poisson's ratio of the FG beam along the thickness. The porous FG beam is embedded within an elastic substrate, namely Kerr elastic foundation, while the displacement field of the beam is governed by a Refined Higher Order Shear Deformation Theory (RHSDT). The effectiveness of the Rayleigh-Ritz method is attributed to the utilization of the Boundary Characteristics Orthogonal Polynomial as a shape function. The computational efficiency of this technique and its ability to avoid ill-conditioning for a higher number of polynomial terms stem from the orthogonality of the Boundary Characteristics Orthogonal Polynomial. Parametric studies encompassing Hinged-Hinged (HH) and Clamped-Clamped (CC) boundary conditions have been conducted. The validation of the present model involves comparison with existing literature in specific cases, demonstrating significant agreement. Additionally, a pointwise convergence analysis is performed. Furthermore, a comprehensive exploration of the impact of the power-law exponent, porosity volume fraction index, and elastic foundation on the natural frequencies is undertaken.

Keywords: Functionally Graded Porous Beam; Vibration; Kerr Elastic Foundation; RHSDT; BCOP.

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Submission ID: 68

Development of Aluminium Based Functionally Graded Porous Material by Selective Laser Melting

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ABSTRACT

Functionally graded porous materials (FgPM) are those in which porosity changes by direction. FgPMs are created to solve the problems of optimal material mixing in alloys and delimitation in composite materials. Due to their sophisticated structure, functionally graded porosity material will be challenging to fabricate. In this research work, designing and development of FgPM using selective laser melting (SLM) and AlSi10Mg alloy. The novelty of the work was that component fabricated via SLM technique was graded along a linear direction to determine the effect of directional porosity. Initially, the material was analyzed by physicochemical analysis like energy dispersive spectroscopy (EDX), scanning electron microscopy (SEM) and X-ray diffraction (XRD). Latterly, SLM printed FgPM structure was analyzed using mechanical characterization in both heat-treated and as-built components. The results concluded that the hardness of the heat-treated sample has been reduced by solution treatment quenching and artificial aging. However, the value of compression strength was 9236 kg/m^2 and hardness was 139 ± 5.64 HV for as-printed parts. The X-ray tomography was utilized for examination of the fabricated pores which confirmed that the linear direction grading was successfully done with structure pores.

Keywords: Functionally graded porous material; SLM; Additive manufacturing; Mechanical properties.

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Submission ID: 69

A Review of the Tribological Properties of Polymer Nanocomposites

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ABSTRACT

Promising materials with improved qualities above their constituent parts are polymer nanocomposites. Because of its exceptional lubricating qualities, low density, high strength, and

thermal stability, hexagonal boron nitride, or hBN, is a particularly alluring nanofiller. Recent studies on the tribological characteristics of polymer nanocomposites based on hBN are compiled in this review. Numerous investigations have demonstrated that hBN can greatly increase polymer composites' resilience to wear. De Oliveira et al. (2023), for instance, discovered that hBN added to polyimide (PI) decreased wear rate by up to 90% when compared to PI alone. Similarly, Madhukar et al. (2019) discovered that hBN added to aluminium alloy AA7150 could result in a 50% reduction in wear rate. The complex wear process of hBN-based polymer nanocomposites is dependent on a number of variables, including the kind of polymer matrix, the amount of hBN present, and the working environment. Nonetheless, it is widely accepted that hBN's lubricating qualities are a major factor in lowering wear. In addition to improving wear resistance, hBN can also reduce the coefficient of friction (COF) of polymer composites. For instance, Yetgin et al. (2020) discovered that hBN added to polyamide 6 (PA6) could decrease COF by as much as 30%. Comparably, Ferreira et al. (2021) discovered that hBN might lower COF by as much as 40% when added to ultra-high-molecular-weight polyethylene (UHMWPE). The development of a tribofilm on the composite's surface is the cause of the decrease in COF. The tribofilm functions as a protective layer that lowers wear and friction and is made up of polymer chains and hBN nanoparticles. In general, hBN shows great promise as a nanofiller to enhance polymer composites' tribological characteristics. It is a useful material for many applications due to its capacity to lower wear rate and COF.

Keywords: Polymer nanocomposites; Hexagonal boron nitride (hBN); Tribology; Wear resistance; Coefficient of friction (COF).

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Submission ID: 70

Development and Mechanical Characterization of Hybrid Polymer Composite Reinforced with Zinc-Oxide

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ABSTRACT

Polymer-reinforced composites are replacing metal matrix composites in terms of lightweight to high strength ratio which are employed in many fields such as aerospace, railways, sports, etc. By combining glass, flax, and nano-zinc oxide, this research developed a novel hybrid polymer composite. Nano-zinc oxide in various wt.% (0, 0.1, 0.2, 0.3, 0.4, and 0.5) is incorporated into composite materials. Field emission scanning electron microscopy (FESEM) and mechanical testing were conducted on all the samples. The highest values of tensile strength, flexural strength, inter-laminar shear strength, and hardness were found to be 122.63 MPa, 195.53 MPa, 23.45 MPa, and 57.68. All these values were obtained at 0.3wt% of zinc oxide of hybrid polymer composites and the highest impact strength was found to be 260.39 J/m obtained at 0.25wt% of the zinc oxide of hybrid polymer composites.

Keywords: Hybrid polymer composites; Nano-Zincoxide; Epoxy; Composite.

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Submission ID: 71

Mechanical Characterization of Hybrid Polymer Composite Reinforced with Graphene-Oxide

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ABSTRACT

In this paper, a Hybrid polymer composite is developed which has light-weight to high strength ratio. Due to this characteristic of polymer-matrix composite, it starts replacing the metal-matrix composite in a variety of domains, including sports equipment, drugs vehicles, automobile, aerospace industries, railways, etc. A hybrid polymer composite is developed by employing hand layup method and material used is epoxy as matrix material incorporated with nano-grapheneoxide, kevlar fiber and banana fiber. Composites are made by incorporating different wt.% of nano-grapheneoxide i.e., 0 wt.%, 0.25 wt.%, 0.50 wt.%, 0.75 wt.% and 1 wt.%. Mechanical characterization of all the samples is done and its highest values found to be 130.75 MPa, 218.17 MPa, 29.28 MPa and 72.58 for tensile strength, flexural strength, inter-laminar shear stress and hardness respectively. All these values are obtained at 0.5 wt.% of nano-grapheneoxide. The highest impact strength was found to be 370.2 J/m at 0.25 wt.% of nano-grapheneoxide. FESEM test was conducted to check the homogeneity of the composites.

Keywords: Kevlar fiber; Banana fiber; Nano-graphene oxide; Polymer-matrix composite.

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Submission ID: 72

Determination of Optimal Process Parameters in AWJ Machining of AA-6061 [B_4C-S_iC] Hybrid Metal Matrix composite using Grey Relational Analysis

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ABSTRACT

Engineering Optimisation plays a crucial role in addressing a wide range of engineering problems. Parametric optimization is a systematic and efficient approach to determining and adjusting the machining parameters to achieve the best possible machining results. Aluminium and its composites are extensively employed in several automotive industries due to its exceptional properties and high tensile strength. This study examined the machinability of aluminum alloy (Al 6061) through the utilization of the abrasive water jet cutting technique. The primary parameters affecting machinability,

such as abrasive flow rate, nozzle speed, and stand-off distance, are adjusted to achieve optimal values for output parameters such as material removal rate and depth of penetration. The classical Taguchi approach is not suitable for performing multi-objective optimization. The Grey Relation Analysis, in conjunction with the Taguchi method, introduces a novel approach to multi-parameter optimization by employing the Grey-Taguchi method. According to the results, the abrasive flow rate and nozzle speed are the key parameters for achieving improved output values.

Keywords: AWJ cutting; Depth of penetration; MRR; Grey relational analysis.

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Submission ID: 73

Tribological and Profilometer Analysis of Hybrid Metal Matrix Composite under Varying Normal Load and Sliding Velocity

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ABSTRACT

This work investigates the tribological properties of a hybrid Al7075 metal matrix composite (MMC) reinforced with CDA (cow dung ash) and SiC (silicon carbide) particles. The combination of traditional reinforcement with a non-traditional and environmentally friendly substance such as CDA presents a novel approach to improving the matrix material's tribological performance. To fabricate the hybrid composites, a two-stage stir-casting procedure is utilized, which ensures that SiC and CDA are distributed evenly throughout the aluminum matrix. An optical microscopy study was conducted on the composite material to analyze its microstructure. The Vickers micro-hardness test was used to determine the composite's indentation resistance. Tribological analysis of the developed composite was assessed by wear testing on a pin-on-disc set-up. Under varying normal loads and sliding velocities, composite samples were measured for wear rate. FESEM, along with EDS and profilometer analysis, was used to examine the morphology and surface roughness of worn-out surfaces. The findings of this study not only contribute to a better understanding of hybrid metal matrix composites, but they also provide a sustainable and environmentally friendly solution by incorporating CDA as a reinforcement.

Keywords: Metal matrix composite; Stir casting; Tribology; CDA.

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Submission ID: 75

Investigating the Effect of Ply Angle on Different Dome Geometry

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ABSTRACT

This research addresses challenges in determining variations in composite winding angles along the meridian line for various dome geometries in composite pressure vessels. Computer-aided manufacturing software is utilized to record thickness and angle variations on the dome geometry. This tabular data is then used in the lookup table in Ansys ACP for the linear elastic analysis of a single composite layer on the liner. This study expands the focus to different dome geometries, emphasizing the critical role of composite ply angles in shaping the mechanical properties of pressure vessels. The selection of ply angles significantly impacts deformation and stress distribution, necessitating a thoughtful balance for enhanced structural efficiency. The results of this study show that lower helical angles provide better strength protection in the dome section. This research study also provides a comprehensive understanding and contributes valuable insights to designing resilient and efficient composite pressure vessels tailored to specific performance requirements.

Keywords: Ansys composite pre-post; Ply angle; Computer-aided manufacturing; Ply sequence.

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Submission ID: 76

Effect of Cleat Material, Cleat Thickness and Bolt Diameter on Moment Rotation Capacity of FRP Beam-To-Column Joint: Experimental and Numerical Investigation

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ABSTRACT

Glass Fiber Reinforced Polymer (GFRP) structural sections find application in various construction projects, including footbridges, roads, and railway bridges, temporary and emergency framed structures, stand-alone lightweight structures constructed above existing buildings, and modular buildings. Steel-like sections are nowadays manufactured through the pultrusion technique and are used in framed structures. The GFRP sections can be connected via bonding, bolting, or hybrid (a combination of bonding and bolting) using cleats, plates, cuffs, etc. Cleats with bolted connections are interesting due to their fast employability. This paper discusses an exterior beam-column flange cleated connection using GFRP I-Section as the beam and the column. The study was conducted

experimentally under monotonic loading and numerically using finite element software ABAQUS. A comparison is made between the rotational stiffness offered by the stainless-steel cleat and the GFRP cleat on the GFRP beam-to-column joint. The effect of GFRP cleat thickness and bolt diameter on the behaviour of the beam-to-column joint is also assessed. Load-deflection, Moment-rotation and Failure modes are studied for different cleat thicknesses, cleat materials and bolt diameters. It was observed that there is a 42.01% increase in the rotational stiffness when a 10 mm GFRP cleat is used over a 6mm GFRP cleat. Steel cleats exhibited 38.35% greater stiffness when compared to GFRP cleats of the same thickness. By increasing the bolt diameter from 8mm to 14mm, an 85.78% increase in the rotational stiffness was observed.

Keywords: Pultruded FRP sections; Beam-to-column joint; FRP cleat; Rotational stiffness; FEM.

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Submission ID: 78

Effect of Surathkal Beach Sand on Mechanical Properties of Polymer Composites

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ABSTRACT

Although beach sand is available in abundance, its usage in structural applications has been limited. Prior studies betray that the sand taken in a nanoparticle size for the preparation of polymer nanocomposites yields in improved mechanical and physical polymer properties, also the addition of nanophase structure to the polymer has been found to be increasing toughness and cyclic fatigue resistance of the epoxy polymer. The present work uses beach sand as the filler for the reinforced epoxy matrix. Sand epoxy composites, with different particle sizes (150 μm, 300 μm, 420 μm) and varying filler percentages (5%, 10% and 15%) were investigated for mechanical properties. Beach sand nano-particles were considered as high-potential filler materials in the present study due to their molecular size in a reinforcement and polymer nanocomposites made out of them offer the possibility to develop new materials with unusual properties. As a result, the mixture of 10 % filler sand with a particle size of 150 μm showed highest tensile and compressive strength and addition of sand particles beyond 10 % led to creation of voids, thereby resulting in decreased strength. It is also observed that uniform distribution of sand particles within the matrix and interfacial bonding was the main contributing factors to the increased mechanical properties. The FE analysis of sand epoxy composites was also carried out using ABAQUS finite element analysis tool for flexural failure analysis. Simulations were recorded in various instances till failure.

Keywords: Beach sand; Polymer composite; Density; SEM (Scanning Electron Microscope); ABAQUS-Finite element tool.

Submission ID: 79

Mechanical Behaviour of Direct Connection Methods in FRP Beam-to-Column Joint

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ABSTRACT

Pultruded Glass Fiber Reinforced Polymer (GFRP) sections are used as beams and columns in framed structures nowadays. The utility of open sections in beam-to-column joints are extensively studied by researchers, but study on closed sections is limited. Most commonly used connections in FRP sections are bolted connections, bonded connections, and hybrid connections. Studies are conducted in beam-to-column joints using an additional connecting element like cleat, cuff, and sleeve in addition to bolt/threaded rods and adhesives. A direct connection between beam and column without any additional attachment is studied here. GFRP box sections are used as columns and two parallel flanged sections placed back-to-back are used as beams. A 2D interior beam-to-column joint with direct connection between the members is studied under monotonic loading at the free ends. This study compares the mechanical behaviour of through-bolted connections using GFRP threaded rod and stainless-steel (SS) threaded rod. It is followed by a study on adhesively bonded connections and hybrid connections. When compared to GFRP threaded rod, connection using SS threaded rod performed well in terms of rotational stiffness and ultimate load carrying capacity. Hybrid connection showed 2.97 times rotational stiffness and 1.22 times load carrying capacity compared with SS threaded rod connection. Hybrid connection ensure a safer and stronger connection design. Apart from rotational stiffness, Load-Deflection characteristics, and Failure modes are also studied.

Keywords: FRP beam-to-column joint through bolted connection; Bonded connection; Hybrid connection; Interior beam-to-column joint.

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Submission ID: 80

Effect of Boundary Conditions on Bistable Behaviour of Rectangular Composite Laminates

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ABSTRACT

Unsymmetric composite laminates are potential candidates for applications in morphing structures due to bistable characteristics that manifest large deformation between the two stable states. For its integration to a larger structure, it is important that specific boundary conditions are imposed at its edges. However, applying boundary conditions leads to a drastic change in the strain energy landscape, resulting in a loss of bistability. This indicates a strong interplay between geometrical parameters and boundary conditions. Therefore, the potential of any multistable structure can only be realised through external connections (boundary conditions at edges). In this work, we propose a three-sectioned laminate that remains bistable under simply supported boundary conditions at the edges. Through numerical analysis, we explore the influence of boundary conditions on the bistable behaviour of composite laminates, considering both single-section (purely unsymmetric) and three-section configurations. A comparison of the bistable behaviour of both types of laminates is also conducted. Later, FE results are also validated by making a semi-analytical model, and good agreement is observed between them. The findings of this study contribute to a better understanding of the underlying mechanisms governing the behaviour of multistable structures under an imposed boundary condition, thereby aiding in the design and optimisation of such structures for diverse applications.

Keywords: Bistability; Bifurcation point; Apadptive structure.

