Proceedings of the 67th Congress of

THE INDIAN SOCIETY OF THEORETICAL AND APPLIED MECHANICS

(An International Conference)

December 14-16, 2022

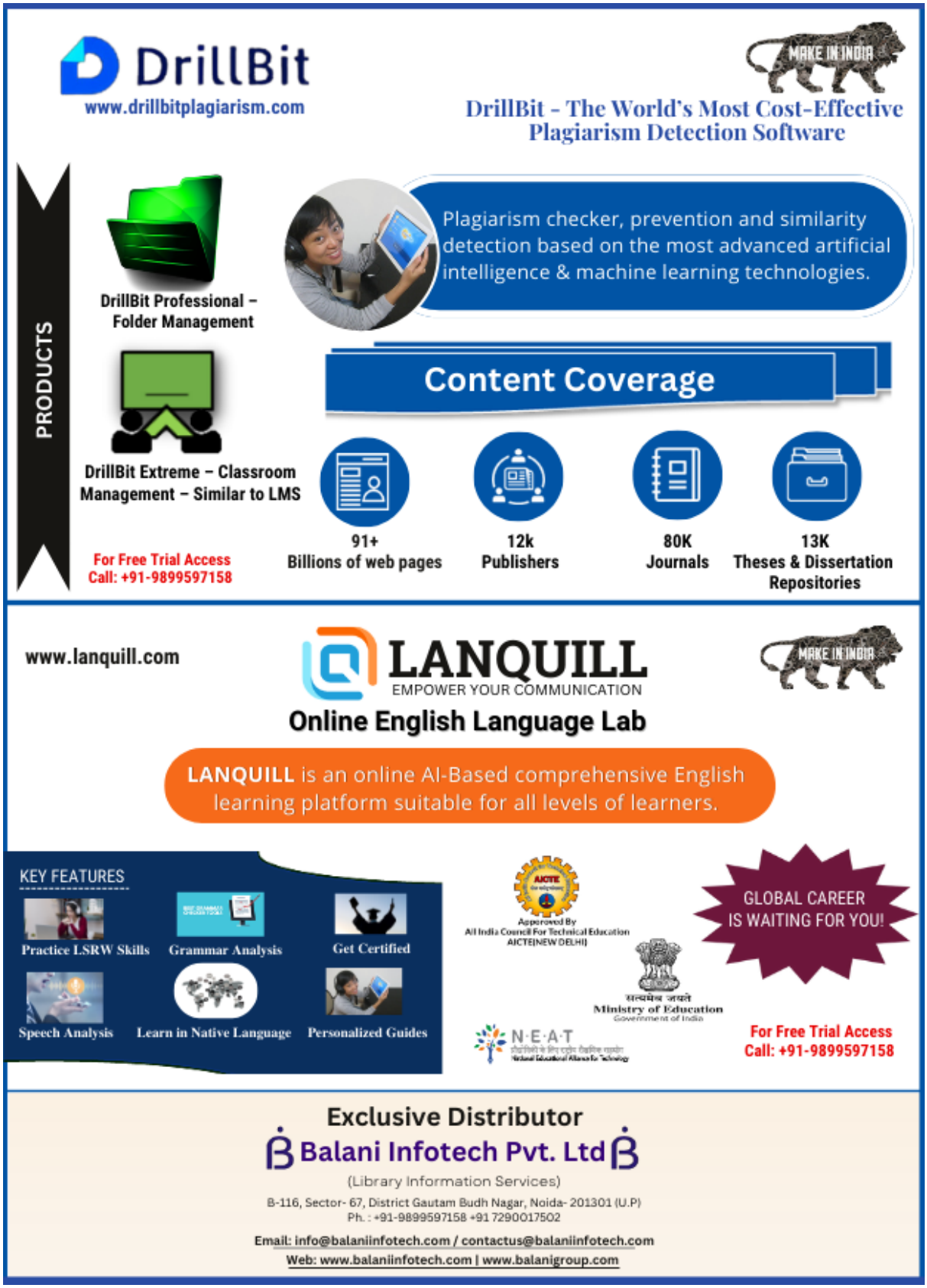
Held at

Indian Institute of Technology Mandi

Editor

Prof. Dipak Kumar Maiti

The Indian Society of Theoretical And Applied Mechanics
Indian Institute of Technology
Kharagpur-721302, India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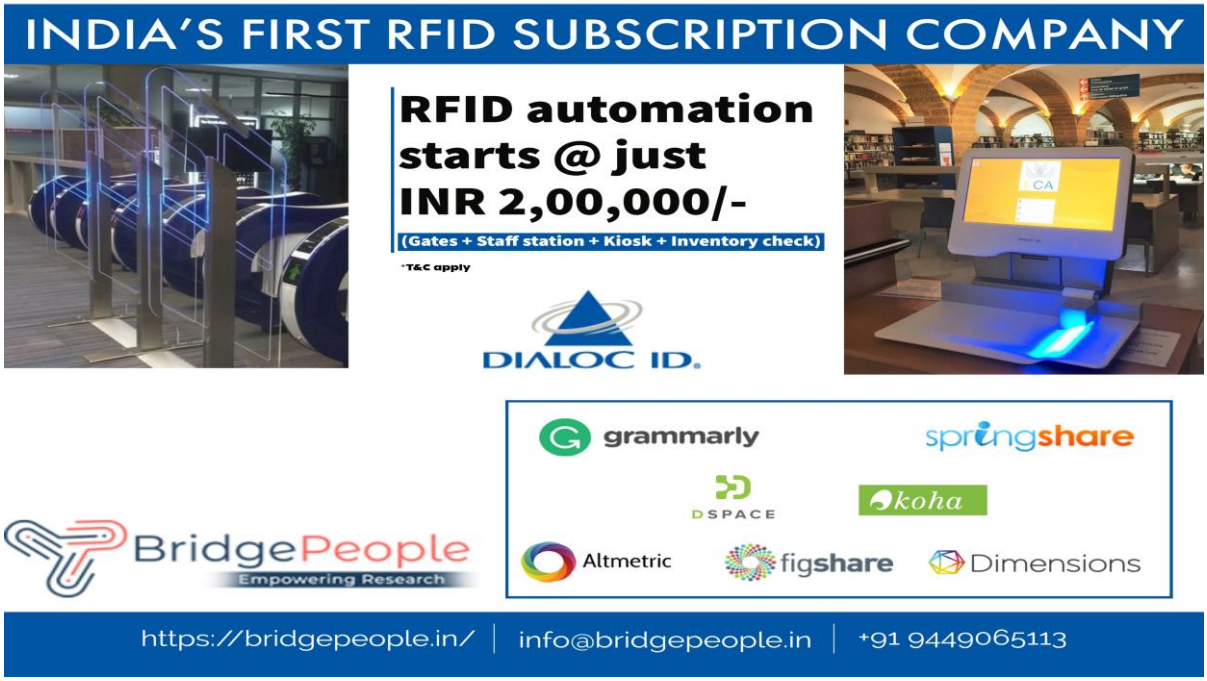
About ISTAM

The Indian Society of Theoretical and Applied Mechanics was established in 1955, with its headquarters at Indian Institute of Technology, Kharagpur. ISTAM was formed by the think tanks of the post independent India for providing a common platform to the Scientists, technologists and the engineers to share and discuss the current research work conducted by them individually or in groups to seek the solutions to the emerging problems of the society for better living conditions. During the congress, five memorial lectures in honor of B.R.Seth, P.L.Bhatnagar, B.Karunesh, A.S.Gupta and G.I.Taylor are given by eminent researchers from across the world and also several invited lectures are arranged to cover the current trends of various topics of Mechanics. The Annual Congress of the Society have been held at various IITs, Universities, NITs, Engineering colleges and other reputed research establishments in different parts of the country. It has been attracting a large number of research workers not only from our country but also from abroad. The society has gone a long way in promoting inter-disciplinary research in Basic Sciences and Applied Mechanics. The Society has specific philosophy to encourage young scientists in the form of awards. Papers submitted are peer reviewed and are published in the form of e-proceedings. Abstracts of papers that are presented in the Congress are published in Book of Abstract.

Five Memorial lecturers commemorating Prof. B. R. Sheth, Prof. P. L. Bhatnagar, Prof. G.I. Taylor, Prof. B. Karunes and Prof. A.S. Gupta are delivered during every ISTAM Congress. Also several invited talks are arranged. ISTAM conducts an award session for the Young Scientists below 30 Years working in the areas of Mechanics of Solids, Mechanics of Fluids and Experimental Techniques. Presently the society has about 42 corporate members and above 1300 Life Members.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MESSAGE FROM THE PRESIDENT, ISTAM (2022)

After two years, ISTAM Congress is being organized in physical mode. There has been a lot of excitement among researchers to take part in it. I welcome all the delegates to ISTAM 2022 Congress organized by IIT Mandi and I hope that three days of academic deliberation will allow us to witness the advances made in various areas of mechanics. We are fortunate that a number of leading researchers have agreed to spare time to with us and enlighten us through Plenary, Memorial and Invited Lectures. It is not to belittle the participation of those who are going to take part in contributed talk sessions which are very important in the sense that we are being able keep ourselves abreast of the research carried out by young researchers, especially of our country. This three-day period of the Congress allows all to participate and interact actively and keep themselves updated on the present state-of-the-art of research in mechanics.