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Submission ID: 81

Comparative Study of Hemp and Flax Based Bio-Composites at Different Weight Fraction

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ABSTRACT

Composites based on biopolymers (bio-composites), which are derived from renewable resources have gained attention from researchers and industrialists worldwide. Due to their environmental sustainability, eco-friendliness, process-ability and suitability for copious applications bio-composites are being used. Bio-composites integrated with natural fibres is going to be the finest choice for completely biodegradable composite materials. Poly lactic acid or polylactide (PLA) is a thermoplastic biodegradable polymer that can be obtained from entirely renewable resources like wheat, rice, corn and sweet potato etc. In the present work, hemp and flax natural fibres will be used as reinforcement. The composites of hemp and flax fibre with PLA as matrix will be made by using compression moulding technique. The fibre weight fraction of 20%, 30% and 40%, respectively would be used to manufacture the biodegradable composites. The manufactured composites would be characterized using field emission scanning electron microscopy (FESEM) to analyse the morphology. The Ultimate tensile strength of the manufactured composites will also be analysed as per the ASTM D3039.

Keywords: Bio-composite; PLA; Natural fibres; Flax fibre; Hemp fibre.

Submission ID: 82

3D Printing of Hydrogel Composites for Bioprosthetic Tricuspid Heart Valve – A Review

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ABSTRACT

Heart valve disease, a major concern worldwide, is treated with the aid of mechanical or bioprosthetic heart valves. Mechanical heart valves are durable and have a longer life span, and patients require anticoagulation medicines to avoid blood clotting. On the other hand, bioprosthetic heart valves have a shorter life span (10–20 years), where patients do not require anticoagulation medicines. 3D-printed synthetic valves can help overcome these problems. The four valves in the heart are the aortic, pulmonary, tricuspid, and mitral valves. This review focuses on the tricuspid valve, which has three leaflets: anterior, posterior, and septal, that allow blood to pass from the right atrium to the right ventricle while preventing it from flowing backwards. Tissue-engineered heart valves (TEHV) are fabricated using hydrogels that act as a scaffold and help in active extracellular matrix (ECM) remodelling for proper valve functioning. Natural hydrogels provide good biocompatibility but have poor mechanical properties. In contrast, synthetic hydrogels can be tuned to achieve desirable mechanical properties. This study aims to apply hydrogels for heart valve tissue engineering by considering its dimensions, design criteria, materials and methods used for fabricating tissue-engineered heart valves, mechanical properties (fatigue behaviour), testing for cell culture, and future directions.

Keywords: 3D printing; Hydrogel; Tricuspid heart valve; Tissue engineered heart valve.

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Submission ID: 83

Design and Performance Evaluation of a Ceramic Composite Insulation for High-Temperature Applications

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ABSTRACT

Thermal insulation materials play a crucial role in limiting heat transfer and reducing overall energy consumption. Hollow ceramic microspheres (HCM) have gained popularity for insulation due to their cost-effectiveness and high thermal resistance, particularly at elevated temperatures [1]. This study focuses on the development and characterization of a heat-insulating ceramic composite (HICC) composed of HCM beads, ceramic (alumina) fibre, silica. A homogeneous mixture was prepared by

combining raw ingredients with basic mixture of sodium-silicate binders and a dispersing agent (Nonylphenol Ethoxylate) using a high-speed stirrer. The microstructural morphology of the composite was analysed using scanning electron microscopy (SEM), and its thermal conductivity was measured to assess the impact of ceramic fibre and microspheres on performance. Incorporating ceramic fibres and hollow particulates of various sizes to create multi-scale pore sizes significantly reduces high-temperature conductive and convective heat transport [2]. In the temperature range of 100°C to 700°C, the heat-insulating properties of the composite were compared with those of a conventional insulation blanket viz. ceramic-wool blanket and glass-wool blanket. The results, as shown in Fig. 1, demonstrate that the thermal conductivity of HICC is lower than that of traditional inorganic insulating materials at corresponding temperatures. Furthermore, the developed composite was applied to a cylindrical high-temperature thermal storage (DN, 150 mm) to showcase its applicability as a high-temperature thermal insulator. Real-time recordings of surface temperatures revealed that the ceramic composite exhibited excellent insulating qualities. In comparison to a conventional ceramic-wool blanket HICC requires a 65% thinner layer to deliver equivalent thermal insulating performance. This research provides valuable insights into the development and characterization of a novel ceramic composite insulation material for high-temperature applications, offering significant energy savings and a reduction in greenhouse gas emissions. The excellent workability and thermal insulating capabilities position HICC as an attractive alternative to conventional inorganic insulation materials.

Keywords: Thermal insulation; Composite; High-temperature; Ceramic.

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Submission ID: 85

A Numerical Estimation for Transverse Deformation Behavior of the Unidirectional Fiber Reinforced Composite

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ABSTRACT

A calculation method proposed for the transverse deformation behavior of unidirectional fiber reinforced composite must the effects of the microstructural decoration including shape, distribution geometries and orientation of composite components together with the deformation properties of its components. In this study, the microstructural decoration was considered with a simple geometrical parameter (Gf) for the fiber and the representative volume element (RVE) containing the fiber. Two different characteristic distribution geometries, named square packing and triangular packing, were considered for the fiber distribution geometry along with the respective loading directions. The transverse elastic moduli and transverse tensile deformations obtained using the proposed numerical method in this study showed very good agreement with the experimental findings given in the literature

Keywords: Composites; Deformation; Transverse.

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Submission ID: 86

A Comprehensive Literature Review on Bamboo Fibre-Reinforced Composites: Mechanical Properties, Manufacturing Processes, and Applications

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ABSTRACT

This paper provides an overview of bamboo as a versatile and sustainable material. This work reviews research done into the study of structural, mechanical, and physical characteristics of bamboo composites along with various methods used for obtaining bamboo composites. A review of the existing applications in the furniture, automotive, and construction industries is presented. The proposed work for bamboo composites includes a wide variety of research, development, and innovation projects aimed at achieving the full potential of bamboo as a sustainable and high-performance reinforcing material in composite applications. The gaps in the existing research are identified which help the paper can serve as a valuable resource for researchers, industry professionals, and policymakers working in the domain of bamboo and its composite materials. Literature review indicated that there is a lack of standardized mechanical properties, needed for industry standards. There is an absence of structural design codes for bamboo composites. Limited long-term durability studies are found. Need for further research in the area of multi-material composites and optimization of processing techniques is required. Life cycle assessment of bamboo composite products is needed.

Keywords: Bamboo; Bamboo composites; Bamboo fibre; Composites; Fibre.

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Submission ID: 88

Meso-scale Approach for Predicting Thermo-mechanical Characteristics of Marine Grade Glass Fiber Reinforced Polymer Composites

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ABSTRACT

Glass fiber-reinforced polyphthalamide (PPA) composites combine the robust properties of PPA with the strength and stiffness imparted by glass fibers. This work proposed a meso-scale modelling approach to predict the thermo-mechanical properties of short glass fibers reinforced polyphthalamide

matrix (PPA). The proposed computational model is capable to predict the thermo-mechanical properties of composite structures with matrix-fiber volume fraction over the temperature variations. The proposed model is validated with existing literature and further extended to parametric studies. After defining the characteristics, mixing, and microstructure of the two materials (phases), a representative volume element (RVE) is created with three different fiber orientations: 0^o, 45^o, and 90^o. A complex optimization procedure is involved in the impacts of glass fiber volume fraction in polyphthalamide composites at different temperatures ranging between 0^o and 60^o C. Additionally, for a large range of volume percent across temperature variation, the elastic properties are also predicted. From the presented numerical cases, the fiber volume fraction and temperature fluctuations show a substantial impact on the elastic characteristics of glass fiber polyphthalamide composites used in maritime applications.

Keywords: Thermo-mechanical properties; Glass fiber polymer composites; Homogenisation; Marine composites.

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Submission ID: 89

Simultaneous Stiffness and Damping of Triangle and Hexagon Based Composite Structures

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ABSTRACT

Recently, the so called architectured composites have garnered interest in design of materials with enhanced properties. This class of materials offers the opportunity to tune microstructure/geometry along with combination of materials for achieving the properties of interest. Using distinct architectures and altering their design and materials can assist in tailoring mechanical qualities. In this work, the simultaneous stiffness and damping properties, that are otherwise competing in the engineering materials are numerically investigated for two architectures, namely triangle based, and hexagon based structures. Finite element analysis of the representative unit cells is performed to obtain the quasi-static tensile response and damping behavior under different frequencies. The simulations are performed with combinations of geometry and different constituent materials. PMMA and PU are used as stiff and viscous materials, respectively to achieve simultaneous stiffness and damping. The properties are then calculated from the simulation results. It is observed that PU filled PMMA structure based on triangular geometry offer higher stiffness than the hexagonal geometry, however, reversal of material choice makes the hexagonal geometry favorable for stiffness. This is observed for both when the two geometries with same side length and wall thickness as well as same volume fraction of the materials. In terms of simultaneous stiffness-damping, hexagon based architecture outperforms its counterpart with same volume fraction of materials. Hexagon with same side length and wall thickness has better simultaneous stiffness-damping than hexagon with same volume fraction.

Keywords: Architectured composite; Hexagon; Triangle; Finite element analysis; Stiffness.

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Submission ID: 90

An Energy Based Perspective into Deformation of Plates with Anisotropic Material Properties

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ABSTRACT

This study presents a systematic and mathematically rigorous approach for deriving a displacement based reduced-order plate model. The presented approach refrains from ad hoc or a priori assumptions. It treats a plate as a 3D structure and gradually develops a reduced order 2D model for it, accounting for its geometry and keeping strains bounded by $\varepsilon \ll 1$ consistently. The final strains obtained through the present approach exactly match those given by Classical Plate Theory (CPT), demonstrating that the present plate theory is energetically equivalent to CPT plate theory.

Keywords: Anisotropic material; Plate; Triangle; Classical plate theory.

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Submission ID: 91

Geometrical Fluid Model for Blood Rheology and Pulsatile flow in Stenosed Arteries

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ABSTRACT

Considering blood to be a non-Newtonian Carreau liquid, this indirect numerical model investigates the pulsatile blood flow in a constricted restricted conduit that has a gentle numerous stenosis inside the view of an increasing body speed. Asymptotic answers are obtained for the flow rate, pressure inclination, speed profile, divider shear pressure, and longitudinal impedance to stream after the use of the twofold irritation approach to the problem of the succeeding non-straight limit esteem. It has been observed that the speed of the blood increases when there is an increase in the point of tightening of the conduit, the body speed increase, and the power regulation file. However, this rheological manner of behaving changes to one of longitudinal impedance to stream and divider shear pressure when each of the previously mentioned boundaries increases. It has also been seen that the divider shear pressure in the blood stream greatly increases when there is an increase in the maximum depth of the stenosis, but that it significantly decreases when there is an increase in the pulsatile Reynolds number. This is an interesting phenomenon. The assessments of the amount of growth in the longitudinal resistance to

flow increase overall with the increment of the maximum depth of the stenosis and the Weissenberg number. Additionally, it is noted that the average speed of blood increases noticeably with the growth of point of tightening of the corridor and body speed increase border. This is something that can be observed.

Keywords: Geometry of artery; Pulsatile blood flow; Numerous stenosis.

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Submission ID: 93

Comparative Study of Diagrid & Voronoi grid in Tall Building using SAP2000: A Way Forward

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ABSTRACT

Due to structural effectiveness and potential for beautiful architecture, diagrid structures are frequently utilized for today's tall buildings. This allows for the study and testing of innovative grid designs. An irregular grid refers to the uneven arrangement of buildings in an urban or architectural setting, whereas a diagrid particularly refers to a building's structural structure, which consists of diagonal components creating a grid for support. The two ideas have to do with various facets of building construction and design. One of the grids selected for this is the asymmetrical grid. This study used irregular geometry fortall buildings, so identifying pertinent structural systems is essential for better overall performance. For this tall skyscraper, an irregular grid was selected for the outside grid. Analysis and design were carried out in SAP2000 for lateral loads. Various models were prepared for different geometries. Due to inclined columns lateral loads are resisted by axial action of the diagonal compared to bending of vertical columns in framed tube structure. Diagrid structures generally do not require core because lateral shear can be carried by the diagonals on the periphery of building. Analysis and design of 25, 35 and 45 storey diagrid steel building is presented. A regular floor plan of 30m × 30m size for square and 30m × 40m for rectangular are considered.

Keywords: Rhino 3D; Unconventional grid; SAP2000 and tall building.

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Submission ID: 94

Microwave Drilling of Sisal Epoxy Composite Plate under Graphite Tool with Conical Tip

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ABSTRACT

Fiber-reinforced polymer composites (FRPCs) are renowned for their exceptional strength-to-weight ratio and durability, making them invaluable in industries like automotive and aerospace. However, their manufacturing poses challenges, particularly in drilling high-quality holes without compromising the material's integrity. Conventional drilling methods often result in fiber damage, reducing the component's strength and lifespan. To address these issues, microwave-assisted drilling has been explored in this study, focusing on sisal epoxy composites. By utilizing plasma generation near the drilling tool's tip through microwave interaction at 2.45 GHz and 720 W power, the research aims to mitigate the drawbacks associated with conventional drilling. A graphite tool is selected for its high melting point and ability to maintain its shape during the microwave drilling process, ensuring consistent performance. The study investigates the effects of a conical tip on drilling accuracy, assessing parameters such as heat-affected zone (HAZ), overcut, circularity of holes at entry and exit points, and hole taper. Characterization methods, including optical microscopy, are employed to analyze the drilled holes. The findings reveal that HAZ is more pronounced at the entrance compared to the exit, while the circularity of holes is higher at the exit. These insights contribute to optimizing the drilling process, enhancing hole quality, and ultimately improving the overall performance and reliability of FRPC components in various applications.

Keywords: Composite plate; Graphite tool; Microwave drilling; Sisal epoxy.

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Submission ID: 96

Thermal Vibration Characteristics of Functionally Graded Carbon Nanotube Reinforced Sandwich Plate with Auxetic Core using Isogeometric Analysis

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ABSTRACT

This study focuses on analysing the thermal vibration behaviour of a sandwich plate with functionally graded carbon nanotube-reinforced composite (FGCNTRC) facings and an auxetic core with tunable material properties using an isogeometric approach. Non-uniform rational B-Spline (NURBS) basis functions are utilised to approximate both the geometry and unknown variables of the problem. The strain displacement assumptions are based on a non-polynomial higher-order theory, and the discrete governing equations for the free vibration behaviour of the sandwich plate in the thermal environment are derived based on Hamilton's principle. The effective material properties, including Young's modulus, mass density, Poisson's ratio, and thermal expansion coefficients, are determined using the extended rule of mixture with CNT efficiency parameters that account for the size dependence. Several parametric studies are conducted to understand the influence of three different types of CNT distribution patterns in facings, namely uniform distribution (UD), FG-O, and FG-X, the geometrical

parameters of the auxetic core, CNT volume fraction, temperature distribution and boundary conditions on the eigen frequencies of the sandwich plate. The accuracy and reliability of the proposed method are verified by comparing the natural frequencies with those available in the literature that are determined using different numerical approaches. New results on the eigen frequencies of the sandwich plate with tunable material properties, hitherto not found in the literature, are presented for the first time.

Keywords: Auxetic core; Isogeometric analysis; FGCNTRC; NURBS; Non-polynomial theory.

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Submission ID: 97

Blast Response of Sandwich Panel with Re-Entrant Auxetic Core

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ABSTRACT

In the current scenario, the major design consideration for military infrastructure and vehicles is to improve the energy absorption capacity of structures against far-field or near-field blast attacks. This study investigates the performance of a sandwich structure with an auxetic re-entrant core with negative Poisson's ratio to sustain a close-field blast using commercial software LS-DYNA. The spherical air blast loading model is based on the conventional weapons effects program (CONWEP). The dynamic response of a sandwich structure subjected to a high strain rate is described using the Johnson-cook model. The different combinations of top and bottom facings include aluminium alloy (AA5083-H116), steel (AL6XN) and carbon fiber reinforced plastic (CFRP). The auxetic core is assumed to be made up of AA5083-H116 or steel (AL6XN). The sandwich structure is subjected to 1 to 5 kg of trinitrotoluene (TNT) spherical air-blast loads at stand-off distances ranging from 145.86 mm to 500 mm. The blast resistance performance of a structure is measured using skin deflection and energy absorption. The present results for deformation response and energy absorption capacity of the sandwich structure are validated with experimental results available in the literature. Thereafter, a comparison of the blast performance of a sandwich structure with different combinations of materials for face sheets and core is performed, and conclusions made are included, which may serve as benchmark solutions for the efficient design of blast-resistant structures.

Keywords: Auxetic core; CONWEP; Johnson-cook model; LS-DYNA; Blast loading.

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Submission ID: 98

Natural convection heat transfer through composite aluminum heated tube

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ABSTRACT

In this work, natural convection heat transfer from the heated tube to fluid has been investigated. The density difference which occurs due to temperature variation, is the main cause of the flow of fluid inside the tube. When fluid temperature rises due to surrounding conditions, then fluid starts to rise and the movement of adjacent colder fluid occurs to fill that gap. The natural convection method is commonly used in electronic equipment, where maximum numbers of equipment are placed on a single small board. If proper heat transfer does not happen from that board to the surroundings, then failure of the total system may occur. As the forced convection heat transfer method is not practically feasible for such small boards, the natural convection method is suitable for these cases. Properties of heat flow by the medium through the vertical tube and the method to enhance natural convection heat transfer have been presented in this work. The vertical tube is made of composite aluminum (Al-Al Composite tube) which is a non-magnetic material having good thermal conductivity properties. For heat transfer from a heated system, aluminum is preferred because of its high strength-to-weight ratio, lightweight, non-toxic, and better corrosion resistance. The vertical tube is 50mm in diameter and its length is 550 mm. The ratio of length to diameter of the arrangement is 11. Constant heat flux is maintained on the tube wall. Internal rings are provided inside the test section having a dimension of 6 mm thickness having a square cross-section. Rings are placed inside the tube with equal spacing between them to enhance heat transfer.

Keywords: Density; Vertical tube; Natural convection; Heat flow; Internal rings.

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Submission ID: 107

Recent Trends in Depositing Composite Layer on AISI 1020 Steel Substrate by Different Cladding Methods: A Review

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ABSTRACT

AISI 1020 carbon steel is a potential substrate material for cladding in the present era due to its wide

applications in various engineering fields. The key features, advantages and limitations of various cladding methods to improve the poor tribological properties of AISI 1020 carbon steel using a suitable heat source such as laser beam, plasma arc and tungsten inert gas (TIG) arc is described in this paper. Researchers used different ceramic particles (oxides, carbides, nitrides and borides of metallic elements) as well as high entropy alloy (HEA) powders for the fabrication of single and overlapped tracks over the surface of AISI 1020 steel. The key findings of the latest work of the researchers in this particular field of research are discussed here. Moreover, the in-situ synthesis mechanism of new metal compounds in the cladded layer as well as monitoring of molten pool thermal history while cladding have positive effects in terms of improved tribological properties of substrate and the same is discussed in this paper. This paper will contribute as a reference article for the researchers working in the field of composite layer deposition over AISI 1020 carbon steel surface through different cladding methods.

Keywords: Steel matrix composites; Plasma transferred Arc (PTA) cladding; TIG cladding; Laser cladding; Coating materials.

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Submission ID: 108

Synthesis of Cerium Oxide Nanozymes and their Antibacterial Action

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ABSTRACT

The escalating threat of antibiotic-resistant bacteria has posed a critical challenge to the successful diagnosis and treatment of infectious diseases, leading to intensive exploration into nanotechnology-based alternative antimicrobial strategies for combating multidrug resistance in microorganisms (Huh et. al., 2011). Many nanoparticles (NPs) with enzyme-like activities (nanozymes) have emerged as promising candidates to perform effective antibacterial effects owing to their high enzyme-like activities. Cerium oxide (CeO2) NPs (compared with other NPs such as ZnO NPs, Ag NPs, and TiO2 NPs) have gathered attention for their robust antimicrobial properties, holding the potential to overcome multidrug resistance. They show a unique antibacterial mechanism arising from their characteristic multi-enzymatic potential and mixed valence states, as reported by Zhang et. al. 2019. This study explores the synthesis parameters, characterization techniques, multi-enzymatic activity, and reactive oxygen species (ROS)-generating potential of CeO2 nanoparticles in different buffers and pHs, explores their prooxidative potential, and sheds light on their potential as effective agents against resilient microbial strains. Two samples of CeO2 NPs were synthesized through the hydrothermal method of synthesis by varying the concentration of cerium salt used as a precursor, and the nanostructures were characterized by UV-visible spectroscopy, X-ray photoelectron spectroscopy (XPS), X-ray diffraction analysis (XRD), Raman spectroscopy, and energy dispersive X-ray spectroscopy (EDAX). The ROS-generating potential of the nanoparticles was analyzed using a fluorescence-based assay using terephthalic acid (TA), and 9,10-anthracenediyl-bis(methylene) dimalonic acid (ABDA) as probes. The antibacterial activity of CeO2 NPs was tested against gram-positive (S. aureus) and gram-negative (E. coli) bacteria, respectively. The comprehensive investigation explored here is aimed at providing a significant contribution to the ongoing search for novel antibacterial agents, which will help advance the creation of nanoparticle-based solutions for

combating bacterial infections.

Keywords: Nanoparticles; Cerium oxide; Antibacterial activity; Reactive oxygen species.

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Submission ID: 110

Machinability Study of the Carbon Fiber Reinforced Polymer (CFRP) using Ultrasonic Assisted Rotary Electrochemical Discharge Machining (UR-ECDM) Method

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ABSTRACT

Carbon fibre reinforced polymer (CFRP) polymer has an outstanding characteristic such as high strength, low weight, and high resistance to the temperature, and it exhibits various applications in the field of aerospace, automotive, sporting goods, defence and marine products. For CFRP, drilling of the holes remains the most common secondary machining operation. Despite its widespread use, difficulties such as burring, poor surface quality, poor geometrical features and delamination continue to limit its use. Ultrasonic assisted rotary electrochemical discharge machining (UR-ECDM) appears as a novel machining technology for drilling holes in composite materials. The present study focusses on the simulation as well as the experimental study of the CFRP in terms of material removal, circularity error (CE), and surface roughness (SR). The multi-spark finite element model is developed to analyze the machinability of the CFRP. The plots of the temperature distribution within the CFRP are utilized to predict the material removal which is further validated using the experimental results. A fair consensus has been noticed between the simulation and experimental results. The effect of various input parameters on response characteristics is also discussed. Results demonstrated that UR-ECDM process can be used to drill holes in CFRP with excellent geometrical features.

Keywords: CFRP; Ultrasonic; Surface roughness; FEM; Multispark.

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Submission ID: 111

Fatigue Study of Composite Lug

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ABSTRACT

Lugs are specialized pin joints utilized in connecting various load-bearing structures, such as mechanical systems and aircraft structures, which endure cyclic loading primarily at their pin-hole interfaces. This combination of high stress concentration can lead to crack initiation and propagation, highlighting the increasing importance of fatigue studies on lugs for overall structural integrity. Recently, composite materials have gained popularity due to their differing fatigue degradation nature compared to metallic components, with fiber-reinforced composites exhibiting less deterioration in bearing capacity under cyclic loading conditions. This study focuses on evaluating the crack initiation and propagation life of Carbon Fiber Reinforced Polymer (CFRP) lug specimens using a fracture mechanics-based Linear Elastic Fracture Mechanics (LEFM) approach. A numerical iterative method is employed to determine the final crack length, incorporating strain energy release rate through Virtual Crack Closure Technique (VCCT) using Ansys Workbench, and applying Paris's law to estimate propagation life. This analysis contributes to predicting specimen initiation life, revealing that CFRP lugs demonstrate high durability even in challenging conditions. These findings suggest opportunities for enhancing their performance and indicate their potential for use in load-bearing applications, potentially offering superior properties for specific needs.

Keywords: Lug; Stress life; Linear elastic Fracture mechanics; CFRP; Virtual crack closure technique (VCCT).

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Submission ID: 112

Damage Detection in Composite Structures using Time-Frequency Analysis

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ABSTRACT

The problems of crack initiation and debonding in interfaces is a problem of interest in dynamical systems made of composite materials. Vibration-based methods for detection of these defects would involve spectral analysis of the dynamic response such as acceleration. The change in frequency, owing to the change in stiffness, consequent to the initiation of a crack is representative of the impending damage. A time history representative of the breathing crack behaviour and a spectral analysis of the signal using the Fast Fourier transform (FFT) algorithm is shown in current study, resulted in two frequencies, indicating the presence of two frequency components in the signal but not the presence of a single frequency component in different durations of the signal. This is due to the averaging of the spectral content inherent to spectral analysis. The time variation in spectral content can be extracted only by time-frequency analysis of the signals. Such analysis is done using the short time Fourier transform (STFT), which involves spectral analysis of the time signal over shorter intervals. However, it is not devoid of averaging. Hence, an alternative signal analysis method know as single frequency filtering (SFF) is adopted, which tries to overcome spectral averaging by weighting the signal such that the instantaneous information is emphasized. The results of this analysis are shown in current study Thus, the present study will demonstrate the detection of the breathing crack present in the interface of composite materials, using time-frequency methods of analysis.

Keywords: Composite structures; Breathing cracks; Fourier transform; Short time Fourier transform; single frequency filtering.

Submission ID: 113

Studies on Fiber/Matrix Interface Degradation in Composites Due to Moisture Absorption

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ABSTRACT

Moisture absorption investigations were carried out on glass/epoxy and carbon/epoxy composites. It was observed that moisture absorption caused more significant degradation of the fiber/matrix interface in carbon/epoxy composites compared to glass/epoxy composites. This paper detailed the studies to verify the extensive interface degradation in moisture-absorbed carbon/epoxy composites. Measurements of contact angle, Fourier Transform Infrared Spectroscopy (FTIR) analysis, and tensile testing were conducted on post-cured moisture-absorbed carbon/epoxy composites. The studies showed the possibility of relatively incompatible sizing/surface treatments in carbon fibers. This could have impacted the curing and moisture absorption and thereby resulted in larger interface degradation in moisture-absorbed carbon/epoxy composites.

Keywords: Degradation; Composites; Moisture; Interfaces.

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Submission ID: 115

Sub-Surface Damage Detection in GFRP Composites using Electrical Impedance Tomography

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ABSTRACT

The inherent challenge of detecting inconspicuous or sub-surface damage in composites necessitates innovative health monitoring approaches. Electrical impedance tomography (EIT) is a promising technique to detect damage, but literature work is limited to through-hole damage detection and rarely on sub-surface damage. This study explores the characterization of sub-surface damage in glass fiber reinforced polymer (GFRP) composites using EIT. Carbon nanofibers (CNF) were added during the vacuum bagging process to provide GFRP with intrinsic conductivity. Damage was induced using low-velocity impact and quasi-static indentation. A hemispherical indenter was used to create sub-surface damage, and continuous monitoring via EIT was conducted after each indentation and impact test. Two electrode configurations, single surface-mounted and double surface-mounted, were employed with various current injection patterns to assess sensitivity and accuracy for sub-surface damage detection. Conductivity change maps were generated by solving forward and inverse problems

using EIDORS, an open-source software for EIT. The quasi-static indentation test was performed for dent depths of 0.5 and 1 mm using single surface mounted electrodes. Although the former is not detected, the 1 mm indentation damage was detected as shown in the figure. The effectiveness of the EIT approach was validated through a non-destructive testing (NDT) method. The study includes a comparative analysis of results between single and double surface-mounted electrode configurations, providing insights into their respective sensitivities and accuracies. Overall, this research contributes to advancing the understanding of sub-surface damage detection in GFRP composites, offering a promising methodology for real-time health monitoring of composite structures subjected to controlled testing conditions.

Keywords: Damage; GFRP; EIT; Composites.

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Submission ID: 116

Investigation and Analysis of Energy Absorption Capacity of Epoxy/Carbon Woven Composites with Weave Patterns

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ABSTRACT

Woven composite materials have become more prominent in various industries in recent years, including aerospace, defense, automobiles, etc. The material used for making automobile coverings and aerospace parts should have good impact strength and energy absorption capability for its damage resistance and safety. The composites consist of interwoven fibers in a symmetric pattern, have enhanced mechanical properties like good strength, stiffness, and impact resistance. This research aims at investigating the effect of the weave pattern of carbon fibers on the mechanical properties and energy absorption capabilities of the woven composites. Epoxy as a matrix with carbon fiber reinforcement of different weave patterns (plain, twill, and stain weave) were used for the study. A multi-scale computational approach (meso-macro scale) was employed for computational investigations. Digimat software is used to determine the homogenized properties of epoxy/carbon reinforcement composite at meso-scale with various weave patterns. Simulation of the tensile test and ballistic impact test are conducted at macro-scale using ANSYS Workbench to analyze the energy absorption capacity of various weave patterns. From the results, it is sufficient to conclude that woven patterns have more energy absorption capacity and that twill weave patterns absorb more energy than stain and plain weave patterns.

Keywords: Woven composite; Weave pattern; ANSYS; Energy absorption; Ballistic impact.

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Submission ID: 117

Vibration Analysis of Doubly Curved Shells Laminated Composite using Carrera Unified Formulation

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ABSTRACT

We establish the state equations for doubly curved, orthotropic shells in an orthogonal Cartesian coordinate system. Modelling orthotropic and anisotropic doubly curved shells in two dimensions, the Carrera Unified Formulation (CUF) technique uses an eight-noded quadrilateral element (Q8) to integrate higher-order shear deformation. The paper uses the Finite Element Method (FEM) to investigate vibration analysis of laminated composite doubly curved shells while accounting for various curvature radii, edge constraints, and six distinct kinds of boundary conditions. Different lamination forms, including two layer, three-layer, cross-ply laminates (CP), and angle-ply laminates (AP) configurations with symmetric and antisymmetric lamination arrangements, are selected. A unified numerical solution is provided for thin and moderately thick laminated shells. An equivalent single layer with Taylor series expansion is utilized to characterize the displacement field to consider laminated shells. The use of the methodology yields insights into the structural behavior and design issues for doubly curved shells under various scenarios and configurations. Numerical findings are provided for comparison with solutions from the literature to assist designers in determining whether to consider the effects of transverse deformations under different circumstances. The CUF approach generates numerical findings, emphasizing its versatility for diverse laminated composite doubly curved shells.

Keywords: Composite laminates; Finite element analysis; Fundamental nucleus.

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Submission ID: 120

Study on a Combined Pile Raft Foundation Having Batter Piles Subjected to Lateral Loads Using Finite Element Analysis Software

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ABSTRACT

A series of Finite Element Analyses was carried out on a Combined pile raft foundation (CPRF), using the software PLAXIS 3D, to understand the behavior of the foundation system and changes in deformation. Soil models of fine sand, coarse sand, and clay were used in the analysis to support the CPRF. It was observed that CPRF in clay was able to withstand more lateral load compared to that in sand. The raft was modelled as a plate element and the piles as embedded beams. Lateral load was applied to the foundation system. Deformation was observed in foundations with vertical piles and batter piles to find the optimum combination. Batter Piles placed in the direction opposite to the applied lateral load were observed to give lesser deformations than batter piles placed in the same direction of applied load or vertical piles. Next, a parametric study with batter angles 15°, 20°, 25°, 30° was studied. Analyses using other parameters such as varying raft depths, pile lengths, pile diameters and pile shapes were also carried out.