ISTAM, a well-established platform for researchers in all areas of mechanics, has been able to command respect from all researchers, even from different research community. This has been possible due to the immense selfless hard work and dedication from a section of people since its inception. This 67-year old organization has been able to capture the heart of many. We hope, in the coming years, we will be able to attract more people under the umbrella of ISTAM. As a national organization, ISTAM has utmost responsibility to carry out more tasks for the benefit of researchers in mechanics. Among them, starting some region-wise ISTAM chapters to conduct local activities, thinking of publishing a journal in mechanics, giving recognition to established researchers, are some that can be given due consideration in near future.

I am grateful to the previous Executive Council for thinking of me worthy of becoming President of this prestigious organization. I have given my honest and sincere efforts in carrying out my responsibility. However, I must honestly admit that I could not complete some tasks that I thought of completing during my tenure. Being the President of ISTAM for one year has brought me much closer to the organization, and I promise to work selflessly for ISTAM in coming years and try my level best to help in bringing ISTAM to a higher level. It is not an easy task to host the annual congress of such an organization – that too with international flavour. I take this opportunity to heartfully thank Dr. Rajendra Kumar Ray and all the colleagues at IIT Mandi and its management team for taking up the responsibility of organizing the 67th Congress of ISTAM. I am fully confident that this successful event will be etched in our memory forever.

Wishing you all a very happy and fruitful ISTAM 2022 Congress! Have a productive and enjoyable 2023.

SWAROOP NANDAN BORA
President, ISTAM (2022)
Professor, Department of Mathematics
Indian Institute of Technology Guwahati

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PREFACE

Dr. Dipak Kumar Maiti
Professor, Department of Aerospace Engineering
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The Indian Society of Theoretical and Applied Mechanics (ISTAM) was established in the year 1955 under the dynamic leadership of Professor B. R. Seth as its Secretary and Prof. K. S. Krishnan as its President, with its headquarter at Department of Mathematics, IIT Kharagpur. Since then, the annual convention of the Society has been held at various IITs, Universities, NITs and other Engineering Institutes of national repute in different parts of the country. It has been a forum for promoting interdisciplinary research in both Theoretical and Applied Mechanics. It has been attracting large number of researchers not only from India but also from abroad. The 67th Congress of the Indian Society of Theoretical and Applied Mechanics (ISTAM) an International Meet, will be held at IIT Mandi, Mandi during 14th to 16th December, 2022. I take this opportunity to thank the administration of IIT Mandi, Mandi for coming forward to host this congress. There has been an overwhelming response for this congress. Over 300 researchers from India and abroad are going to take part in this congress. On behalf of the Society, I take this opportunity to express my sincere gratitude and thanks to all these eminent researchers for readily agreed to take part in this congress.

A complete electronic proceeding of the 67th Congress of ISTAM is being brought out in the form of E-Proceeding and is made available to all the participants through the ISTAM official website. Extended abstracts of the research papers are received in the first phase of the electronic submission process, which are thoroughly scrutinized. The abstract or the full paper of these approved articles is received during the second phase. All these papers are published in the e-proceedings. I am confident that this congress will help in establishing contact between likeminded researchers and will lead them grow to greater heights. I am delighted to welcome all the participants and am sure that all will have fruitful discussions during the 67th Congress of ISTAM.

Prof. Dipak Kumar Maiti
Secretary, ISTAM

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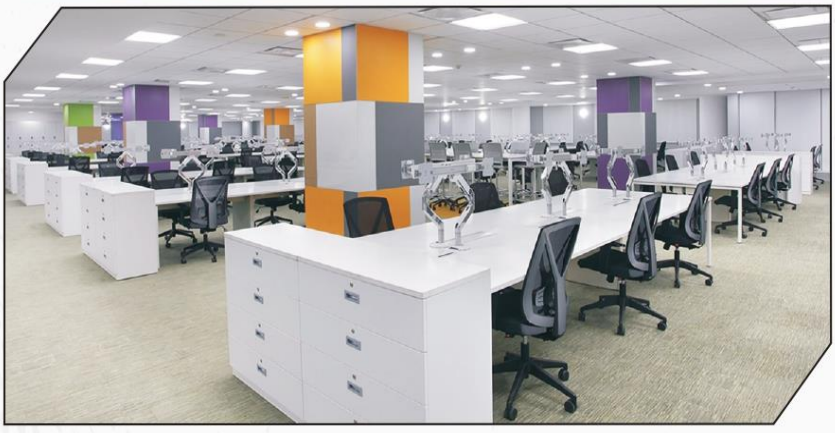

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An Mathematical Treatment of Hysteresis in Storage-Discharge Relation

Prof. Vijay P. Singh
Distinguished Professor, Regents Professor
Department of Biological & Agricultural Engineering and
Zachry Department of Civil & Environmental Engineering
Texas A&M University
College Station, Texas 77843-2117, USA

The storage-discharge (*S*-*Q*) relation, widely employed in water and environmental engineering, is found to exhibit a single loop or double loop, often referred to as hysteresis. The nature of hysteresis depends on system geometry and external forcing and sinks. Despite its ubiquitous use, a mathematical treatment discussing what causes the storage-discharge relationship to exhibit a looped behavior does not seem to have been analyzed. This study analysesthe *S*-*Q* relation analytically using the kinematic wave theory for a watershed represented by a plane, considering simultaneously rainfall, infiltration, and surface runoff or overland flow. For purposes of simplicity and tractability of analytical solutions, both rainfall intensity and infiltrationrate are assumed to be constant. Depending on the duration of rainfall, two cases-equilibrium andpartial equilibrium-are distinguished. The hysteretic *S*-*Q* relationship is different for these two cases and requires a close scrutiny which is pursued in this study. It may be emphasized that the assumptions of constant rainfall intensity and infiltration rate, rectangular geometry, and kinematic wave theory will not undermine the dynamics of hysteresis.

Keywords: Storage-discharge relation, Rectangular plane section, Hysteresis,Loop, Kinematic wave theory, Infiltration rate, Rainfall intensity

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Composites for large structures

Dr. Makarand Jodhi
Scientist 'G'
AR&DB, DRDO, India

Composites usage has grown by leaps and bounds globally in many sectors, from consumer goods to space applications, due to the inherent advantage the material offers, in terms of high specific strength and stiffness, tailorability, providing different functionalities etc. In the Indian context, the drivers of this technology, as elsewhere, has been the defence and space applications.

At R&DE(E), Pune, a DRDO systems engineering establishment, considerable amount of work has been carried out over the past two decades for developing cutting edge products for our defence forces. In tandem, development of technologies specifically required for manufacturing these products satisfying certain functional requirements and establishing a good understanding of mechanics of these materials for such applications, has been the focus.

Vacuum assisted resin transfer moulding (VARTM) and resin film infusion (RFI) are two out- of-autoclave manufacturing processes for composites that hold promise for replacing autoclave curing. These processes enable manufacture of very large and thick composites structures with very good mechanical properties. Adding fillers, sensors etc to the structure for imparting certain functionalities to the products is also possible with these processes.

Since composites are amenable for embedding sensors, structural health monitoring of composites structures is practically possible and real time damage detection can be attempted. Similarly, various fillers for enhancing mechanical properties, imparting low radar visibility, providing *in-situ* damage mitigation/self-healing also comes within the realm of reality.

Composites being layered structures, though brittle in nature, are inherently damage tolerant. Therefore, their use for armour application as well as for blast resistant structures has a great appeal.

This presentation is an attempt to give a summary of the work done at R&DE(E) for developing manufacturing process, adding functionalities to composites, and understanding the behaviour of composites subjected to conditions such as ballistic impact, fatigue etc.

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The Company executed more critical Projects such as Koteshwar Hydro Electric Project (400 MW) of 100 M height across Bhagirathi River placing 40,000 Cum of concrete in a month. The total Concrete quantity is 10,00,000 Cum. It facilitated to generate Hydel Power more than contemplated Power of 400 MW in a minimum recorded time, when compared to any other Hydel Projects in India.

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Current Activities on Research and Development of Aero Gas Turbine in Korea

Prof. Changduk KONG
Professor, Emeritus / International Visiting Professor
Department of Aerospace Engineering, College of Engineering, Chosun University/Department of Aerospace Engineering, IIT Kharagpur

Aero-propulsion is a very important system to produce the thrust force for flying the aero vehicle. Since the first experimental Whittle gas turbine engine in 1937, aero gas turbine engine has become a major powerplant for most aero vehicles.

This lecture aims to introduce current status of the research and development of air-breathing propulsion systems which have been carried out by several major aero propulsion related research institutes, companies, universities and societies in Korea.

Even though Korea has a short history in air breathing propulsion system, its technology and engineering have been rapidly developed through lots of activities such as research and development, manufacturing, maintenance and overhaul by research institutes, companies and universities.

In Korea, the aero gas turbine's R&D started from development of a small turbojet engine for a decoy mission RPV at ADD (Agency for Defense Development). Based on this experience, ADD developed the 1000 lbf thrust turbojet engine for missiles. Since ADD's development experiences and aerospace companies' businesses on maintenance, overhaul, parts localization, license production of military and civil engines, Korea has the capability to develop gas turbine engines.