Keywords: Pile raft; Batter piles; Deformation; Lateral load; Parametric study.

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Submission ID: 123

Tribological and Mechanical Behaviour of Hydrogel Nanocomposites: A Review

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ABSTRACT

Hydrogels, remarkable for mimicking the properties of living tissues, are finding widespread use in biomedical applications like tissue engineering, drug delivery, and biosensing. This review study compiles recent studies on the tribological characteristics of polymer nanocomposites incorporating Hydroxyapatite (HAP), Graphene (Gr) and calcium phosphate (CaP). It was observed that, the addition of HAP increases the amount of HAP in cell culture scaffolds surges the elastic modulus, cell adhesion and viability which has been shown in numerous investigations which significantly enhance tensile and flexural strength of polymer composites. However, Poly (ethylene glycol) diacrylate Graphene (PEGDA/Gr) shows the maximum amount of compressive strength with a 150.3% increase over unfilled PEGDA. Observing many of the research is being caried out and, it is seen that the Gr and CaP can support cellular development and showed similar biocompatibility. Various test such as MicroCT ant the Rheological tests had been carried out to see the cell growth and their composition under appropriate environment. It can be concluded that various micro/nano fillers increase the mechanical and tribological properties of hydrogel nanocomposites. This review study will pave a way to design and develop mechanically robust Hydrogels nanocomposites in biomedical field such as bone cartilage and tricuspid heart valve and drug delivery.

Keywords: Nanocomposites; Nanofiller; Tribology; Mechanical properties; Hydrogels.

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Submission ID: 125

Effect of Surface Modifications on Drag Reduction of Delta Wing

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ABSTRACT

In our steadily advancing world, air travel has emerged as one of the predominant modes of transporting both people and goods. However, achieving economically efficient supersonic speeds for passenger aircraft has posed a significant challenge for manufacturers. The development of supersonic aircraft has been underway for more than seven decades. Delta wings stand out as a pivotal innovation in supersonic air travel, offering exceptional efficiency in lift and drag properties at high speeds. However, their efficiency diminishes at lower speeds primarily due to the elevated drag characteristics exhibited by the wing. In this project the Coefficient of Drag of a 76/40 double delta wing with and without modifications are numerically and experimentally analysed. The modifications applied were Dimples and Tubercles. It was found that the results from numerical analysis and experimental analysis agree with each other. It was also found that Delta wings with Tubercles modification gave the best results in drag reduction. The Delta wing with Dimples did not cause much change.

Keywords: Delta wing; Surface modifications; Tubercles; Dimples; Drag reduction.

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Submission ID: 126

Development of Mg-Zn-Zr Composites with Refined Microstructure using Friction Stir Processing

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ABSTRACT

Mg-alloys have gained a lot of interest as possible materials for human bone implants, due to their exceptional biocompatibility and Young's modulus matching with that of cortical bone. However, the commercially available Mg-alloys suffer from several microstructural defects such as micro-cracks, nonhomogeneous microstructure, and several others. The friction stir processing (FSP) approach has the potential to overcome such limitations by refining the microstructure with very fine grains. In the present study, single pass and multi-pass FSP to develop Mg-composites by reinforcing the Zr particles in the as-cast Mg-2Zn alloy (BM). The experimental findings demonstrate that using multi-pass FSP, Mg-composites with fine grains and uniform microstructure can be achieved successfully. Using 3-pass FSP, the homogeneous microstructure with an average grain size of 8 µm has been obtained for the Mg-Zn-Zr composite, whereas the average grain size of as-cast Mg-2Zn was 63 µm. The newly developed Mg-Zn-Zr composite using 3-pass FSP has shown significant improvement in mechanical properties as compared to as-cast Mg-alloy and single-pass FSP-treated Mg-Zn-Zr composites.

Keywords: Friction stir processing; Mg-Zn-Zr composites; Grain refinement; Mechanical properties.

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Submission ID: 132

A Comparative Exploration of Tensile and Flexural Resistance in Kevlar and Carbon Fiber-Reinforced Thin Composite Structures

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ABSTRACT

There are many uses for thin composite structures reinforced with woven fabrics, particularly with kevlar and carbon fibers, in a variety of industrial domains, particularly in the production of military jets and aircraft based on their higher specific strength. The goal of this study is to compare the tensile and flexural properties of carbon and kevlar-reinforced metal sheet laminates within the common matrix of epoxy. The study covers every step of the process, including sample preparation, testing, and analysis. Flexural and tensile strength values were analysed for 70 percent volumetric ratios. This study also investigates the effect of interfacial adhesion between the metal sheet and the fiber/matrix on failure. This analysis is supported by test results and scanning electron microscopy (SEM) images. The key contributions of this study lie in enhancing understanding of the bonding mechanisms between fibers and metal sheets. Additionally, the tensile and flexural resistance of fiber laminates, specifically those reinforced with Kevlar and carbon, are comprehensively analyzed, providing valuable insights for applications in various industrial sectors.

Keywords: Metal-fiber laminates; Carbon fiber; Kevlar fiber; Fiber-metal composites; Volumetric.

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Submission ID: 136

Investigating the Crashworthiness Behaviour of Crash Box Filled with Hybrid Lattice Filler

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ABSTRACT

Drawing on the advantageous characteristics of lattice structures and thin-walled tubes for better energy absorption and enhanced crashworthiness, this study investigates a crash box filled with hybrid lattice filler. We introduce two hybrid lattice structures, denoted as AuxCon hex-1 (AuxeticConventional Hexagon-1) and AuxCon hex-2 (AuxeticConventional Hexagon-2), which were

designed by combining conventional honeycomb and auxetic honeycomb cells in two varied arrangements. These hybrid lattice configurations were used as fillers within a crash box. A numerical investigation of quasi-static compressive loading was conducted using ABAQUS™ Explicit solver to investigate the efficacy of the two hybrid filling structures on the energy absorption capacity of the crash box. The numerical approach was first validated with an experimental investigation reported in the literature for a thin-walled tube filled with a honeycomb lattice structure. The findings of this study show that the energy absorption is increased with the hybrid lattice, and more specifically, the crash box filled with AuxCon hex-1 hybrid lattice performs better. This research contributes valuable insights into the efficacy of hybrid lattice fillers in crash box applications, emphasizing their potential significance in advancing impact resistance through the tailored design of geometric and material parameters for optimized energy absorption capabilities.

Keywords: Crash box; Auxetic; Hybrid lattice; Energy absorption.

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Submission ID: 139

Surface Roughness Improvement of 3D Printed PAHT CF15 Composites using Laser Texturing

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ABSTRACT

Polyamide High Temperature composites infused with 15% chopped carbon fiber (PAHTCF15) possesses high temperature resistance and impact strength. It is also inert to many chemicals making it a lucrative choice for many applications. Products can be 3D printed using PAHT CF15 filaments on a normal 3D printer into different shapes easily. 3D printed PAHTCF15 is hygroscopic in nature. Also, the 3D printed products have poor surface finish inherently. This makes them unsuitable for many applications. Post processing of 3D printed PAHT components using conventional techniques like grinding and coating is a time consuming and labour intensive process. Laser surface texturing have been used for altering the surface properties of different materials previously. Fiber lasers are usually used for cutting and micromachining of metals. Polyamide composites can also be machined using fiber lasers. In this research work, fiber lasers have been used to improve the surface finish of the 3D printed PAHTCF15 composites. 3D printed PAHTCF15 samples were scanned under a nanosecond 70W fiber laser in order to improve surface roughness of the samples. Experiments were conducted at different power and scanning speeds to determine the optimal parametric set up. Laser beam was scanned in to two different directions namely longitudinal and transverse to alter the surface roughness. It was observed that transverse scanning resulted in better surface finish of the 3D printed PAHT CF15 samples at 4 mm of defocus.

Keywords: PAHTCH15; Surface finish; laser; Surface texturing.

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Submission ID: 141

Effect of Fabrication Defects on Elastic and Fatigue Properties of Carbon Fiber Reinforced Polymer Composite

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ABSTRACT

In the present work, a vacuum-bagging resin infusion microwave curing process is implemented to manufacture carbon fiber-reinforced polymer composite (CFRPCs) laminate. The manufactured composite has two distinct volume fractions of fabrication defects void 0.785% and 1.51% by volume. Mechanical properties like ultimate tensile strength, elastic modulus, and fatigue life cycles are predicted at room temperature using a computer-controlled dynamic universal testing machine. Further, the fatigue life of fabricated composites is predicted at different cyclic load amplitudes (40%, 60%, and 80% of UTS) by considering the stress ratio (R = 0.1, 0.3, 0.5, 0.7, and 0.9). Fabrication defects like void volume fractions are calculated and correlated with the composite material's mechanical properties and fatigue life cycles. The optical morphology of the composite materials before and after the failure is analysed using scanning electron microscopes. Mechanical and fatigue strength are significantly affected by the voids present in the composite as fabrication defects.

Keywords: Carbon fiber-reinforced polymer composite; Stress ratio; Fatigue life cycles; Fabrication defects.

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Submission ID: 142

A Technical Status Review of 3D Printing advancements and Application for Military Engineering

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ABSTRACT

One of the fastest growing technological deployments across diverse domains is of three-dimensional printing (3DP), with precision and time saving as two major attractive parameters for its application across various domains. The last three decades have witnessed increasing applicability of additive manufacturing, 3D Printing technology (3DP), solid free form fabrication, and layered manufacturing,

across diverse sectors of industrial, commercial, art, and engineering. Yet, one of the least permeated domains by 3DP technology remains to be military engineering and defence application for crisis management. It is of para-mount importance to collate the literature as presented in the paper as a status quo of the 3DP technology and their applicability for military engineering and crisis time deployment for capitalizing on time saving feature and precision feature owing to associated high risk and sensitive nature of military engineering applications. It is imperative that the concepts covered in the below paper be further researched for defence applicability, and lessons learned by few case studies where 3DP have been used for military engineering.

Keywords: Additive manufacturing (AM); 3D Printing (3DP); Military engineering.

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Submission ID: 143

Status of Technological Developments in Materials for 3D Printing and Application in Military Engineering

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ABSTRACT

It is imperative to ensure the permeation of technological advancements in every human endeavor including military engineering. As a nation keeping abreast with the latest advancements and its application for defense domain is a necessity to maintain stable geo-politics and economic stability, specifically for a rapidly growing economy of a developing nation such as India. The history, technology, recent trends, and challenges associated with 3D printing have been explored comprehensively in this paper highlighting the potential application to be adopted for defence use. The issue with delay in adoption of any technological advances in tangential domains is owing to the fact that most research are fragmented and applications are patented with limited access to information. This paper presents an aggregated knowledge base of the various techniques developed in the field of 3D printing with potential of application for defence. It illuminates the innovative integration of 3D printed materials with additives, examining their usage and significance in military applications. Additionally, the paper explores the latest technological advancement in concepts of origami engineering, raw spider silk, and Kevlar and chitin research to showcase the potential of using these concepts in conjunction with 3D printing for application in defense. The narrative is enriched by three case studies illustrating past and future applications of 3D-printed materials in military contexts.

Keywords: 3D printing; 3DP material; Military engineering.

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Submission ID: 147

Machining of Composite Materials using ECDM Process: An Overview

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ABSTRACT

Electro chemical discharge machining (ECDM) is an emerging technology that can be used to machine any type of material regardless of their electrical and thermal conductivity, mechanical strength and hardness. In recent years, ECDM has been extensively used to machine glass material for the fabrication of micro features. However, in some investigation's composite materials (such as polymer and metal matrix composites) have been attempted to explore the process feasibility. In view of this, several alterations have been performed in the basic configuration of ECDM process. In this paper, a comprehensive review is presented on these alterations and hybrid methods used to machine composite materials. The effect of process parameters on machining performance is also described irrespective of material composition and ECDM based hybrid process. Process and material removal mechanisms for ECDM based hybrid methods such as grinding assisted ECDM, rotary mode ECDM and rotary disc grinding assisted ECDM are also demonstrated during the processing of different composite materials. Apart from the drilling operation with ECDM, several other process variations like W-ECDM, ECDM milling are also included to describe the process feasibility towards the machining of different features on composite materials. The process challenges and future opportunities are also identified and included in this paper.

Keywords: Electrochemical discharge machining (ECDM); Metal matrix composites; Polymer matrix composites.

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Submission ID: 148

A Review on Processing of Natural Fiber Polymer Matrix Composites Via Microwave Energy

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ABSTRACT

Natural fiber polymer matrix composites (PMC's) are in high demand owing to their widespread applications in the aerospace, automotive, marine, construction, and sports industries. In recent years, several methods have been employed to fabricate natural fiber PMC's such as hand layup, autoclaving, filament winding, injection molding, compression molding, and microwave compression molding. Among these methods, microwave compression molding is an emerging method that helps to uniformly distribute heat across the entire mold surface and takes less time to manufacture PMC's

compared to other processes. However, in recent years, various investigations have been performed to fabricate natural-fiber-based polymer composites using different fibers and polymer materials. In this paper, a review of these materials and their fabrication procedures with microwave processing is presented. The effect of microwave-based process parameters, such as power rating and exposure time, on the material properties is also demonstrated. Furthermore, an insight of the microwave-based joining process is also addressed along with a detailed process parameter analysis. In addition, this study presents challenges and opportunities for the future.

Keywords: Natural fiber polymer matrix composites; Microwave energy; Joining; Compression moulding.

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Submission ID: 149

Drilling of Polymer Matrix Composites using Ultrasonic machining process:An overview

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ABSTRACT

Polymer matrix composites (PMC's) are a versatile class of materials used in several industries, such as automobiles, aerospace, sports, and medicine, to fabricate different components, owing to their excellent mechanical properties, high strength-to-weight ratio, and good corrosion resistance. However, the assembly of these components can be ensured through fastening methods, accompanied mainly by holes drilling in the PMC's. Several machining methods have been employed to drill holes in PMC's including conventional drilling, ultrasonic machining, abrasive jet machining, laser beam machining, and water jet machining. Among these methods, ultrasonic machining exhibits several advantages over other processes owing to its low operational cost, ease of use, and compact setup. In recent years, ultrasonic machining (USM) has been extensively used through different variations to drill holes in natural, glass, and carbon fiber polymer composites. This paper presents an overview of all the process variations in the ultrasonic machining process used to drill holes in PMC's. The effects of process parameters, such as power rating, amplitude of vibrations, tool rotation speed, and frequency of vibrations, on the drilled hole quality are also included. The process and material removal mechanisms have been discussed from the perspective of different fiber materials. Challenges with respect to all process variations are also included, and their respective feasible solutions are proposed as future opportunities.

Keywords: Polymer matrix composites (PMC's); Ultrasonic machining (USM); Natural fiber; Glass fiber; Carbon fiber.

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Submission ID: 151

Systematic Review for Developing Armored All-Terrain Vehicle for Special Army Operations and War Time

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ABSTRACT

The technological advancements for vehicles and material sciences dictate the deployment of modified vehicles for military purposes especially during war time. This study presents a comprehensive analysis of various literature for an armored vehicle specifically tailored for special army operations like ground-to-ground combat and infantry fighting. The vehicle integrates innovations for enhanced off-roading capabilities while maintaining efficiency and effectiveness through design optimization. The study not only focuses on the vehicle's performance but also its design, frame, body materials, but also enhance the protective features, all at a low cost. The paper systematically reviews various all-terrain vehicles, exploring new technologies and applied methods that contribute to advancements in engine power, body safety, chassis strength, and overall stability. The paper serves as a valuable resource for understanding and implementing cutting-edge technologies in the development of agile, protective, and efficient armored vehicles for specialized military operations.