Recently ADD and Hanhwa Aerospace Company who is a major aerospace propulsion company has developed the 5500 lbf and 10,000 lbf class turbofan engines for special purpose UAVs that will be completed by 2025, based on development of the 5000 lbf class turbofan engine common core.

According to KARI (Korea Aerospace Research Institute)'s 2030 technology road map on the air breathing engine, KARI planned to develop the 1700 shp class turboshaft/prop engines and the 3000 lbf class turbofan engines for civil and military use UAVs by 2025, and the 12000lbf class open rotor engines for manned vehicles and RBCC high speed engines by 2030.

ADD and KARI has gas turbine test facilities such as the component test facilities of compressors, turbines and combustors, and the high altitude test facilities.

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Fluid-structure interactions: multiple lock-ins

Prof. Sanjay Mittal
Professor
Department of Aerospace Engineering
Indian Institute of Technology Kanpur, India

One of the important phenomena associated with fluid-structure interactions is lock-in. The structure undergoes large amplitude oscillation and the vortex shedding frequency shifts to a value close to the natural frequency of the structure. The phenomenon has been mostly studied for the case of a single-degree-of-freedom structure that has one single natural frequency. What does lock-in look like when the structure has multiple degrees of freedom? The vortex-induced vibration of a flexible filament attached behind a stationary cylinder is studied in the two-dimensional, laminar flow regime. We explore the response of the filament for a wide range of flexibility and inertia. Lock-in with a large number of normal modes of the filament, each in a different regime of reduced speed, is observed. Reduced speed is the free-stream speed of the incoming flow non-dimensionalized with the first natural frequency of the structure and the diameter of the cylinder. Several branches, based on response of the filament, are identified and the contributions of various structural modes along these branches are quantified. Contribution from a particular structural mode increases significantly during lock-in, accompanied by a large amplitude of vibration. The transition between different branches is found to be hysteretic and intermittent. The flow exhibits a variety of vortex-shedding patterns, including the 2P+2S mode. The modes of shedding show a systematic variation with amplitude and frequency. The map of vortex-shedding patterns in the amplitude–frequency plane resembles the corresponding map for forced vibration of a rigid cylinder. The transformation of wake from one mode of shedding to another is explained phenomenologically. Variation of rate of energy transfer between the fluid and filament with space and time is analysed to determine optimal placement of transducers for harvesting energy.

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Clear water scour erosion at bridge pier

Prof. Damien Pham Van Bang
Professor
National Institute of Scientific Research,
University of Québec, Canada

Scour erosion near soil foundation of hydraulic structures is an important issue for civil engineers. Depending on the flow conditions, erosion may happen and compromise the stability of structures such as bridges, dams, dykes or embankments. Thus reliable predictions of scour erosion is needed to protect society against climate change effects. Despite the plethoric number of experimental and numerical studies on scouring at bridge piers, or the large number of formulae to predict the scour hole depth, we still have difficulties to model the physical processes of erosion accurately. The local interaction between hydrodynamic and morphodynamic is an important aspect to consider for accurate prediction of the dynamic of scouring. And many formula only applies for the final 'steady-state' value starting from an ideally-initially 'flatty bed' conditions that is submitted to high speed flows or in live-bed conditions (Roulund et al, 2005).

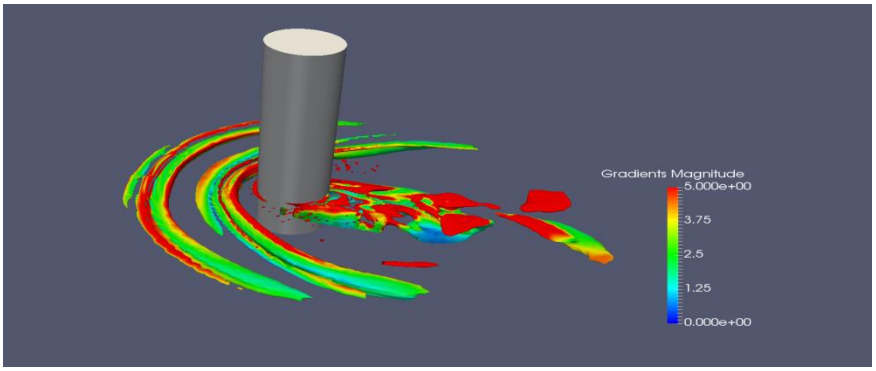

Figure 1. Flow patterns near the bed of a vertical cylinder (Re_D=4460, flow from left to right): horseshoes vortices upstream-, wakes vortices downstream the cylinder

This new study focus on the clear water regime of sour erosion. This situation is encountered when the flow is globally-sufficiently slow for not eroding the bed, but locally fast enough at the hydraulic structure for triggering sediment motion. In this regime, scour

depth is small when compared to live-bed conditions, but becomes not negligible with long time.

More surprisingly is the resulting erosional pattern at low speed which shows the localization of scour holes downstream the structure (Lachaussée et al. 2017) only: this means that the wake vortices have stronger erosional effects than the horseshoes ones. To better understand the scouring processes at low velocity and detail how the horseshoes vortices are weaker than the wake counterpart, we propose a numerical study based on NSMP3D in-house code (Zhang et al., 2020).

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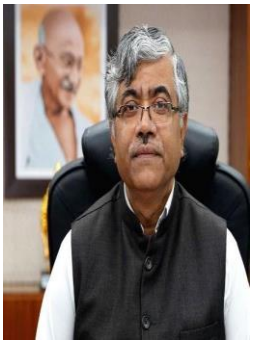
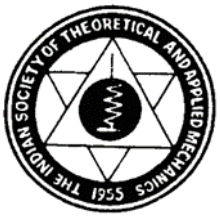
Microfluidics to explore biophysics of human body

Prof. Sarit K.Das
Professor
Department of Mechanical Engineering, Indian Institute of Technology Madras, Chennai, India



In the past two decades, microfluidics has been applied in every possible field to explore the application of physics of fluids at the micro level. In specific, the field of human biophysics has become the frontier area of research due to the microfludics ability to mimic human biophysical factors such as chemical gradients, thermal gradients, fluid flow induced shear stress, capillary action, mass diffusion, oxygen and pH gradients. This has greatly benefited biomedical field in terms of improving the health care. Taxis, a mechanism in which cells undergo directed migration in response to biophysical gradients has been largely applied for disease diagnosis *eg.,* isolation of circulating tumour cells or microbes from blood sample. The migration and expression of cells in phenomena such as differentiation of stem cells and metastasis of cancer cells critically depend on physical factors such as fluid shear stress which has been studied in details in the recent times. Further, with microfluidics the human physiology had been mimicked *in-vitro* leading to the development of organ-on-a-chip models. These models are key to understand the organ's functions, diseased conditions and for drug discovery. Various research groups are already working on complete human-on-a-chip by having multiple organs-on-a-chip. The success in human-on-a-chip model in turn will have greater impact on the world's biomedical market as it can reduce the cost of drug discovery and development significantly. The number of clinical trials can be brought down and the drug failure at the human trials can be avoided entirely. Pancreas-on-a-chip, lung-on-a-chip, heart-on-a-chip, kidney-on-chip, liver-on-chip and gut-on-chip are few organ-on-a-chip models are to be noted which have already been developed. There are many reported works on multiple organ-on-a-chip models as well. With all these, it must be noted that this much advancement in health sector has been made possible only by looking into the combined the impact of biochemical and biophysical factors. As we know, in nature all the gradients (velocity, temperature and chemical) coexist and they are analogous to each other. In human body as well, all the three factors coexist and one has to consider momentum, energy and mass transfer processes to predict the biophysical phenomena. The current lecture brings about the basic principles of biomicrofluidics and its specific application in understanding the biological phenomena.



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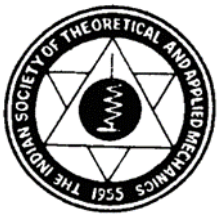
On a locking-free shell element and nonlocal approaches for modeling of architected materials

Prof. J.N. Reddy
Distinguished Professor and O'Donnel Foundation Chair IV, Director, Center of Innovation in Mechanics for Design and Manufacturing, Department of Mechanical Engineering, Texas A&M University, Texas

The lecture will present the speaker's recent research in: (1) the development of higher-order, locking-free shell finite elements for large deformation of laminated and functionally graded plate and shell structures, (2) nonlocal approaches for modeling architected materials and structures and a graph-based finite element analysis of fracture. The seven-, eight-, and twelve-parameter shell elements developed are based on modified first- order and third-order thickness stretch kinematics, and they require the use of fully three- dimensional constitutive equations. Through the numerical simulation of carefully chosen benchmark problems, it is shown that the developed shell elements are insensitive to all forms of numerical locking and are the best alternative to 3-D finite elements in saving computational resources while predicting accurate stresses. The graph-based finite element approach with nonlocal criterion (called GraFEA) to study fracture in solids is found to be very robust and accurate in predicting fracture. The approach has the ability to model discrete microcracking with random crack orientations. The computational technique also incorporates a probabilistic approach to damage growth by using a measure of "microcrack survival probability" and its evolution. The approach will be demonstrated using several examples.



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Held at: IIT Mandi, India
14-16 December, 2022

Chemical Reaction-Induced Hydrodynamic Instabilities in a channel flow

Prof. Manoranjan Mishra
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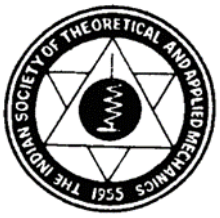
Department of Mathematics, Indian Institute of Technology
Ropar, Rupnagar, Punjab, India.

The study of hydrodynamic instabilities in a stratified flow has gained significant attention in the scientific community for its applications in industries and environments . Viscous fingering(VF) instability occurs when a less viscous fluid tries to push a more viscous one in the porous media or Hele-Shaw cell, where the flow equations are expressed by a simple empirical rule known as Darcy's law. Far from Darcy's flow regime, i.e., in a pressure-driven flow governed by the Navier-Stokes equations, if fluid flows in a channel uniformly in the vertical direction for a long time, the flow reaches a steady state with a fully developed parabolic velocity profile. Moreover, with this velocity profile that has a shear or a vertical gradient, if a less viscous fluid pushes a more viscous one, Kelvin-Helmholtz-type Instability (KHI) is encountered alongside the pure diffusive miscible VF . Such KHI is found when a reactant A displaces another reactant fluid having the same viscosity following a simple A+ B→C reaction kinetics . The governing equations become a set of coupled non-linear PDEs, which are solved using a diffuse interface finite volume method. Depending upon the product's viscosity, K-H billows occur at either A-C or C-B reaction front. Further, the onset times of Instability (t_{on}) are found through direct numerical simulations for various governing non-dimensional parameters such as the mobility ratio (R_c), Damköholer number (Da), Péclet number (Pe), and Reynolds number (Re). The detailed modeling phenomena in comparison to the corresponding Darcy's regime will be discussed in this talk, and how this chemo-hydrodynamic KHI enhances the mixing of the product fluid will be shown.



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Flow and Heat Transfer over Dimples in the Turbulent Channel Flows

Prof. Khoo Boo Cheong
Professor in Fluid Mechanics,
Dept. of Mechanical Engineering,
National University of Singapore, Singapore

Dimples have been used effectively for many heat transfer enhancement applications due to the relatively high heat transfer efficiency. The flow over dimples are relatively complex, and flow visualization experiments have shown the presence of a region of separated flow at the upstream portion of the dimple, particularly for deeper dimples. This region of flow separation generally reduces as the Reynolds number increases. At sufficiently high Reynolds numbers, the region of separated flow can shrink until it is eliminated for dimples of moderate depth to diameter ratios. For very shallow dimples with depth to diameter ratios of less than 5%, no flow separation is observed, even at low Reynolds numbers.

Both hot-wire velocimetry and numerical simulations via DNS and DES of dimple arrays in fully developed turbulent channel flows were conducted to study the flow further. The dimples studied consists of shallow smooth edge dimples of various shapes, including axisymmetric circular dimples, skewed circular dimples, elliptical dimples, teardrop-shaped dimples as well as diamond-shaped dimples. These dimples all have a fixed spanwise width, and a depth to spanwise width ratio of 5%.

These studies show the presence of two high speed streaks and streamwise vortices within these dimples. Increasing drag reduction below that of the flat plane channel flow was generally observed for most of these dimples as the Reynolds number increases. At low Reynolds numbers, a drag increase is observed. The presence of spanwise flow at the dimple surface at the location of the high speed streak regions is accompanied by reductions in the Reynolds stress u'u', showing reduced turbulence production and increased flow stability at these locations. Such reductions in turbulence production accompanying spanwise flow motions near the wall is also observed for drag reducing flows involving spanwise wall oscillations or near wall streamwise vortices, suggesting a similar mechanism for drag reduction at work with the flow over these dimples.

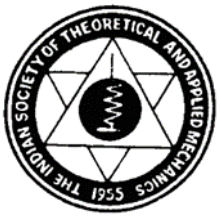
For circular axisymmetric dimples, flow separation is a commonly observed flow feature occurring over the upstream edge of the dimple. The flow then reattaches within the dimple depression, forming a region of recirculating flow within the dimple depression. This separated flow lowers heat transfer enhancement and increases drag due to the dimples.

Moving the deepest position of the dimple downstream by skewing the axisymmetric dimple reduces the wall slope at the upstream portion of the dimple, resulting in reduced separated flow, and enhancing heat transfer and increasing the drag reduction observed with these dimples. Reduced vortices emitted from these dimples shown by the DNS with the deepest point shifted downstream also suggests reduced turbulent energy production at the upstream portion. Shifting the deepest point too far back however, results in a steep downstream dimple wall. The flow impingement onto the steep dimple wall results in increased form drag, raising the overall drag if the deepest point is shifted too far back. At the same time, heat transfer is not significantly increased because of the elimination of the flow recirculation when the deepest point is shifted sufficiently far back.

A numerical study conducted for deeper circular skewed dimples with depth to diameter ratio of 15% and with its deepest point shifted downstream however shows that the previous trend of drag variation seen with shallow dimples with depth to diameter ratio of 5% with movement of the deepest point is not the same for such deeper dimples. For circular dimples with depth to diameter ratio of 15%, shifting the deepest point from 0.2 diameters upstream of the dimple center to 0.2 diameters downstream of the dimple center is not accompanied by any reduction in drag as is the case with dimples with depth to diameter ratio of 5%. For these deeper dimples, the upstream and downstream wall slopes are already relatively high such that a shift in the deepest point downstream does not reduce the flow separation at the upstream portion significantly. However, the shift in the deepest point downstream increases the already steep downstream wall slope, so that flow impingement is increased and this results in a drag increase instead when the deepest point is shifted downstream.

To avoid raising the downstream wall slope that results in increased drag as the deepest point is shifted downstream, the circular dimple can be modified to an elliptical, teardrop or diamond shape. Streamwise elongation of the dimple allows the reduction of both the upstream and downstream wall slopes. This reduces both the flow separation at the upstream portion of the dimples, as well as the flow impingement at the downstream portion of the dimple. This combination results in significantly increased drag reduction for these non-circular dimple shapes. Among these, the diamond dimples show the greatest drag reduction, with the drag being almost 8% less than that of the plane channel flow. At the same time, heat transfer is also increased above that of the plane channel flow for all these dimple shapes.

Analysis of the heat transfer efficiency in terms of the volume goodness factor highlights the flow parameters that are significant for heat transfer enhancement by the dimples. For heat transfer, deeper dimples with depth to diameter ratios of more than 10% perform best for circular axisymmetric dimples. However, when the deepest point is shifted so that the dimples are skewed, the volume goodness ratio can be further increased as the dimple depth increases. Modification of the dimple shape to an elliptical, teardrop or diamond shape also changes the heat transfer efficiency. A general observation that can be made is that dimple geometries with higher drag reduction tends to have lower heat transfer efficiency. However, even with dimples that show a lower drag compared to a plane channel flow, it can also have enhanced heat transfer compared to it, showing the usefulness of dimples for heat transfer applications as well.



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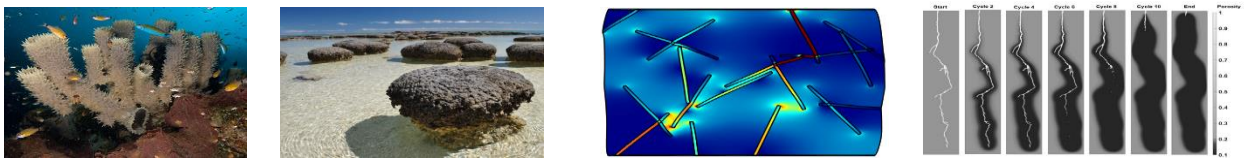
Experimental and Numerical Models for Self-Healing, Self-Sensing Concrete

Prof. Abhijit Mukherjee
Professor
Curtin University, Australia

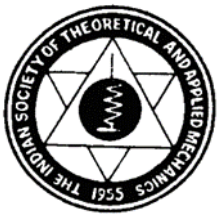
Concrete is the most used manufactured material worldwide. However, the CO_2 emission from concrete is unsustainable. On the other hand, a sizable proportion of concrete facilities have deteriorated prematurely and their maintenance or renewal is a formidable economic and technical challenge. Present technologies for maintenance of concrete built facilities is manual, unreliable and hazardous. There are examples in nature, such as corals, stromatolites and beach rocks that are concrete like materials capable of growing and healing in case they experience damage.

In this paper, a new class of cementitious materials with both self-healing and self-sensing capabilities is introduced that will obviate the monitoring and repair functions to a great extent. Natural self-healing systems is introduced. A technology update for emulation of self-sensing and self-healing that have been developed separately, is presented. Our approach toward integrating these two functions is elaborated. Multi-physics models validated by extensive experimentation are presented. These models are useful in design of sensing and healing systems.



a b c d

Figure: Naturally growing cementitious systems (a) corals; (b) stromatolites; Synthesised materials (c) electrical field in a self-sensing material and (d) gradual healing of self-healing material



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Flow past bluff bodies: From a body fitted to immersed interface finite difference approach

Prof. Jiten Kalita
Professor
Department of Mathematics,
Indian Institute of Technology Guwahati, India

This talk is concerned with the simulation of incompressible viscous flows past bluff bodies in the finite difference framework. Firstly, we discuss the relative advantages and disadvantages of discretization of the Navier-Stokes equations and subsequent computation in the original physical and transformed computational plane. The need for a body-fitted grid for tackling the boundary of the bluff bodies and its limitations in the finite difference framework will also be discussed through fluid flow simulations. In the process, how the immersed interface approach enables overcoming this issue will be illustrated through simulations of flow past complex shaped bluff bodies by a recently developed HOC immersed interface method by the author and his group.