Keywords: Armoured vehicle; All-terrain vehicle (ATV); Military engineering.

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Submission ID: 152

Investigating the Impact of Varied Current and Rotational Speeds on the Machining Performance of Al7075 Alloy using Electrical Discharge Turning

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ABSTRACT

This comparative study of the Electrical Discharge turning (EDT) machining process was conducted on Al7075 alloy, varying current intensities and rotational speeds. A 10 mm diameter A7075 aluminum alloy served as the workpiece material, and EDT technique was employed with a custom-built rotating spindle on a die sinking EDM machine. Copper electrodes of 2.1 mm diameter were used to form grooves on the cylindrical workpiece. The study investigated the impacts of various current (6A, 9A, and 12A) and rotational speed (1200, 1300, and 1400 RPM) on Material Removal Rate (MRR), Tool

Wear Rate (TWR), and Overcut (OC). The experimental results revealed that increasing current led to higher MRR, TWR, and OC, attributed to the generation of heat energy for melting and vaporization. Similarly, higher rotational speeds resulted in increased MRR, TWR, and OC, with centrifugal force aiding in debris removal. This work summarizing that the current had a more pronounced effect than rotational speed on the machining characteristics of Al7075 alloy in the EDT process.

Keywords: Al7075; EDT; MRR; TWR; Overcut.

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Submission ID: 153

Free Vibration Response of Thickness-Tapered Laminated Plates Under Hygrothermal Conditions

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ABSTRACT

The ply-drop technique is used to introduce thickness tapering in laminated plates. In addition to optimizing material usage, it tailors the stiffness to meet the functional requirements. The present study reports novel results pertaining to the natural vibrations of thickness-tapered laminated rectangular plates under hygrothermal conditions. The finite element model is developed employing layered tapered plate element based on Reddy's higher order shear deformation theory. The influence of taper configuration, ply orientation, side to thickness ratio and thermal conditions on the fundamental natural frequency is investigated.

Keywords: Free vibration; Ply-drop; Hygrothermal.

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Submission ID: 155

Crack Growth Study in Carbon Fiber Reinforced Composite (CFRC) using Phase Field Method

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ABSTRACT

Carbon fiber-reinforced composites (CFRCs) have broad applications in aerospace, electronics, automobile, and marine industries due to their superior properties like high modulus, lightweight, good wear and corrosion resistance, and high strength. Past failures show that the failure of these

composites depends on the loading type and materials used. This work proposes a hybrid phase field model to analyze the effect of loading manner on fracture behavior and mechanical response of the carbon fiber-reinforced composite. An in-house MATLAB code based on phase field formulation has been prepared to perform numerical simulations under plane strain conditions. A two-dimensional, four-noded, quadrilateral element has been taken for all numerical studies. The load-carrying capacity and crack path obtained in different cases are briefly discussed and compared in the present work. A crack deviation and merging phenomena are observed during the crack growth analysis of carbon fiber-reinforced composite specimens. Also, a numerical case is taken to validate the present phase field model, the results of which are in good agreement.

Keywords: CFRCs; Crack growth; Mode-II fracture; Phase-field model.

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Submission ID: 158

Physicochemical Analysis of PCL/Mwcnts Nano-Bio-Composites as A Maxillofacial Implant Material for Bone Tissue Regeneration

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ABSTRACT

Maxillary fractures are considered to be the most significant bone issues in dental field. Owing to the complicated anatomy, expectations from patients, and uniqueness with regards to the defects, the surgical restoration and refurbishment of most of the maxillofacial imperfections, are perplexing even for the most experienced specialists. In this work, the emphasis is on the development of a nano-bio composite materials to augment the effects of cell-based TE for the regeneration of bones. This work utilizes the materials, poly caprolactone (PCL) and multiwalled carbon nanotubes (MWCNTs) for the scaffolding by incorporating the solution casting methodology as the preparation route for the fabrication of PCL/MWCNT composite with MWCNT weight percentage (wt%) of 1. Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) analysis were performed on pure PCL as well as the composite samples so as to determine the overall structure, the levels of crystallinity it exhibits and to obtain the general morphology. XRD was taken and it reveals the presence of qualitative crystalline phases of pure PCL, indicating that the polymer is semicrystalline. The XRD pattern of the PCL/MWCNT composite shows the decrease in the crystallinity. Pure PCL and PCL/MWCNT samples were also utilized to conduct the FTIR test. The FTIR test results of the PCL/MWCNT composite would also show a decrease in the intensity of some of the absorption bands that correspond to the functional groups in the PCL. Also, the scaffolds were observed under a scanning electron microscope and the SEM analysis demonstrated the effective mixing, dispersion, and interfacial bonding between PCL and MWCNTs in the composite material. These conclusions identified the prospective utilization of PCL/MWCNT composites as a viable option for various applications including maxillofacial implants that require enhanced mechanical properties and tailored functionalities.

Keywords: Rapid manufacturing; Patient specific implants; nano-biocomposite material.

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Submission ID: 159

Enhancing Corrosion Resistance of Aluminum 6082 in Aqueous Urea Solution: A Cost-Effective Polymeric Coating Approach

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ABSTRACT

Aqueous urea solution, notably used in emission systems, can corrode metals like aluminium due to its mildly alkaline nature and susceptibility to contamination. Despite the corrosion resistance of aluminium from a protective oxide layer, impurities in the urea solution can degrade this layer, accelerating corrosion. This study investigates a cost-effective, robust polymeric coating to prevent such corrosion. This coating is an epoxy composite of bisphenol-A based epoxy resin and an amine hardener reinforced with 5% alumina and 5% silica micro fillers, and is applied to aluminium 6082 samples using a spray gun. Some samples are pre-coated with a commercial epoxy zinc primer to enhance adhesion. The performance of these composite coatings, with and without primer, was compared to bare aluminium through 25-day immersion tests in pure and contaminated aqueous urea solution. After a 96-hour salt spray test, bare aluminium discoloured 30% of the area, indicating signs of corrosion, while the epoxy composite coatings with and without primer showed no signs of decolourization. A 10% area under blistering was observed on the scratched epoxy composite coating but none on the epoxy composite coating with primer. SEM and FTIR analyses were conducted for morphology, filler dispersion, and the curing process. The results showed that the epoxy composite coating system with the primer performed significantly better.

Keywords: Epoxy coatings; Corrosion resistance; Aluminium alloy; Aqueous urea; Micro fillers.

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Submission ID: 160

Optimization of Material Characteristics in LTD of ZTA Composite

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ABSTRACT

Zirconia Toughened Alumina (ZTA) a ceramic based composite material has gained more attention from aerospace and biomedical industries to make parts of implants, combustion parts, armour, and inserts. Because its mechanical properties especially toughness and hardness which are admirable. Unpleasant machining behaviour retards the ZTA applications. Laser trepan drilling (LTD) is a thermal energy-based drilling process that is used to make macro-sized hole in difficult-to-machine materials. The present paper revealed the optimum values of processing parameters to optimize the material characteristics, namely recast layer thickness and microcrack width. The processing parameters are taken as laser pulse width, pulse frequency, speed and assist gas pressure. The mathematical relationship between processing parameters and material characteristics is developed using an artificial neural network. The optimum values of processing parameters for considered material characteristics are validated with a confirmation test. An overall variation of 12% and individual variation of 18.79% and 5.29% were found in both characteristics at optimum level of processing parameters.

Keywords: Laser trepan drilling; ZTA composite; Microcrack width; Recast layer thickness; Optimization.

Submission ID: 162

Hybrid Composite Aluminum 5083 Reinforced with Titanium Dioxide and Haematite

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ABSTRACT

The effect of presence of TiO2 and Fe2O3 micro-particles on the hardness, wear, corrosion resistance, and tensile strength of Al5083 alloy is investigated in this study. TiO2 and Fe2O3 micro-powders at different wt. % (0%, 2%, 4% and 6% each) were added as reinforcements in to aluminium matrix and the composite was prepared by stir casting. SEM images of the prepared samples exhibited an even spreading of reinforcements in the base material. The corrosion resistance, tensile strength, wear resistance and hardness of the base material was identified to be improved with increase in weight percentage of the reinforcing medium. However, at high wt. %, the tensile strength exhibited a lowering tendency due to the possible formation of agglomerates of the micro-particles with in the material. The resistance of the base alloy against corrosion appeared to be substantially improved by the addition of TiO2 and Fe2O3 and the trend was positive with increase in weight percentage of the micro-constituents. Thus, addition of micro-particles like TiO2 and Fe2O3 can improve the mechanical as well as physical properties of Al5053, enabling it to find significant application in marine, automobile, chemical and aviation fields.

Keywords: Hybrid composites; Corrosion resistance; Tensile strength; Hardness; Wear resistance.

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Submission ID: 163

Nonlinear bending analysis of sandwich beams with auxetic honeycomb core and curvilinear fiber facesheets

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ABSTRACT

Sandwich composite structures are special types of composites in which two stiff facesheets are provided along with a soft core in between. Auxetic honeycomb core sandwich composite structures have an excellent energy absorption capacity, are lighter, stiffer, and have a higher strength-to-weight ratio. In this paper, the nonlinear bending analysis is carried out for sandwich beams with an auxetic honeycomb core. The finite element study is performed using a first-order shear deformation theory. The facesheets are made of variable stiffness composite laminate (VSCL) sheets. To produce a VSCL, the fiber orientation is varied continuously across each layer. In constant stiffness composite laminate, the fiber orientation is kept constant throughout the layer. The von Kármán type nonlinear strain-displacement equations are used to account for geometrical nonlinearity. The Newton-Raphson iteration method is used to solve the nonlinear equations. The study is performed with various facesheet-core arrangements and boundary conditions.

Keywords: Sandwich structures; Auxetic honeycomb sandwich; Curvilinear fiber; Nonlinear bending; Variable stiffness composite laminate.

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Submission ID: 164

Deep Learning Approaches for Vision Transformers Based Detection of Surface Defects in Aluminium Die Casting

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ABSTRACT

The Transformers are modules that map data (textual or image) into embeddings conventionally used in natural language processing. These are currently examined for utility to industrial work situations that generate huge amount of visual data during processing or quality inspections. The present research adopts a novel method based on Visual Transforms (ViTs) for surface defect detection in Aluminium

die castings as an alternate approach to Convolution Neural Networks (CNNs). This technique overcomes limitations in local feature extraction of CNN method through 'self-attention methods' to capture global dependencies in fault pattern. The work highlights adept nature of ViTs in detecting complex anomalies thereby introducing better robustness and accuracy. The comparative values redeem intrinsic benefits of ViTs and associated long term relationships with defective images captured. The Visual transforms are promising to revolutionize fault detection through deeper insights by improved scalability and adaptability that form vital requirement in current production scenario. The results reveal huge potential for non-invasive fault detection of aluminium die casting as a route to practice sophisticated quality policy using the proposed technique.

Keywords: Aluminium die casting; flaws; Multi-layer perceptron; Transformers; Transform encoding.

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Submission ID: 166

Warpage in 3D Printed Nylon-Based Carbon Fibre Composites

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ABSTRACT

Additive manufacturing has revolutionized the production of polymeric parts with its capability to produce complex geometries with customized properties. Due to the characteristics of semi-crystalline polymer materials, they are being produced widely using additive manufacturing processes. However, warpage is a major challenge in semi-crystalline polymer materials, and it can significantly impact dimensional accuracy and overall part quality. For 3D printed parts to have accurate dimensions, structural integrity, and functional performance, warpage in materials must be understood and controlled appropriately. In this study, the warpage behaviour of 3D printed short carbon fibre-reinforced nylon composite is numerically investigated using the DIGIMAT commercial package software. A parametric study of the effect of fibre reinforcement is conducted. The robustness and accuracy of the presented computational approach are validated with literature and extended to parametric studies.

Keywords: Additive manufacturing; Polymer composites; Warpage; Digimat.

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Submission ID: 168

Thermal Buckling of 3d Printed Auxetic Core Sandwich Beams

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ABSTRACT

Experimental investigation carried out on the thermal deflection behavior of 3D printed poly lactic acid sandwich beams possessing positive, negative, and zero Poisson's ratio cellular cores is presented. Using a fused deposition modelling based 3D printer, sandwich beams were fabricated and investigated for thermal buckling under different heating conditions. Influence of Poisson's ratio of the core and orientation of the beam on thermal buckling also studied. It is found that Poisson's ratio of the core influences the thermal deflection of the beams remarkably. The sandwich beam having a vertically oriented core with zero Poisson's ratio exhibited superior buckling resistance compared to the other two cases.

Keywords: Thermal deflection; Poisson's ratio; 3D printing; Sandwich beam.

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Submission ID: 169

Free vibration analysis of Functionally Graded Folded Plates under Thermal Environment

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ABSTRACT

As the Functionally graded materials are most likely to be used under high thermal environments, the free vibration analysis, a fundamental dynamic characteristic, of functionally graded folded plates under thermal environment holds significant importance in understanding their mechanical behaviour and potential applications. Modal analysis of all side clamped (CCCC) functionally graded folded plates in the thermal environment is done using First order trans-verse shear deformation theory (FSDT). Power law variation and temperature dependent material properties are considered. A finite element program in MATLAB environment is developed for the present study applying folded plate transformation considering 8-noded elements. The investigation explores the impact on natural frequency due to the change in crank angle, thickness, temperature field (uniform/linear temperature rise), and gradient index. The findings have undergone validation against reputed publications.

Keywords: Functionally graded; Folded plate; Thermal environment; Finite element analysis; First order shear deformation.

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Submission ID: 175

Investigation on Corrosion Behavior of Polydimethylsiloxane and Nanofillers-Based Polymer Nanocomposite Coated Galvanized Iron

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ABSTRACT

The paper focuses on developing polydimethylsiloxane (PDMS) and nanofillers (ZnO and SiO2) based polymer nanocomposite solutions for coating galvanized iron (GI) using sol-gel dip coating method and investigating its corrosion behavior. The nanofillers in varying wt. % (0, 2, 4, 6, 8, and 10) are incorporated in the solution of PDMS and xylene for developing a nanocomposite coating solution. The solutions are characterized by pH, viscosity, and non-volatile matter. It is observed that all the solutions are basic. The viscosity (10.28-47.43 %) and the non-volatile matter (8.06-15 %) of the solutions are observed to be increasing with an increasing nanofiller % as compared to the base solution (PDMS and xylene). The developed solutions are coated on the GI substrate and tested for wettability, XRD, FTIR, and electrochemical responses. The wettability and the XRD tests confirm the hydrophobic and amorphous nature of the coated surface, respectively. The Si-O-Si groups are observed at 1088 cm-1. The electrochemical analysis shows that the impedance resistance of the coated surfaces is higher than that of the surface coated with the base solution. Further, the corrosion rate of the coated surfaces decreases with the % of the nanofillers. The coating with 10% nanofillers exhibited the highest impedance resistance and the lowest corrosion rate, finding applications in construction, marine, and naval.

Keywords: Sol-gel coating; Polydimethylsiloxane; Nanofillers; Hydrophobicity; Corrosion behavior.

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Submission ID: 177

Frequency Domain Analysis of the Viscoelastic Based Structure using Complex Modulus Method

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ABSTRACT

This paper presents a frequency domain analysis of a viscoelastic based curved panel using the complex modulus method. A Linear Finite Element Model is developed to investigate panel behavior under base and force excitations, respectively. The viscoelastic material is modeled by the complex modulus method along with a four-parameter fractional order derivative model. The usage of the complex modulus method results in the complex nature of displacements and forces. Displacement and force transmissibility are evaluated by effectively handling the complex nature of the displacement and forces, respectively.

Keywords: Force transmissibility; Displacement transmissibility; Viscoelastic; Complex modulus method.