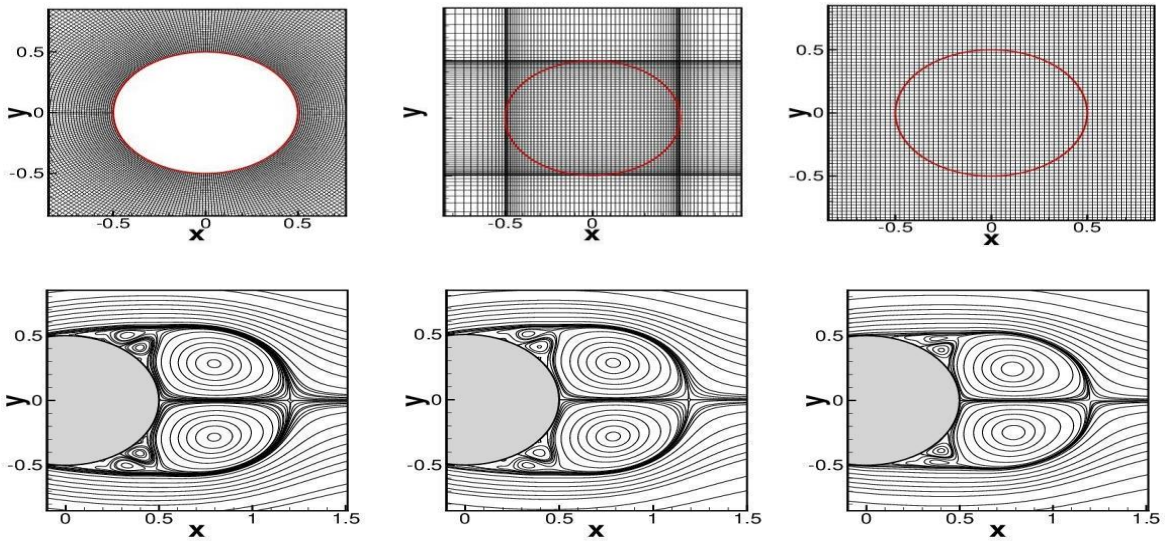
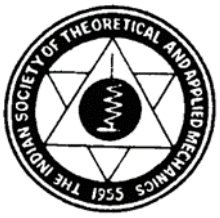


Figure: Simulation of flow past a circular cylinder in uniform flow for Re=3000. Top, the grids used in three different finite difference approaches. Bottom, the corresponding streamlines at time t=2.5.



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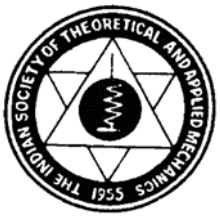
Flexural-gravity wave scattering by a crack in a floating ice sheet within the framework of blocking dynamics

Prof. Trilochan Sahoo
Professor
Dept. of Ocean Engineering and Naval Architecture, Indian Institute of Technology Kharagpur, India

There exists a region in the frequency space in homogeneous/stratified fluids, in which the dispersion relation associated with flexural gravity waves possesses multiple propagating wave modes. This multiplicity leads to mode conversion during wave scattering. In one of these modes, the associated energy propagation direction is opposite to the direction of the incident wave, making enforcement of the Sommerfeld radiation condition challenging. In this talk, the focus is on two canonical problems associated with flexural-gravity wave scattering by a crack in a homogeneous fluid as well as in a two-layer fluid having an interface. The solution process for this class of problems involves the appropriate transition of wave modes within the blocking frequencies, which is obtained with the help of the dispersion curve. The reflection and transmission coefficients are generalized in the case of multiple propagating wave modes, and the associated energy balance relations are derived using Green's integral theorem. The scattering matrices are generated to describe all the possible transmitted and incident wave modes for the physical problems. This study reveals the occurrence of removable and jump discontinuities on the reflection and transmission coefficients at the saddle as well as blocking frequencies and at the frequency for which incident wave mode changes. Irregular plate deflection and interface elevation patterns are found due to the superposition of multiple propagating wave modes within the primary and secondary blocking frequencies. The method adopted here can be applied to handle various scattering problems involving multiple propagating wave modes in hydroelasticity and allied branches of mathematical physics and engineering.



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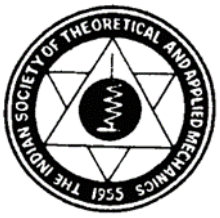
Towards understanding collagen self-assembly – an asymptotic analysis approach

Prof. Adrian Muntean
Professor
Department of Mathematics and Computer Science, Karlstad University, Karlstad, Sweden

Biological matter is hierarchically structured. In this talk I discuss a two-step assembly process of a fibrous polymer - a key building block of collagen. Assuming that the time scales at which assembly steps take place are sufficiently well separated, we set up a coupled system of master equations to which we apply a periodic homogenization asymptotic procedure to yield a continuum description in terms of partial differential equations that describes ensemble/bulk measurements. We use the upscaled evolution equations to reproduce and interpret recent anomalous turbidity measurements. This is an update of results reported previously in the reference B. S. van Lith, A. Muntean, C. Storm "A continuum model for hierarchical fibril assembly", EPL 106(2014) 68004



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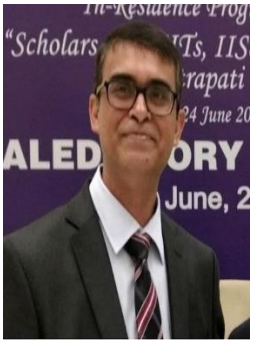
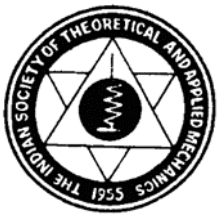
Inverse heat transfer technique for continuous casting problems

Prof. Prabal Talukdar
Professor
Department of Mechanical Engineering,
Indian Institute of Technology Delhi, India



Determination of heat flux at the mould-strand interface is important to determine the solidification characteristics of the strand and also to determine the correct taper of the mould in a continuous casting process. However, the measurement of heat flux in a continuous casting mould is a challenging task. Inverse heat transfer technique is one of the possible methods for estimating the heat flux at the mould-strand interface. In the present work, such inverse heat transfer technique has been used for estimation of heat flux in both billet and slab casting moulds. Inverse technique using both deterministic as well as probabilistic methods are attempted in this work and challenges faced in this regard are discussed.

Mathematical models are developed to determine the heat flux across the hot surface of continuous casting mould from limited data of temperature measurement. The models have been developed for both billet (2-D) and slab (3-D) casting geometries. Conjugate gradient method has been used as a deterministic method and the challenges faced in this class of problems have been discussed. As an alternative to this method, other probabilistic methods like Salp swarm Optimization algorithm have been proposed and found to have certain advantages. Plant measurement data of temperature have been used required for the inverse heat transfer models.



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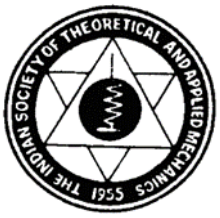
Recent studies on the eigenfunction matching method for solving problems of water wave scattering, breaking, and dissipation

Prof. Chia-Cheng Tsai
Professor, Director
Bachelor Degree Program in Ocean Engineering and Technology and Center of Excellence for Ocean Engineering,
National Taiwan Ocean University, Keelung 202301, Taiwan

In this talk, I will introduce my recent studies on the eigenfunction matching method (EMM) for solving problems of water wave scattering, breaking, and dissipation. These include problems of viscous or inviscid waves scattering by arbitrary bottoms, tension-leg, and/or surface-piercing structures. The Bragg reflections of oblique water waves by periodic surface-piercing structures over periodic bottoms are also reported. In addition, the combined effect of shoaling, breaking, and energy dissipation of oblique water waves by multiple variable permeable and impermeable breakwaters across the surf zone is investigated. By the assumption of small wave amplitude, the linear wave theory is employed in the EMM formulations. In the solution procedure, the tension-leg or surface-piercing structures and the bottom profiles are sliced into a number of shelves separated by abrupt steps. On each shelf, the solution is composed by eigenfunctions with unknown coefficients that represent the wave amplitudes. Upon applying the conservations of mass and momentum, a system of linear equations is obtained and then solved by a sparse-matrix solver. The effects of shoaling, breaking, and energy dissipation are implemented into the proposed eigenfunction matching method by using the energy-dissipation factors, which are modeled by empirical formulas. The proposed EMM is validated by several examples in the literatures. Numerical results indicate that the EMM are accurate up to four decimal places. Furthermore, the EMM is shown to be more efficient than the traditional solutions by the mild-slope equations for short waves because multiple waves can be approximated by few shelves.

Keywords: Eigenfunction matching method; Step approximation; Tension-leg structure; Surface-piercing structure; Weak viscous Bernoulli's equation; Oblique wave; Bragg reflection



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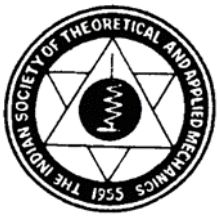
Stability of non-isothermal Poiseuille flow in a fluid overlying an anisotropic and inhomogeneous porous domain

Prof. Premananda Bera
Professor and Head
Department of Mathematics, Indian Institute of Technology
Roorkee, India.

In this talk, using a two-domain approach the thermal convection of Poiseuille flow in an anisotropic and inhomogeneous porous domain underlying a fluid domain will be discussed. Here, the flow of the Newtonian fluid is regulated by Darcy's law in the porous domain with the implementation of the Beavers-Joseph condition at the interface. Concerning the stability of the fluid-porous system, the impact of media anisotropy and inhomogeneity is inspected by the virtue of linear stability analysis along with other governing parameters like depth ratio (ratio of fluid domain's depth to porous domain's depth), Darcy number, Reynolds number, and Prandtl number. How do these parameters affect the mode of instability and the pattern of secondary flow or what is the appropriate physical mechanism behind the type of mode are analyzed. The neutral curves are found to be bi-modal and unimodal in nature with the anisotropy and inhomogeneity leaving their imprint on parametric variation. An increase in anisotropy or decrease in inhomogeneity parameter follows the modal change from unimodal (porous) to bi-modal (both porous and fluid). Also, it has been identified that irrespective of the considered variations in anisotropy and inhomogeneity, the least stable mode for depth ratio < 0.05 is porous, and for depth ratio > 0.16 is fluid. Furthermore, energy budget analysis is carried out to classify the type of instability and validate the type of mode. The instability is found to be thermal-buoyant in nature with the omission of low Reynolds numbers along with very low values of the ratio of permeability in the horizontal to the vertical direction, where thermal-shear instability is witnessed. Likewise, secondary flow patterns in the context of stream function and temperature contour are analyzed to validate the least stable mode and the type of prevailing instability in the fluid-porous system. The presented numerical results find good experimental support with the results of Chen & Chen (J. Fluid Mech., vol. 207, 1989, 311-321) in the limit of natural convection with the isotropic and homogeneous porous domain.



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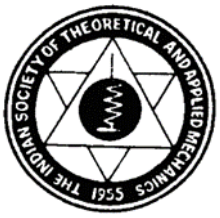
Robotic Grasp under Perpetual Vibration

Prof. Debanik Roy
Scientist and Professor
Division of Remote Handling and Robotics, Bhabha Atomic Research Centre
& Homi Bhabha National Institute, Department of Atomic Energy, Govt. of India,
Mumbai-400085, INDIA

The principles of Newtonian Mechanics are applicable in traditional robotic systems in order to ascertain perfect form & force closure of the robotic grasp. On the contrary, Flexible and Complaint Robotic Systems (FCRS), by and large, are prone to inherent vibration that recreates itself in several modal frequencies. Thus, a stable slip-free robotic grasp under perpetual vibration needs due harnessing of non-linear dynamics from control system standpoint. Natural vibration of FCRS (medium to large trembling under run-time condition) is quantitatively ascertained through modal frequency & Eigen value that finally leads to instability as well as oscillations with high Eigen vectors. Nonethess, stable robotic grasp is delicate as it often calls for 'extra mode shape', i.e. vibration frequencies much beyond the natural frequency. These metrics will be reported in the talk with specific chronological reference to nine indigenously-developed prototypes of FCRS-gripper. These prototypes are essentially jointed structures with multiple inherent degrees-of-freedom so as to combat the external excitation by producing counter-balancing vibration at the gripper-wrist interface. The penetration of such vibration can be analyzed into two metrics, namely: i] rheology-based analysis & ii] tribology-based analysis. In either of the analysis-types, we need to develop customized propositions on 'Contact Mechanics' and 'Impact Mechanics' in order to ensure stable force closure of the grasp. Due to the slender disposition of the FCRS as well as miniature ensemble of its gripper, force of adhesion plays a great role during pre-grasp stage. Thus, a new formulation, namely, *Adhesive (Contact) Mechanics-based grasp model* has been postulated so as to scrutinize real-time gripping of several tiny objects, as experimented with the prototypes developed. The in-situ deflection of the FCRS is evaluated in terms of deformation of multiple strain gauges and/or array of heterogenous sensors, interfaced on the FCRS-link / gripper, aided by a mathematical model. The ensemble domain of grasp by FCRS-grippers will be addressed in the talk with reference to mating hardware of the four indigenously-designed & developed prototypes of flexible robots.



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AWARD SESSION

Onset of Instability and Effect of Diffusion in Miscible Displacements with Non-monotonic Viscosity Profiles(PA0073)

Deepali Goyal
Department of Mathematics, Indian Institute of Technology Ropar, Rupnagar 140001, Punjab, India

Abstract- The influence of diffusion in combination with anisotropic dispersion in the framework of non-monotonic viscosity profiles in a miscible displacement has been investigated. The mathematical model is composed of three coupled equations, namely, the continuity equation, Darcy's equation, and convection-diffusion equation with appropriate boundary conditions. A two-dimensional Hele-Shaw cell is used to model the miscible displacement. The geometric aspect ratio of the Hele-Shaw cell in the large limit, i.e., Transverse Equilibrium (TE), and the small limit, i.e., Dykstra-Parsons (DP), leads to a single integro-differential equation. In the instance of unit aspect ratio, the asymptotic approach is used to investigate the early temporal instability, long wave limit, and the influence of Peclet number (diffusion). Even though the governing equations are non-autonomous in character, the current asymptotic analysis yields an analytical answer that would be impossible to get using other approaches. The transverse flow is dominant at the TE limit, and decreasing the anisotropic parameter causing more fingering. The transverse flow disappears in the DP regime. It is also found that the disturbances increase as the Peclet number and anisotropic parameter increase with the unit aspect ratio. Also, it is observed that in the long-wave limit, the perturbations can be described by the eigenvalues of a certain Strum-Liouville differential equation for early times.

Keywords- Porous media, Viscous fingering, Diffusion

Elastodynamic response of CSH waves in a multi-layered cylinders composed of reinforced and piezo-materials(PA0042)

Sunita Kumawat
Department of Mathematics, BITS-Pilani, Hyderabad Campus, Hyderabad-500078, India

Abstract- The present study fundamentally focuses on analysing the limitations and transference of circumferential shear horizontal (CSH) waves in a four-layered compounded cylinder. The geometrical structure consists of cylinders of infinite length composed of self-reinforced (SR), fibre-reinforced (FR), piezo-magnetic (PM), and piezoelectric (PE) materials. The structure is assumed to be pre-stressed along the azimuthal direction. In order to make the structure sensitive to the application pertaining to sensors and actuators, the PM and PE cylinders have been categorically placed in the outer part of the geometry. Whereas in order to provide stiffness and stability to the structure, the inner part consists of SR and FR materials. The common boundary between each of the cylinders has been essentially considered as imperfectly bonded. At the interface of PE and PM media, mechanical, electrical, magnetic, and inter-coupled types of imperfections have been exhibited. The closed-form of dispersion

relation has been deduced for two contrast cases i.e. electrically open magnetically short (EOMS) and electrically short and magnetically open (ESMO) circuit conditions. Dispersion curves have been plotted to illustrate the salient features of parameters like normalized imperfect interface parameters, initial stresses, and radii of the concentric cylinders. The comparative effect of each one of these parameters on the phase velocity of the wave has been enlisted and marked individually. Every graph has been presented with two successive modes for a comprehensive understanding. This theoretical study may be implemented to improvise the performance of surface acoustic wave (SAW) sensors and actuators consisting of piezo-electric quartz and piezo-composite concentric cylinders.

Keywords- CSH waves, Imperfect interface, Self-reinforced, Fibre-reinforced, Piezo-magnetic, Piezo-electric, Initial stress, ESMO, EOMS.

Analysis of flexoelectricity on SH wave dispersion in a loosely bonded electromagnetic composite(PA0053)

Mahargha Biswas

Abstract- Present research article manifests the transference of Love-type shear horizontal (SH) wave in the presence of flexoelectric effect in a loosely bonded piezo electromagnetic composite structure at the microscale level. The considered structure consists of a piezoelectric microplate bedded over a piezomagnetic halfspace. The piezoelectric and piezomagnetic phase interface is considered sliding or loosely-bonded interface. Complex frequency equations are obtained in form of determinants for electrically and magnetically open and short cases. Numerical example and graphical illustrations are made to monitor the influence of affecting parameters like flexoelectric coefficients, piezoelectric coefficient, bonding parameter, and plate thickness. This research may be utilized to understand the size-dependent behavior of dispersion of surface wave.

Keywords-Flexoelectricity, piezoelectricity, piezomagnetism , loose bonding.