Submission ID: 178

Experimental Investigation on use of Parali Powder as Partial Replacement of Sand in Concrete for Sustainable Development

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ABSTRACT

In order to address the issue of parali burning sustainably, an experimental study was conducted to investigate the replacement of natural fine aggregates (sand) with parali powder in concrete, up to a dosage of 20%. Workability, Strength, and Water Absorption parameters of code compliant study mixes with 5%, 10%, 15%, and 20% replacement of sand with parali powder were determined for the M20 concrete grade having binder ratios at 0.45, 0.5, and 0.55. The replacement leads to a decrease in compressive strength; however, all study mixes meet the designed compressive strength requirements. It is also observed that all the replaced mixes attain the code compliant workability, flexural strength, and ten-sile strength, along with permissible water absorption.

Keywords: Parali powder; Concrete; Sand; Workability; Strength.

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Submission ID: 179

Effect of Composition on Structural Evolution and Glass Forming Ability of the Zr-Ag Alloys during Rapid Solidification Process using MD Simulations

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ABSTRACT

Bulk metallic glasses (BMGs) are amorphous alloys produced using the rapid quenching method from fully relaxed liquid state. BMGs possess unique properties like high mechanical strength, enhanced plastic properties, increased corrosion resistance, improved creep and wear resistance, outstanding electrical and magnetic properties. One of the key scientific terms used to characterize the BMGs is their glass-forming ability (GFA). Among all the glass-forming alloys, Zr-based alloys exhibit superior GFA. In this study, the structural evolution and GFA of Zr_{100-x} Ag_x (x=25, 36, 50,75) alloys has been studied by using molecular dynamics (MD) simulations with second nearest neighbor modified embedded atomic method (2nn-MEAM) potentials. Various techniques such as the volume-temperature curve, reduced glass transition temperature (T_{rg}), coordination number, radial distribution

function (RDF) and Voronoi cluster analysis are employed to obtain the results. The formation of glassy structures of Zr-Ag alloys is confirmed by the splitting of the second peak in the RDF curve during the cooling process. T_{rg} of the alloys is estimated from their respective glass transition temperature (T_g) and the liquidus temperature (T_l). The observations revealed that Zr50Ag50 alloy has the highest GFA. From the Coordination number analysis and Voronoi cluster analysis, Zr50Ag50 metallic glass has also shown a higher population fraction of icosahedral clusters confirming its better GFA as compared to other compositions of the alloy.

Keywords: BMGs; MD simulations; 2nn-MEAM potential; GFA; Zirconium.

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Submission ID: 181

Fatigue and Modal analysis of Pylon of Aircraft using Metal Matrix Composites

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ABSTRACT

The aviation sector is working to make airplanes lighter to conserve fuel and eventually reduce overall expenses. This study presents the efforts made to decrease the weight of pylons through material composition changes. The specimen is prepared using a mixture of boron carbide (B_4C) and aluminum or titanium powder. This study focuses on using metal matrix composites instead of titanium alloy, which is often employed, to reduce weight while maintaining the structure's ideal strength. Modeling uses Dassault Systèmes products like SolidWorks®, and Abaqus®, software. Commercially accessible analytic products like Abaqus®, and Ansys®, software were used for the analysis. For modeling and analysis, the dimensions of the pylons and the load data are obtained from available literature sources. The model's fatigue life and modal frequency data were examined. The results were compared with accessible data from the literature and quantitatively examined for fatigue life and critical frequency.

Keywords: Pylon; Aerospace; Metal matrix composite; Modal analysis; Topology optimization.

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Submission ID: 182

Determination of Effective Mechanical Properties of Menger Sponge-Based Composite: A Finite Element Study

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ABSTRACT

Menger sponge has tunable electrical and mechanical properties with the hierarchical structure, which makes this structure more favourable for various applications, particularly for lightweight aerospace structures. In this paper menger sponge-based photo-strictive composite actuator is proposed. It consists of piezoceramic Menger sponge fractal shapes with square cavity-based fibres of different orders embedded in a soft nonpiezoelectric matrix. A numerical study has been carried out to investigate various orders (0th, 1st, 2nd, and 3rd) of such hierarchical structures with square-shaped cavities to determine their effective properties. The finite element method has been considered for a unit cell. The formulation of boundary conditions has been emphasized. The average volume method has been considered, which enables the simulation of all modes of overall deformation resulting from arbitrary combinations of electrical and mechanical loading. This numerical method provides a potential tool for rapidly calculating their effective properties. The results derived from the numerical approach are juxtaposed against those acquired through the analytical technique across various orders of the Menger sponge.

Keywords: Menger sponge; Effective properties; Fractal shapes; Piezoceramic menger sponge; Hierarchical structures.

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Submission ID: 183

Effect of Light and Heavy Fluid Loading on the Vibroacoustic Behaviors of Viscoelastic Composite Core Sandwich Panel

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ABSTRACT

The paper describes about the vibroacoustic behavior of fiber reinforced viscoelastic composite core sandwich panel. A coupled structural acoustics analysis is carried out in FEM domain to obtain the Sound power level (SPL) of the sandwich panel backed by a rectangular acoustic cavity. The Vibroacoustic response is studied under the influence of light and heavy fluid medium like air and water. A harmonic analysis is carried out to obtain forced response under influence of mechanical load. Effect of damping and modal loss factor on the peaks of the SPL curve is studied by using fiber reinforced viscoelastic composite core. The effects of the light and heavy fluid on the sound radiation capabilities of the damped sandwich panel is also studied. Various parametric studies are carried out in terms of fiber stacking sequence and thickness of different layers of the sandwich panel to minimize the SPL in a broad frequency range.

Keywords: Sandwich plate; Vibroacoustic; Viscoelastic composite; Finite element.

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Submission ID: 185

Comparative Finite Element Analysis of CoCr and CFR-PEEK Tibial Implant for Total Ankle Replacement

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ABSTRACT

CoCr metal alloy is traditionally used as an implant material for total ankle replacement (TAR). The Young's modulus of CoCr is very high when com-pared with the tibia bone which contributes to stress shielding. Stress shielding serves as a trigger for the resorption of the bone owing to bone remodelling and subsequently implant failure. These problems can be addressed by using a material whose Young's modulus is comparable to the bone. Therefore, the composite CFR-PEEK can serve as a promising alternative implant material. The current study aims to compare the biomechanical performance of CoCr and CFR-PEEK tibial implants for TAR based on stress shielding and implant-bone micromotion. The finite element (FE) models that were used for analysis, represented the intact tibia bone, the implanted tibia bone with CoCr, and the implanted tibia bone with CFR-PEEK. The proximal part of the tibia was fully constrained. The load of 937.5 N was applied distally to represent the neutral loading condition during normal walking. The results showed that stress in CoCr model was very low in comparison to the intact bone. Whereas, in CFR-PEEK model stress in the tibia bone was much higher than CoCr model. Therefore, stress shielding will be lesser for CFR-PEEK model. Implant-bone micromotion of CFR-PEEK was higher than the CoCr model. Nonetheless, micromotion was within the permissible limit of 50 μm. Therefore, it can be concluded that considering both the stress shielding and implant-bone micromotion CFR-PEEK is a good alternative implant material for TAR.

Keywords: Total ankle replacement; Tibial implant; Implant material; CoCr; CFR-PEEK.

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Submission ID: 186

Design & Analysis of Piezoelectric Energy Harvester for the Cochlear Implant

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ABSTRACT

The current cochlear implant is bulkier and has several external com-ponents, such as a microphone, a speech processor, and a transmitter, which are not aesthetically appealing for the user. They are battery operated, which forces the user to undergo surgery after their expiration, and battery disposal poses an environmental threat. Piezoelectric energy harvesting offers a promising solution to convert ambient mechanical vibration into electrical energy. This work focuses on a microelectromechanical system (MEMS) based cantilever piezoelectric energy harvester to utilise the ear drum vibrations for the cochlear implant. The proposed MEMS-based design integrates the arrays of the cantilever beams, each embedded with piezoelectric material and a tip mass, to effectively capture and convert the ear drum vibrations into an electrical signal. A novel energy harvester is designed with biocompatible material as the piezoelectric material. The de-signed energy harvester can be easily placed on the ear drum. The proposed energy harvester mimics the natural operation of the cochlea by eliminating the use of a microphone, speech processor, transmitter, etc.

Keywords: Piezoelectric energy harvesting; Cochlear implant; Finite element method; MEMS; Multi frequency.

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Submission ID: 187

Finite Element Modelling of Re-entrant Honeycomb Auxetic Metamaterial and to Find its Effective In-plane Properties

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ABSTRACT

Auxetic metamaterial, owing to its unnatural properties such as negative Poisson's ratio, garnered the researcher's attention. It finds its application in various fields like protective gear, impact absorption, flexible electronics, smart fabrics, acoustic and vibration damping, biomedical implants, and lightweight structural materials. The current study conducts a comprehensive investigation of re-entrant honeycomb auxetic structures, because of the complex geometry of auxetic metamaterial, the inherent property of the material is not sufficient enough to predict the response. Effective in-plane properties, i.e. (E_1, E_2, G_{12}, v_{12}, v_{21}) are required to be evaluated based on the orientation of geometry. In this research paper, the finite element method has been used to predict the effective properties of auxetic metamaterial. The unit cell is considered, and it has been modeled using a beam element. Periodic boundary conditions have been considered to predict the effective properties. Further, the finite element method is used to predict the structure's response under a given boundary condition. Numerical results have been validated with existing literature.

Keywords: Re-entrant honeycomb; Auxetic structure; Effective material properties; Finite element method; Metamaterial.

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Submission ID: 188

Buckling and Free Vibration of Nonuniformly Heated Functionally Graded Polymer Composite Plates Reinforced with Graphene Nanoplatelets

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ABSTRACT

Using a finite element method, the free vibration and buckling behavior of functionally graded polymer composite plates enhanced with nanoplatelets of graphene under nonuniform temperature fields was studied with (graphene platelets) GPLs evenly distributed throughout the polymer matrix in every layer, the weight fraction of GPL nanofillers varies layer-by-layer along the thickness direction. The modified Halpin Tsai model is used to compute the effective Young's modulus for each layer and its distribution type, and the rule of mixing is used to get the mass density and Poisson's ratio. The impacts of boundary conditions, GPL distribution patterns, % weight fraction of GPL, Thermal buckling induced by nonuniform thermal loading, and the heated plate's free vibration behavior are all examined in depth using parametric research. The critical buckling temperature (CBT) of the plates is shown to be impacted by temperature fields & functional grading.

Keywords: Graphene nanoplatelets; FGM; Temperature field(nonuniform); Thermal buckling.

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Submission ID: 189

Video motion amplification technique for structural health monitoring for concrete bridge structures

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ABSTRACT

Health monitoring is essential to ensure structural safety and integrity. Vibration-based health monitoring techniques are very popular these days to identify damage in a structure through frequency analysis. Video-based health monitoring could be a game changer or revolutionary in the realm of health monitoring that can replace traditional damage detection approaches that utilize sensor data which is expensive and time-consuming. Video motion amplification is a state-of-the-art technique that can capture subtle vibrations through a high-speed camera. It is based on the concept that some signal information is hidden, unseen to the normal eye, and captured through high FPS video recordings that can be extracted using signal processing. Further, that information can be used for damage detection and health monitoring. A concrete bridge structure is chosen as a case study for the current analysis.

Keywords: Concrete; Health monitoring; Concrete bridge; Video motion amplification.

Submission ID: 191

Uncertainty Quantification of a Concrete Gravity Dam using Polynomial Chaos Expansion

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ABSTRACT

The failure of a large dam may pose severe risks to human lives and substantial economic impacts. The complex behavior of dams is influenced by diverse uncertainties, including variations in material properties, environmental dynamics and operational factors which collectively impact their performance and safety. This study investigates the uncertainty associated with structural material in concrete dams using Polynomial Chaos Expansion (PCE) by focusing on key material properties with assigned probability distributions reflecting real-world variability to understand their influence on dam performance. Through PCE, uncertainty propagation is efficiently managed, enabling the characterization of structural response. The findings offer insights into the complex interplay between uncertain material properties and dam safety, facilitating informed decision-making for risk management and resilience enhancement. By quantifying uncertainties and assessing their impact on structural performance, this research contributes to the development of methodologies for optimizing maintenance strategies and improving the long-term performance of concrete dams.

Keywords: Concrete dams; Uncertainty quantification; Material uncertainty; Polynomial chaos expansion.

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Submission ID: 197

Load Carrying Capacity of Repaired Al7075-T6 Alloy through Carbon Fiber Reinforced Epoxy Patch

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ABSTRACT

Cracks in the structures can lead to catastrophic failures; for this rea-son, arresting the crack is extremely important. The present research focuses on enhancing the load carrying capacity (LCC) of cracked Al7075-T6 alloy specimens using a composite patch repair technique. A unidirectional carbon-fiber-reinforced epoxy (CFRP) patch was used to repair the cracked aluminum alloy. Uniaxial tensile tests on flat dog bone specimens of aluminum alloy (Al7075-T6) with notch, fatigue pre-crack, and patch were conducted to determine their LCC. The LCC of the repaired specimen improved by 18.4% compared to the cracked specimen. A kink was observed in the load versus displacement curve, indicating the crack arrest. Patch thickness was varied to determine the effect of patch thick-ness on

LCC. The patch thickness doesn't affect the LCC significantly. As the thickness of the patch decreased, LCC increased slightly. After the test, it was observed that the failure was entirely due to adhesive failure, and the patch remained undamaged. Fractographic analysis was carried out using scanning electron microscopy (SEM) to investigate crack formation and observe the material's response to static loading. Notably, the patch did not influence the characteristics of the fractured surfaces, yielding consistent surface impressions.

Keywords: Crack; Repair techniques; Uniaxial tensile loading; Composite patch; Fractography.

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Submission ID: 200

Study Of Mode-I Interlaminar Fracture Toughness in Triaxial Braided Composites

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ABSTRACT

The delamination characterization in composite laminates has conventionally in-volved the assessment of the critical strain energy release rate, al so known as fracture toughness, through double cantilever beam (DCB) experiments. This work aims to determine the mode I fracture toughness of triaxial braided composite (TBC) specimen without and with addition of Graphene nanoplatelets (GNP). The TBC specimens were produced from glass fiber braided preforms and epoxy resin and 0.5 wt% GNP using vacuum bagging technique. The Glass fiber preforms are braided at [0 / ± 45°] braid angle on a vertical maypole braiding machine. Results indicate an increase of 27% in the mode I interlaminar fracture toughness due to the addition of GNP owing to the interaction of nanoparticles, fiber and matrix. Also, braided composites have shown better performance in terms of fracture toughness when com-pared to other unidirectional or woven reinforcements.

Keywords: Triaxial braided composite; Graphene nanoplatelets; Fracture toughness; Crack growth.

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Submission ID: 204

Model Assisted Non-Destructive Evaluation of Defects Using Terahertz Time Domain Analysis

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ABSTRACT

Current and future detectors for high-energy particle physics like those at Large Hadron Collider (CERN) and EIC at Brookhaven National Lab pose high demands for the structural materials in a high-radiation environment where the accumulated radiation dose leads to defects like voids and cracks due to de-gassing and thermal cycling in the polymeric composite materials. In this work, terahertz time-domain spectroscopy (THz-TDS) is used for strain mapping of a polydimethylsiloxane (PDMS) doped with passive highly dielectrostictive strontium titanate (STO). A polarization polarization-dependent analytical model for the correlation of volumetric strain to the measured change in time of arrival for a THz pulse is developed. The model consists of effects due to changes in the dielectrostrictive properties of the composite due to changes in STO particle density and the change in thickness of the sample upon application of strain due to Poisson's effects. The stress relaxation behavior of the composite is studied to avoid change in strain during the measurement window. The analytical model is validated with results using an open hole tensile and a circular edge notch specimen. The THz strain mapping results are compared with a scale-dependent finite element model (FEM) and surface strain measurement using the digital image correlation (DIC) method. The experimental results show sensitivity to material features like particle clumping and edge effects. THz strain map shows good agreement with FEM and DIC results proving the applicability of this technique for surface and sub-surface strain mapping in polymeric composites. The experimental results for THz-TDS-based volumetric strain maps agree with the results from DIC surface measurements as well as predictions using finite element models. This forms a robust analytical approach for the development of stress mapping and fracture front mapping in multilayer composites. The model inefficiencies at lower strain levels can be understood and mitigated by having better THz sensors and improving the signal-to-noise ratio.