Dynamical behaviour of torsional surface wave in layered dry sandy media(PA0071)

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Abstract- This present study dwells the characteristics of torsional wave propagation in dry sandy layer lying over non-homogeneous dry sandy media. The material properties of the lower medium are predicated to change exponentially with the depth of the media. Displacement components in both the medium are found and use to educe the velocity expression under the considered geometry using the separation of variable method. The

obtained dispersing mathematical statement agrees with the standard Love wave equation. Influence of the proposed parameters on wave velocity has been shown by the graphic illustration using MATLAB. The results evince that the non-homogeneity allied with lower media perturb the wave velocity substantially. The result of this study may provide more deeper understanding of propagation aspect in non-homogeneous dry sandy materials, offering a conjectural roadmap for layout and optimization in the earthquake engineering areas.

Keywords: Sandy medium, torsional surface wave, phase velocity, non-homogeneity

Contributory Paper(FM: Fluid Mechanics)

Thermoconvective linear and nonlinear stability of a double-diffusive Hadley-Prats flow by Soret effect and internal heat source in a horizontal porou (PA0001)

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Abstract- A mathematical and physical model is developed for studying the onset of double-diffusive convective fluid flow in an infinite parallel horizontal porous layers with temperature gradient, internal heat generation, Soret effect and mass flow. Darcy's model is deployed for the porous medium which is considered to be isotropic and homogenous. A linear and nonlinear stability analysis is conducted and transverse or longitudinal roll disturbances are examined. The nonlinear stability analysis is derived by using the energy method. The dimensionless emerging eigenvalue problem is cracked numerically with fourth order Runge-Kutta and shooting methods for both cases of disturbances i.e. longitudinal and transverse rolls. In both the cases of linear and nonlinear stability theories, the onset criterion for all possible modes is derived analytically. Critical value of wave number and critical value of vertical thermal Rayleigh number Rz are identified. Linear and nonlinear stability analysis showing that growing the value of Lewis number in the porous medium stabilizing the process of convection for together the positive and negative values of vertical solutal Rayleigh number Cz. It is also observed that an enlargement in the value of Cz from the negative to the positive, the critical value of Rz is decreased. This suggest that the porous medium system becomes unstable with as Cz as increases. Increased internal heat generation causes efficient destabilisation in all areas, since it raises the fluid flow system overall temperature. It is observed that the effect of stabilization or destabilization caused by the Soret parameter is significant for the soret parameters which are less than Sr=2. In the absence of the Soret effect, the linear and nonlinear stability thersholds coincide. In the non-linear case, a destabilising effect is identified at higher mass flow rates. This subcritical instability region is identified between the linear and energy thresholds in the parameter space of the problem considered. Extensive interpretation of the solutions relating to the onset of convection is provided. The study is relevant to geophysical flows and materials processing systems.

Keywords- Thermo-convective instability; Double diffusive convection; Porous medium; Energy stability analysis; Soret effect, internal heat generation, horizo

Theoretical analysis of unsteady buoyant turbulent heat and mass transport from a vertical plate using LRN k-ε model(PA0002)

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Abstract- The authors studied the transient natural convective heat and mass transport of a turbulent flow adjacent to the vertical plate using low Reynolds number k-ε model. The research problem on turbulent flow is assumed to be two dimensional and viscous incompressible. The governing turbulent equations such as continuity, momentum, energy, concentration, turbulent kinetic energy (TKE) and dissipation rate of TKE are considered as per the flow geometry. Due to the non-availability of analytical or direct numerical techniques, the corresponding highly nonlinear PDE's are solved by adopting the standard implicit type of finite difference method namely Crank-Nicolson scheme. Also, this scheme is unconditionally stable and helps to keep the governing turbulent flow equations in discretized form and are solved via tridiagonal matrix algorithm. The simulated results for several control parameters including turbulent Reynolds number are graphically displayed and also analyzed the time averaged velocity, temperature, concentration, turbulence energy and dissipation rate of TKE profiles. To understand the physical phenomenon of turbulent flow, the authors shown the turbulent behaviour of average momentum, energy and mass transfer rates. It has been noted that, the average temperature and concentration fields boosted with rising values of 〖Re〗_t. Also, TKE and dissipation rate of TKE profiles increase with enhancing turbulent 〖Bu〗_t values. In addition, the simulated turbulent flow results from the LRN k-ε model are compared with usual laminar flows as a special case and found to be in respectable agreement.
Keywords- Turbulent energy and mass transfer, vertical plate, k-ε model, turbulence low Reynolds number, free convection.

Study of a supersonic-sonic patch arising in axisymmetric relativistic transonic flows with general equation of state(PA0009)

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Abstract- We prove the existence and regularity of a global smooth solution for a supersonic-sonic patch arising in modified Frankl problem in the study of three-dimensional axisymmetric steady isentropic relativistic transonic flows with a general equation of state over a symmetric airfoil. Such types of patches appear in many transonic flows over an airfoil and flow near the nozzle throat. Using the characteristic decompositions method and a well-known partial hodograph transformation in terms of angle variables, we prove the existence and regularity of solutions in the partial hodograph plane first and then obtain the global solutions in the physical plane by using an inverse transformation.
Keywords- Sonic-Supersonic Patch, Characteristic Decompositions, Partial Hodograph Transformation, Relativistic Euler Equations

Shock wave solution for the planar, cylindrically, and spherically symmetric flows of non-ideal relaxing gas(PA0016)

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Abstract- In the present article, we investigate one-dimensional non-ideal relaxing gas to study solution of shocks for planar and non-planar flows, more specifically cylindrically symmetric,

and spherically symmetric flows. The analytic solution of the problem is determined in the characteristic plane. It signifies that linear solution in this plane reveals non-linear behavior in the physical plane. Also, the condition of shock formation has been determined by analyzing the growth and deterioration of shocks using transport equations. It is observed that nature of the solution completely depends upon relaxing gas parameters and non-idealness. All computations are done using computational package MATHEMATICA.

Keywords- Shock wave, Relaxing gas, Non-ideal gas, Hyperbolic PDEs.

Time-domain simulation of flexural-gravity waves in a compressed sea-ice subject to 2D current over a stratified ocean (PA0018)

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Abstract- Ocean water stratification with respect to density is a natural phenomenon subjected to sudden variations of temperature or salinity along a vertical direction. Typically, strata of water consisting of different densities (individual stratum) are stacked above each other and separated by a thin layer, approximated as a line (for 2D) or plane (for 3D) interface where density varies rapidly and is visualized for mathematical formulation. The upper surface of the water is covered with a compressed ice sheet under the influence of a two-dimensional current. Due to the prevailing global climate change, such a harsh ocean environment is very much apparent, and so is its impact on sea ice in the polar regions. We aim to show the evolution of a Gaussian pulse subject to the ocean current and high in-plane compression, which accelerate the onset of wave blocking, a phenomenon that halts the wave energy propagation and generates multiple propagating wave modes.

Keywords- Compressed sea-ice, Stratified ocean, 2D current, Simulation.

The formation of a shock wave in a two-dimensional supersonic planar and axisymmetric non-ideal gas flow with the magnetic field(PA0019)

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Abstract- This paper presents an analysis of the shock formation in 2-D steady supersonic flow of non-ideal gas with a magnetic field for the planar flow and axisymmetric flows. It is shown that the governing equations describing the non-ideal gas flow with a magnetic field are hyperbolic in nature. Further, using the theory of the propagation of wavefronts defined by weak shock, we derived the transport equations for shock waves which lead to the determination of shock formation distance and provide the conditions of shock formation. The formation of the shock wave is affected by the presence of a magnetic field, non-ideal parameter, and upstream flow Mach number M0>1 is shown.

Keywords- Hyperbolic system · Partial differential equation · Non linear wave · Non-ideal gas ·Magnetic field

Surface wave profile due to oscillatory motion of an asymmetric block of ocean floor(PA0020)

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Abstract- Surface water wave generated due to ocean bottom oscillation is of great significance. In an underwater earthquake, the ocean bed undergoes movement for a short duration which induces wave motion in the seawater that travels along the surface for a significant amount of time. More often than, such wave propagation creates a tsunami at the shoreline. We here consider a somewhat simplified problem of the horizontal and rigid ocean floor, a finite chunk of which oscillates in the vertical direction at a rate that varies with respect to space. Such a variation creates an asymmetric floor surface profile of the oscillating block. The length of the oscillating block is assumed to be infinitely long, and its finite width is fixed. The ocean depth is considered to be constant outside the oscillating block. The boundary value problem (BVP) is formulated using the linearized water wave theory, and a displacement potential function is considered for the wave motion, which is assumed to be irrotational. The water is considered slightly compressible. A Fourier transformation in wavenumber and its inverse are used to solve the BVP that requires finding the residues at the singular points of the integral obtained from the dispersion relation the different wave modes follow. The impact of ocean water compressibility is introduced through the generation of acoustic-gravity waves that significantly alters the ocean surface profile. Assuming the problem as time harmonic, we intend to show the variation in surface profile elevation due to changes in ocean depth, length of the oscillating ocean floor, and its slope. In future, this time-harmonic solution will help finding the surface profile for a time-dependent problem where the temporal rise function of the ocean bottom block is arbitrary.