Keywords: Finite element method; THX-TDS; non-destructive evaluation; Data Science.

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Submission ID: 205

Design and Development of Self-Deployable Composite Structures Using Kevlar Fibre Reinforcement Plastic

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ABSTRACT

The exponential growth of small satellite usage for space applications requires self-deployable systems to be highly storable without compromising the mechanical and functional requirements under deployed conditions. The scope of this paper is to highlight the design, development and realization

aspect of self-deployable composite boom. Composite boom consist of thin walled structure with high strain energy storage capability. Boom has closed cross-section to increase the stiffness by its geometry and at same time to add the flexibility in the structure, a flexure is introduced by providing a mechanical slit at the centre of the boom. Several iterations have been carried out for selection of the material, layup sequence and geometry optimization. To meet the requirement of folding and unfolding behaviour Kevlar Fibre Reinforced Plastic (KFRP) material is used and a slit is optimized for realization of the composite booms. Subtended angle of the slit at the centre of the boom is also optimized. Design iterations are also worked out to optimize the layup sequence of the KFRP laminae w.r.t axis of the boom. Length of the slit has also played significant role in folding and unfolding of the boom.

Keywords: Self deployable; KFRP; Strain energy; Folding; Boom.

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Submission ID: 207

Effect of degradative environments on the performance of fire proximity clothing

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ABSTRACT

Fire fighters frequently wear fire proximity clothing to shield themselves from high heat fluxes especially radiant heat. This proximity clothing is an ensemble of several layers with the outer layer being a laminate of Aluminized Polyethylene terephthalate (Al-PET) film with a flame-resistant fabric, the later usually being a glass or aramid fabric. The primary role of this outer layer is to reflect the radiant component associated with the fire. A common concern revolves around the degradation of the performance of these suits over time with repeated usage, exposure to flames or other factors. This study investigated the effect of these parameters, particularly abrasion and folding operations, repeated radiant and convective exposures, as well as soot deposition on the thermal and radiant protective capabilities of these proximity ensembles. Our studies clearly indicated that repeated short duration exposures to radiant heat does not have any adverse effect on the protective performance of the suit, however the Radiant Protection Performance (RPP) values reduced drastically from 41s for unabraded laminate to 26s (after 300 abrasion cycles) further to 17s (after 500 cycles) and finally to 9s (chemical abrasion). This essentially means that highly abraded samples do not meet the mandatory criteria (RPP $\geq$ 20s) as per NFPA 1971. Similarly, folding operations during storage led to a reduction in the RPP value to 19s. Interestingly, the maximum reduction in protection levels was observed in samples contaminated with carbonaceous soot, which exhibited an RPP of 7s. Our findings address longstanding enquiries regarding the lifespan of aluminized suits. Consequently, our study highlighted the importance of implementing effective cleaning practices not only to minimize potential exposure to smoke contaminants but also to mitigate other performance related concerns.

Keywords: Fire proximity suit; Reflective; Outer shell; Aluminized PET; Heat flux.

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Submission ID: 208

Enhancing Mechanical Properties of Polyethylene-based Nanocomposites Through Graphene Oxide: A Molecular Dynamics-based Study

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ABSTRACT

Polyethylene is a widely used polymer that has garnered substantial attention in various industrial applications. However, their inherent limitation, such as modest mechanical strength, has prompted extensive research efforts to improve their overall performance. In this work, we used detailed molecular dynamics (MD) simulations in conjunction with a reactive force field (ReaxFF) to systematically analyze the mechanical properties of polyethylene (PE), as well as its graphene oxide (GO)-based nanocomposites. Herein, we varied not only the weight percentage of the nanofiller but also the extent of functionalization of OH and O groups in the GO. We found that the addition of GO can improve the tensile strength of polyethylene-based nanocomposites. In addition, we also found the optimal level of functionalization of GO nanofiller to be 50% at 4 wt. % of loading in PE, which is a hydrophobic polymer. This finding indicates that hydrophilic polymers need less anchoring OH groups in the filler, as they have anchoring OH groups within the polymer themselves. Overall, these improvements in the tensile strength of polyethylene will help the industries' fertility to develop better products with higher mechanical strength.

Keywords: Polyethylene; Graphene oxide; Nanocomposites; Molecular dynamics; Mechanical strength.

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Submission ID: 212

Free vibration characteristics of FG beams using finite element analysis

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ABSTRACT

The current research focuses on free vibration characteristics of FG beams using finite element analysis. By applying power law function, the beam has been graded in the axis of thickness. The properties of an effective material of FG beams were determined by employing rule of mixture. A

governing equation depending on Timoshenko beam theory has been derived utilizing the variational principle. Numerical results in terms of natural frequency have been determined using finite element methods. The validation and convergence investigations were carried out to emphasize efficiency as well as the performance of the current suggested model. In the current study cantilever boundary condition has been used. The natural frequency variation for different power indexes (n) has been examined.

Keywords: Finite element analysis; FG beam; Timoshenko beam theory; vibration analysis.

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Submission ID: 213

Structural Analysis of an Ornithopter Wing

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ABSTRACT

An Ornithopter is an aircraft that flies by flapping its wings and de-signers in their attempt seek to imitate the flapping wing flight of birds, bats, and insects. The shape and strength of Ornithopter wings play a vital role in the development of bio inspired flight. This study explores the use of Finite Element Analysis (FEA) for the structural integrity of an Ornithopter wing. It has attempted to evaluate the behavior of the wings under operational conditions by analyzing stress, strain and the displacement of the wing. The results showed the varying distributions of stress, strain and the displacements across the length of the wing. The wing tip, which experiences the least aerodynamic forces, had the lowest strain values of 7.069 x 10-8, while the wing attachment point, where structural integrity is most important, had the highest strain value of 0.00083. The stress study showed a maximum stress of 165.9 MPa at a fixed location of wing, whilst the tip had a low stress of 0.000166 MPa. The displacement analysis revealed a maximum displacement of 46.229 mm at the tip.

Keywords: Ornithopter wing; Structural analysis; Finite element analysis (FEA); Stress; Bio-inspired flight.

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Submission ID: 221

Analysis of Two-Stage Helical Gearbox for All Terrain Vehicle

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ABSTRACT

The main purpose of this paper is to confirm the structural soundness of a two-stage helical gearbox used in BAJA all terrain vehicle (ATV). The gearbox utilizes two consecutive helical gear stages to transmit power from an input shaft to an output shaft. Gearbox provides speed and torque conversions from the engine to the wheels. Gearbox is the main component in the transmission by which speed of the vehicle is controlled and provide the required amount of torque. In this paper CAD software was used to create a three-dimensional model of the transmission system and Finite Element Analysis (FEA) was performed to predict the distribution of stress, deformation and strain in gearbox components such as gears, shafts, bearings and housing. The results of FEA provide valuable insights into the performance potential and structural behavior of the two-stage helical gearbox.

Keywords: All terrain vehicle (ATV); Helical gearbox; Finite element analysis (FEA); SAE BAJA.

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Submission ID: 222

Enhancing the Performance of Injection Moulding Machining Process by using the RSM Techniques

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ABSTRACT

The injection moulding process is sustainable to fabricate the plastic product. The accurate part with good dimensional accuracy can also be produced. The present work is focuses on to analysis the tensile strength of the fabricated specimens by injection moulding process. The input factors such as temperature, packing pressure and injection pressure has selected. A dumbbell shaped specimen has been fabricated and tensile test id performed on the developed specimen to identify the optimum condition. The response surface methodology is adopted to perform the experiments. Also, analysis of variance is used for selection of significant parameters. It was concluded that response surface methodology indicates that melt temperature, packing pressure and injection pressure influence tensile strength by 98.47%, 0.14%, 0.06%. respectively.

Keywords: Injection moulding; Response surface methodology; Ultimate strength; Polymer.

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Submission ID: 225

4D printing using active composite materials

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ABSTRACT

Our approach focuses on printing composite polymers in three-dimensional (3D) architectures with great precision, which can be immediately heated to change their configuration into a new permanent one quickly. When a composite consisting of a glassy shape memory polymer and an elastomer that is programmed with an integrated compressive strain during photo-polymerization is designed, the printed shape of the component is heated and its permanent shape is determined by this process. The object can change into a new, permanent shape that can be reprogrammed into several more shapes when the shape memory polymer relaxes and releases the limitations on the stretched elastomer upon heating. Our primary innovation, the significantly streamlined process of generating intricate 3D reprogrammable structures at high resolution, holds great potential for a wide range of uses in consumer goods, aerospace, medical technology, and other fields. It may even usher in a new era in product design, wherein components are concurrently engineered to exist in multiple configurations while in use.

Keywords: Composite polymer; Shape memory polymer; Reprogrammable structures; 4D printing.

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Submission ID: 227

A Systematic Review of the utilization of various Machine Learning Models to Predict the Compressive Strength

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ABSTRACT

Concrete is a simple, versatile, and powerful building material made of cement, coarse aggregates, and water and others. The manufactured concrete is frequently used in construction practices due to its strength, affordability, and adaptability to different forms. Machine learning (ML), a subfield of artificial intelligence, gives computers the ability to identify patterns in data and draw conclusions without the need for explicit programming. With applications ranging from recommendation systems to the prediction of compressive strength of concrete, ML fosters innovation across many industries including construction sector as it saves the resources and efforts in the laboratory testing. ML

algorithms use a range of parameters, such as component proportions, curing days, and types of aggregate, to predict the compressive strength of concrete. By examining enormous datasets for patterns and correlations that aid in optimizing concrete mix designs for greater strength and longevity, these algorithms revolutionize the building process. Compressive strength is the important output parameter which is taken as per many studies in which various waste materials are used such as fly ash, ground blast furnace slag, sugarcane bagasse ash and others. Furthermore, various ML models K-Nearest Neighbors (KNN), Extra Tree Regressor (ETR), Bagging Regressor (BR), AdaBoost Regressor (AR), Extreme Gradient Boosting (XGB) and others have been used to examine the compressive strength of concrete. The current study aims to provide the essential information that is required to carry out a similar approach for the other pozzolanic materials. Furthermore, the details about the input parameters, and evaluation parameters have also been presented to provide an overview of the cost-effective and effortless method of determining the strength.

Keywords: Compressive strength; Machine learning; Waste; Strength; Algorithm.

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Submission ID: 228

Topology Optimization in Additive Manufacturing in the context of Industry 4.0

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ABSTRACT

This research explores how adding a smart design idea called "topology optimization" to 3D printing can boost Industry 4.0. This work looks at how this robust concept works with 3D printing, making parts stronger and lighter by using materials more wisely. Four parts are manufactured with different composite materials and manufacturability is assessed after topology optimization. Manufacturability assessment is performed on the basis of material required, cost and manufacturing time. The article discusses real-world examples, challenges, and exciting possibilities, aiming to give a clear picture of how topology optimization is shaping the future of product design and manufacturing in order to gain sustainability and manufacturability in Additive Manufacturing.

Keywords: Smart manufacturing; Industry 4.0; Additive manufacturing; Topology optimization; 3D printing.

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Submission ID: 230

Design and Analysis of an Epicyclic Gear Train for Formula Student Electric Drivetrain

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ABSTRACT

The research paper focuses on design and analysis of epicyclic gear train for a formula student electric drivetrain. Epicyclic gear trains provide a wide variety of gear ratios within a compact size. Due to its load distribution, it reduces the wear and increases durability of the system. The dimensions of the gears were finalized using the standard gear design process followed by the designing of the CAD model and finite element analysis of all the components. The mountings and bearings were designed using standard design procedures, along with complete assembly.

Keywords: Epicyclic gear train; Gear design; Formula student electric drivetrain; Static structural analysis.; Finite element analysis (FEA).

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Submission ID: 231

Design and Analysis of Differential Bar of a Rover

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ABSTRACT

In this paper, the analysis of differential bar has been performed for the rocker bogie mechanism-based rover to improve the manoeuvrability and its overall stability. The purpose of this differential bar was to increase the stability on rough terrains, increase traction by maximising the grip and avoid wheel slippage. The analysis was performed by considering five materials for the differential bar, viz., Aluminium 6061 T6, Aluminium Alloy, Ti-6Al-4V Titanium alloy, Stainless steel 316 annealed and Carbon Fibre. Solid modelling software was used to design the 3D CAD model of the differential bar and Finite Element Analysis was performed to optimize the performance of the differential bar. It was found that Ti-6Al-4V Titanium alloy was suitable material for the rover.

Keywords: Total deformation; Wheel load; Von-Mises Stress; Equivalent strain; FEA.

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Submission ID: 233

Thermal and Stress Analysis of Piston and Connecting Rod for Engine Seizure Condition

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ABSTRACT

Pistons in Spark Ignition (SI) engines shoulder the demanding task of navigating the dynamic environment created by combustion. At the core of their function lies the need for pistons to withstand substantial thermal stresses. During the power stroke, combustion induces elevated temperatures, probing the limits of piston materials. Central to the functioning of SI engines is the force exerted on the piston during the power stroke. Rapid expansion of combustion gases subjects the piston to significant pressures, influencing its structural integrity. Temperature rise, inherent to combustion, adds another layer of complexity to piston behavior. The current research scrutinizes the interplay between high temperatures and the pressure acting on the connecting rod of the piston. In essence, this study focuses on the effects of the high temperature faced by pistons in SI engines, emphasizing their resilience against thermal stresses and pressure forces. In this paper, through analytical calculations and Finite Element Analysis (FEA) simulations, the nuanced dynamics governing piston performance during a seizure of an engine have been indicated.

Keywords: Finite element analysis (FEA); Piston head; Connecting rod; SI Engines; Engine seizure.

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Submission ID: 234

Sustainable Composite Manufacturing: Analyzing Toray Industries Inc.'s ESG Framework and Operational Efficiency Strategies

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ABSTRACT

This study offers a comprehensive assessment of Toray Industries Inc.'s performance in environmental, social, and governance (ESG) domains, utilizing established frameworks such as the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB). The analysis utilizes Bloomberg data to assess Toray's performance metrics, including greenhouse gas emission reductions, workplace safety enhancements, and governance diversity improvements. Toray's sustained investment in research and development (R&D) reflects its dedication to innovation and competitiveness, as evidenced by financial and personnel metrics. Key findings highlight Toray's progress, such as reduced

greenhouse gas intensity and enhanced governance diversity, demonstrating a proactive stance on sustainability and social responsibility essential for long-term value creation and stakeholder engagement. This study underscores sustainability's significance in manufacturing and advocates for recommended strategies to drive enduring value creation and contribute to a sustainable future.

Keywords: Environmental sustainability; social responsibility; governance practices; ESG framework; GRI.

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Submission ID: 235

Simulation of Circumferential Semi Elliptical Part-through Crack in Bi-Material Pipe using Extended Finite Element Method

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ABSTRACT

Fracture analysis of crack is very essential to ensure the reliability and avoid the catastrophic failure of engineering components and structures since most of the failures start from the crack which leads to loss of life and economy. In the present study, extended finite element method (XFEM) is used to simulate the circumferential surface crack in bi-material pipe. XFEM is a numerical method developed for modelling the discontinuities without remeshing and mesh refinement. Standard displacement based approximation function is enriched near crack (discontinuities) through partition of unity method. Bi-material consists of two dissimilar materials with distinct properties. In this study, bi-material pipe consists of inner pipe made of steel alloy and outer pipe made of ceramic. A circumferential semi elliptical part through crack at different location is used for 3D linear elastic fracture mechanics (LEFM) analysis of bi-material pipe. Bi-material pipe is subjected to internal pressure and stress intensity factor (SIF) is computed at different location of crack front of semi elliptical surface crack using virtual domain extension approach.

Keywords: 3D fracture mechanics; Bi-material pipe; Crack, Stress intensity factor, XFEM.

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Submission ID: 238

Mechanical behaviour of 3D printed fiber-reinforced soft functional hydrogel composite: A finite element study

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ABSTRACT

The development of Biomimetic micro/nanocellulose based hydrogel composite structures have been made through various techniques for biomedical, soft robotics and energy storage applications. Owing to the unique native properties of cellulose such as biocompatibility, biodegradability and excellent mechanical properties, it offers new strategies for the design of environment-friendly and cost-effective and high mechanical performance composite 3D printed composite hydrogel. Herein, we proposed the fabrication of nature-inspired 3D printed cellulose nanofibers(CNF) based anisotropic functional fibre reinforced hydrogel composite structure and performed its physical and mechanical characterisations. In this work, we proposed to develop 3D-printed multilayered Polyacrylamide (PAAM)/ Alginate (Alg) hydrogel based CNF reinforced mechanically robust functional composite hydrogel structures. In this brief study, our primary focus is to perform finite element (FE) models via implementing measured experimental material properties to explore the CNF reinforcement mechanism in the hydrogel composite structures. The FE modelling is based on an idealised anisotropic hyperelastic model was used to analyse the pre-programmed anisotropic functional composite structure with the computer simulations. It is shown how the improved mechanical and physical properties of the hydrogel fiber reinforced composite printed scaffold can be programmed by varying cellulose fibers/fibrils orientation and matrix compliance, making it suitable for load bearing biomedical applications. We propose that the computational study of the nature-inspired 3D printed helicoidally layup construct based on PAAM/Alg/CNF composite, which offered appreciable stretchability and enhanced anisotropic mechanical properties. It will assist development of more effective composite structure, offering new perspectives for potential application in tissue engineering.

Keywords: Biomimetic, Anisotropic composite; FE modelling; 3D printing

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Submission ID: 246

Intelligent Manufacturing in the Tennessee Eastman Process through Statistical Ranking Model

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ABSTRACT

The most universally acknowledged benchmark for augmentation of effectiveness for chemical process control is the Tennessee Eastman process. Such is its versatility that it has been widely utilized as the threshold for development of numerous fault detection methods that can boost efficiency while simultaneously establishing operational safety. Thus, through this research excursion, we propose a further developed and novel approach towards fault detection through advanced statistical analysis, the Statistical Rank-Based Model for Fault Detection (SRBM-FD). Rather than simply relying on the fundamental accuracy of various Machine Learning and Deep Learning algorithms, the SRBM-FD intends to introduce astuteness in the feature selection process. This is done through a comprehensive ranking framework based on the combined potency of Correlation Ratios (Eta correlation), Spearman and Point-Biserial correlations. The additional focus on the relevance of specific features to fault detection, one is able to streamline the process and in turn, enhance its effectiveness. Through rigorous experimentation and regular comparison with orthodox fault detection methods, we have been able to conceive a more thorough and cohesive process in the form of the SRBM-FD. The versatile and

ubiquitous nature of the SRBM-FD model underscores its potential for use in fault detection across numerous industrial processes that can essentially enhance efficiency and improve operational safety.

Keywords: Intelligent manufacturing; TEP; FDD; SVM; LSTM.

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Submission ID: 250

Static Analysis of Composite and Sandwich Spherical Shells using A Four-Node Flat Shell Quadrilateral Finite Element

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ABSTRACT

This study introduces a static analysis of laminated composite and sandwich spherical shell panels using a novel two-dimensional facet-shell finite element. This element combines the characteristics of plate bending and mem-brane elements, and is based on the zigzag theory, further it is developed by using the discrete Kirchhoff quadrilateral element previously developed by first co-author for analyzing composite plates. The incorporation of a transformation matrix is crucial for transforming local actions and displacements into global actions and displacements. This element, notable for its inclusion of two fictitious degrees of freedom (DOF), supports nine local and nine global DOF per node, effectively bypassing issues associated with ill-conditioned stiffness matrices. The efficacy of this element is verified through rigorous comparisons with existing analytical, 3D elasticity solutions from the literature. It is tested under various boundary conditions, material types, and geometrical configurations, demonstrating robust and accurate performance in evaluating moderately thick and thick spherical shell panels.

Keywords: Composite and sandwich; Zigzag theory, Quadrilateral element; Static analysis.

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Submission ID: 251

Aerodynamic Performance Analysis of a Three-Bladed Vertical Axis Wind Turbine using Composite and Sandwich Materials

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ABSTRACT

This study explores the aerodynamic behavior of a three-bladed vertical axis wind turbine (VAWT) constructed from various configurations of composite and sandwich materials. Employing computational fluid dynamics (CFD) simulations and free vibration structural analysis, the research assesses complex sandwich structure layups including three-layer (45°/C/45°), five-layer (0°/45°/C/45°/0°), and eleven-layer (0°/45°/0°/C/0°/45°/0°/C/0°/45°/0°) configurations. The Fluent software suite resolves the unsteady Navier-Stokes equations using the finite volume method and the SST k-ω turbulence model. The results from CFD and free vibration analyses are synthesized to identify the most effective material configurations and blade designs, optimizing the turbine's performance across various operating conditions.

Keywords: Composite and sandwich; vertical axis wind turbine; computational fluid dynamics; wind tunnel.

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Submission ID: 254

Experimental Investigation and Optimization of Gear Oil for Different Varying Concentration of Graphene Nanoparticles as additive

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ABSTRACT

In present research work, examine the tribological properties of EP gear oil by using graphene nanoparticles (GNP) as additives. All experimental tests were carried out under different concentrations of GNP in lubricating gear oil and load. The wear and friction tests were examined using FOUR BALL TRIBOTESTER- TR 30 L machine. This research work shows that addition of GNP in gear oil with proper concentration significantly minimises the wear and friction. So, improves the tribological properties of gear oil. The dispersedly study of graphene nanoparticles (GNP) in gear oil using Image Acquisition System-IAS sure that graphene nanoparticles show's good solubility and stability in the lubricant and behaves better tribological properties of the gear oil.

Keywords: Tribology; Nanomaterials; Lubrication additives; Wear; Four ball tribotester.

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Submission ID: 256

Polymer based Bilayer Electrospun Scaffold with Enhanced Surface Properties for Skin Tissue Engineering Application

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ABSTRACT

Electrospinning with controlled parameters produces a nanofibrous scaffold that mimics the extracellular matrix, and this technique is currently generating significant interest in developing innovative wound dressing materials suitable for the treatment of both acute and chronic wounds [1]. It's worth noting that while the concept of a bilayer electrospun scaffold for wound healing is promising, research is ongoing in this field, and challenges related to biocompatibility, degradation, and long-term effectiveness need to be thoroughly addressed before widespread clinical applications [2]. Despite the growing interest and potential of bilayer electrospun scaffolds for wound healing applications, there remains a significant gap in this area in terms of long-term biocompatibility, and mechanical stability of the material, and optimal design parameters. Our present work is useful to bridge this gap and establish the feasibility of these scaffolds as effective and reliable solutions for enhancing wound healing processes. In this work, we developed the bilayer electrospun polycaprolactone (PCL) scaffold coated with polyvinyl alcohol (PVA) for wound healing applications. The highly hydrophilic PVA was decorated with the metal-organic framework (MOF), for enhancing the surface properties for cell adhesion. The MOF also function as a nanocarrier for an antimicrobial agent, cephalexin. Physicochemical analysis (XPS, FTIR, SEM, contact angle) confirms the successful coating of PVA on the PCL scaffold. The novelty of this work lies in developing a bilayer electrospun scaffold for skin tissue engineering that combines distinct bioactive agents and structural properties in a single construct. This innovative approach holds the potential to provide enhanced control over wound microenvironments, leading to improved healing outcomes compared to conventional wound dressings.

Keywords: Electrospinning; Polymer; Antimicrobial agent; Skin tissue engineering; Cell adhesion.

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Submission ID: 258

Creating State-of-the-Art Thin Film Nanocomposite Membranes through Cutting-Edge Vapor Phase Interfacial Polymerization for Effective Separation Solutions

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ABSTRACT

In the past decade, significant research efforts have been devoted to the exploration of polymeric membranes, particularly in their application within various industrial gas separation contexts [1,2]. The membrane gas separation has emerged as a widely acknowledged cost-effective approach for producing moderately pure gas streams. The pursuit of economical and environmentally friendly methods for membrane development is of paramount importance in today's landscape. Our work

introduces a pioneering technique: vapor phase interfacial polymerization (VPIP) for the creation of Thin Film Nanocomposite (TFN) membranes, aiming to address challenges in gas and water purification. Notably, nanoparticles play a crucial role in enhancing TFN membranes, seamlessly integrating into both the substrate and top thin layers via interfacial polymerization. The versatility of polymer membranes extends across a spectrum of applications, encompassing water desalination, gas separation, enantiomer separation, flue gas dehydration, and wastewater treatment [1-6]. Our research specifically focuses on TFN membrane development, employing hollow fiber membranes for gas separation and flat sheet substrates for water purification. The TFN selective layer was meticulously applied onto the surface of polysulfone membranes. Significantly, our study yielded compelling results in binary mixture gas separation, particularly in the cases of water vapor/N2 and CO2/CH4. TFN membranes incorporating APTMSH demonstrated notably improved gas permeance and selectivity. Thorough characterization employing various physicochemical techniques confirmed that the addition of APTMSH in the MPD solution, up to 0.5 w/w%, resulted in the highest water vapor permeance (2490 GPU), CO2 permeance (24.3 GPU), as well as remarkable water vapor/N2 selectivity (730) and CO2/CH4 selectivity (41.8), all achieved through APTMSH@TFN membrane. Furthermore, the membranes developed effectively removed contaminants from water, achieving an impressive rejection rate of approximately 99% for heavy metal ions and a pure water flux of 55 LMH. Notably, the incorporation of nanofillers in the VPIP process significantly enhanced the performance of TFN membranes.

Keywords: Vapor phase interfacial polymerization; Thin Film Nanocomposite (TFN) membranes; Gas and Liquid Separation.

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Submission ID: 259

Statistics of Local Fields in Hyperelastic Composites using Full-Field Homogenization

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ABSTRACT

Digital twin of design and manufacturing process of reinforced elastomeric matrices are crucial for evaluating the mechanical behavior of structural component such as tires and soft biological tissues \cite{Kalidindi2022}. This study focuses on investigating an elastomeric matrix reinforced with mica and carbon black spherical particles. It aims to chart the mean as well as statistical variation of local field quantities such as Cauchy deviatoric stress, and deviatoric strain energy. These parameters provide valuable insights on modelling damage and fracture phenomena occurring at both local and global scale of the composite structure. The hyperelastic matrix is modeled with the Saint Venant-Kirchhoff and Neo-Hookean (NH) models, while the inclusions are treated as linear elastic. It enables to investigate geometric as well as material nonlinearity {Geers2017}. A random microstructure is generated using the random sequential adsorption algorithm. Developed representative volume element (RVE) is simulated in finite element (FE) framework by applying periodic boundary conditions {Albiez2019FiniteES}. Hybrid elements are employed in FE simulations to prevent numerical instabilities occurring due to incompressible nature of hyperelastic materials. Figure 1(a) shows the distribution of von Mises stress (σ_{mises}) within the RVE, along with the statistical variation of the same Figure 1(b). Figure 1(c) shows the effective stress and strain curve which aids in

estimating effective material properties.

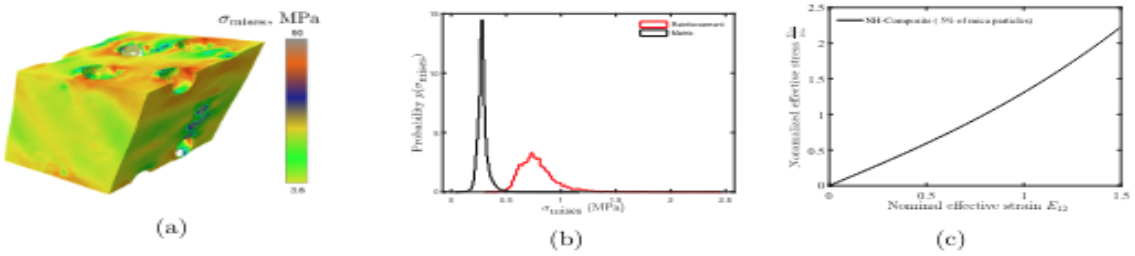

Figure 1: (a) Local exact distribution of σ_{mises} in matrix domain (b) Statistical variation of σ_{mises} in matrix and reinforcement domain (c) Effective stress-strain response of hyperelastic(NH) composite.

Keywords: Hyperelastic; Full-field homogenization; Periodic boundary conditions.

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Submission ID: 271

High Strain Rate Testing and Simulation of 3D-Printed Carbon Fibre Composites

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ABSTRACT

The mechanical properties of 3D-printed composites are crucial for FEA simulations and analyses of high-speed impact, crashworthiness, shock and blast mitigations. In these simulations, quasi-static properties are insufficient to accurately predict the results, as these materials are subjected to large deformations and have different sensitivities to strain rates. Therefore, the present study focused on per-forming dynamic testing at high strain rates on 3D-printed composites fabricated using continuous carbon fibre reinforced with nylon-based ONYX matrix. Nine specimens were printed and tested utilizing the Split-Hopkinson Pressure Bar (SHPB). The true stress and strain properties and the failure patterns were evaluated. Furthermore, these experimental cases were numerically modelled using an explicit finite element solver, viz. LS-DYNA. It was found that the numerical results to be consistent with the corresponding test results, including stress-strain plots and failure patterns.

Keywords: 3D-printing; Continuous carbon fibre; ONYX matrix; High strain rates; LS-DYNA simulation.

Book Editors

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Rajeev Kumar holds a B.Tech degree from Himachal Pradesh University and an M.E. from the National Institute of Technical Teacher's Training, Chandigarh. With over 10 years of experience as an Assistant Professor in various engineering institutes across Himachal Pradesh, he has a strong foundation in academia. Currently, Rajeev is pursuing his Ph.D. at IIT Mandi, Mechanical and Materials Engineering under the guidance of Dr. Sunny Zafar. His research focuses on the manufacturing and characterization of carbon fiber composites for aerospace applications. Hailing from the picturesque town of Chail Chowk in District Mandi, Himachal Pradesh, Rajeev combines his extensive teaching experience with advanced research to contribute to the field of engineering.

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Kishan Dwivedi is currently pursuing his PhD under the supervision of Dr. Himanshu Pathak at IIT Mandi in Mechanical Design. He joined IIT Mandi on November 11, 2019, as a Junior Research Fellow for DRDO project work. His research focuses on computational modelling for fracture, fatigue, and free vibration analysis of composite materials. His Ph.D. thesis topic is 'Fracture Analysis of Composite Materials using Higher-order XFEM Method'. Kishan completed his post-graduation (M.Tech) in Mechanical System Design from NIT Srinagar, Jammu and Kashmir, in 2019. He earned his B.Tech in Mechanical Engineering from KIT Kanpur, Uttar Pradesh, in 2015. In May 2024, he received the SERB OVDF fellowship for collaborative research work for one year at the University of Alberta, Edmonton, Canada.

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