Keywords- Acoustic-gravity waves, ocean bottom displacement, Fourier transformation, surface waves

Double-diffusive convection in Darcy porous layer under inclined temperature gradient incorporating the Soret effect(PA0021)

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Abstract- This article presents linear and global stability results for the problem of double-diffusive convection in a Newtonian fluid saturated Darcy porous layer subjected to an inclined temperature gradient and incorporating the Soret effect. The temperature gradient is "inclined" as it contains vertical and horizontal components resulting from non-uniform heating, unlike the

classical Darcy-B´enard problem in which the temperature gradient has only a vertical component. Since there are two components in the temperature gradient, thus the formulation includes vertical and horizontal thermal Rayleigh numbers as system parameters while studying the stability of the layer. However, we focus on the influence of the horizontal thermal Rayleigh number on the system's stability, measured in terms of the vertical thermal Rayleigh number. The solutal Darcy-Rayleigh number, Lewis number, and the Soret parameter destabilize the vertical thermal Rayleigh number for most values of the horizontal thermal Rayleigh number. We compare the bounds obtained through linear and energy analysis to realize that for the present problem, energy bounds are stronger than the linear bounds, i.e., the subcritical instability exists. We further found that the subcritical instability region increases with an increase in the horizontal thermal Rayleigh number.

Keywords: Porous medium, Inclined

ESR fractional model with non-zero uniform average blood velocity(PA0022)

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Abstract- This article discusses a new solution to the time-fractional ESR model, taking into account the non-zero average blood velocity. We not only obtain an analytic solution to the generalized model of Sharma et al. and da Sousa et al., but also we present some new results which establish that the developed fractional order model is better-suited one by using which predicting the ESR rate can take place more accurately.
Keywords- Fractional derivatives and integrals, Erythrocyte sedimentation rate, Mittag-Leffler function, Wright function, Fractional PDE

Improved model of Reynolds shear stress distribution using modified second log-wake law at the central section of open channels(PA0023)

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Abstract- In natural resources, the velocity distributions of turbulent flow are often accelerated due to log law. For the pipe flow and boundary layer flows these types of laws are originally derived where the solid wall without a water-air interface exists. According to the literature most of the proposed models have not included the proper mathematical model of secondary current in shear stress distribution. Due to that the proper mathematical model is needed which further includes the effect of air-water interface effects. In this study, a new Modified Second Log-wake Law is introduced throughout the whole cross-sectional plane in a wide and narrow open channel. The effect of the water-air interface and bed configuration using the modified second log-wake

law in a whole cross-sectional plane of open channel flows is concluded and a better approximation is given.

Keywords- Reynolds shear stress, MSLWL, Secondary current, turbulent flow, open channel flow.

Onset of porous convection in a viscoelastic fluid with an internal heat source using LTNE model (PA0024)

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Abstract- The e_ect of internal heat source on the oscillatory convective instability in a horizontal porous medium is investigated when the uid and porous matrix are out of thermal equilibrium. The porous medium is saturated with a viscoelastic uid. The Oldroyd-B model of viscoelastic uid is considered. Assuming a small perturbation to the basic state ow, a linear stability analysis is performed to examine the e_ect of internal heat source on the thermal instability of the system. The critical oscillatory Darcy{Rayleigh number and critical wave number is derived for a wide range of parameters' governing the viscoelastic and thermal nonequilibrium e_ects. The e_ect of internal heat source is given by an internal Rayleigh number which is considered in the following ways (i) heat generation in uid phase (RIf) and (ii) heat generation in solid phase (RIs). The sensitivity of governing nondimensional parameters on the system's stability is analyzed and depicted graphically when the thermal non-equilibrium e_ects are prominent.

Keywords- convection, viscoelastic fluid, porous media, internal heat source, local thermal non equilibrium.

Water wave scattering by a circular flexible porous plate(PA0026)

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Abstract-Under the premise of linear water wave theory, the wave force acting on a circular flexible porous plate is investigated. The Fourier-Bessel series expansion approach, coupled with the methods of variable separation and eigenfunction expansion methods, are used to generate a semi-analytic solution. The plate is clamped-moored in order to maintain the appropriate position. The expansion formulas take advantage of the continuity of velocity and pressure as well as the appropriate orthogonal mode-coupling relationship for the eigenfunctions of the plate region to arrive at the system of equations and identify the unknowns. Finally, we analyse the

effect of plate porosity; compression; depth ratio and other physical factors on the vertical wave force acting on the circular flexible porous plate.

Keywords- flexible porous plate, eigenfunction expansion method, vertical force

Linearized Saint-Venant equations with uniformly distributed lateral inflow(PA0027)

SHIVA KANDPAL

Abstract- Full Saint-Venant (SV) equations in its linearized form is a popular choice to study open channel flows. Modified versions of SV equations can also accommodate lateral inflows. In this work, we present a solution for linearized full SV equations by considering uniformly distributed lateral inflow along the channel length for finite length rectangular channel. Our objective is to study the behaviour of the function that controls the role of lateral inflow. We study the behaviour of this function for different parameters at different locations of the channel and we observe that this function gets affected by the presence of both the upstream as well as the downstream boundary conditions.

Keywords- Linearized Saint-Venant equations, Lateral inflow, Convolution, Dynamic wave model.

Pressure variation along the tumor-infected esophagus from cervical to distal end.(PA0033)

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Abstract- This study discusses the non-steady effects associated with finite length tube encountered in real peristaltic pumps, as seen in oesophagus, for example. The purpose of this communication is to diagnose tumour in an oesophagus mathematically. This is modelled by generic bump function of certain height and width. The goal is to assess how pressure varies across the tumour's width. The spatial, as well as temporal, dependence of pressure has been studied in the laboratory frame of reference. The interruption while swallowing through benign oesophageal tumour is confirmed by the abrupt pressure rise across the tumour's width. Tumour

position also plays significant role whether it is at contraction or relaxation of walls. Further, this model is also implemented to the two-dimensional channel flow for an industrial application.

Keywords- Benign tumor; dysphagia; leiomyoma; epigastric; peristalsis; progressive transversal wave

Scattering of surface waves with floating bridge in presence of floating horizontal porous plate over trench type bottom topography(PA0034)

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Abstract: The problem involving oblique wave interaction with a floating bridge in the presence of a floating horizontal porous plate over a trench-type bottom is investigated. The role of the porous plate and the trench is analyzed in detail to reduce wave forces on the bridge. Significant changes are found in forces due to this porous breakwater and trench type of bottom topography compared to the case without breakwater and trench. In addition, the maxima in wave energy dissipation are associated with the minima in wave forces acting on the floating bridge. The findings from the present model are likely to be helpful in understanding the role of porous breakwater and trench in engineering applications.
Keywords: Floating bridge, Horizontal porous plate, Trench, Eigenfunction expansion, Wave forces.

Effect of porous layer fitted on a floating bridge in mitigating wave reflection.(PA0035)

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Abstract- Scattering of oblique water waves by a floating bridge with rectangular porous wall fitted on its vertical sides in finite ocean depth is studied. An oblique water wave interacts with a porous wall and is partially reflected. The whole fluid region is split into five sub-regions in which two regions are porous regions, and the remaining three regions are water regions, and the boundary value problem with respect to the velocity potential is solved in each sub-region by employing eigenfunction expansion technique. In order to figure out the reflection coefficients and hydrodynamic forces, a set of algebraic equations is formed from the appropriate matching conditions. Dispersion relation roots are analyzed and used in the system of linear equations. Significant changes in water wave reflection and forces are noticed due to changes in porosity. A decrease in reflection coefficient is observed as porosity increases. The effect of a number of parameters, such as the width of the porous wall, friction factor, angle of incidence, and draft of the bridge, on the reflection coefficients and hydrodynamic forces, is also investigated. Porosity does not affect the reflection coefficient up to a certain range of the wavenumbers. The behavior

of the reflection coefficient due to changes in the width of the porous wall is also analyzed. It is noted that, because of the rectangular porous wall, a large amount of wave energy gets reflected back, and the waveload thus gets reduced on the floating bridge. Graphs support all of our observations. The excellent agreement between our results and earlier results establish the validity of the present model.

Keywords- floating bridge, porous wall, oblique wave, reflection.

Development and performance evaluation of a novel high density clean packer and completion fluid for oil and gas field application(PA0040)

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Abstract-n We found that the novel clean packer and completion fluid has high density strengths and they can be further improved with additives to lower the damage to the tools and producing formation. All these might allow us to design and develop a clean fluid that is reclaimable, recyclable, safe to handle and do not damage the producing formation or down-hole metals with lesser requirements for cleanup operations and a reduced disposal costs. Our completion fluids results are important for applications in HPHT reservoir. Generally, the packer and completion fluid needs to provide and maintain sufficient pressure on the formation, and this pressure, aids the emplacement of production liners, screens, valves, and other control hardware after drilling but prior to production. In this paper, our results show that, fluid has high density of 13.41 lb/gallon and solid free having optimum rheology (low viscosity). Importantly, high density fluid systems have the ability to control the high reservoir pressure for wellbore stability with high density, which contains solid- free and maintains rheological stability at the HPHT reservoir for minimizing the formation damage and satisfy environmental requirements. As we know that, the era of easy oil and gas has ended and new hydrocarbon fields are being explored and investigated at high combinations high pressure and high temperature (HPHT) wells.

Keywords: Packer fluid, Solid-free, Rheology, HPHT well, High density fluid, Petroleum reservoir, Energy.

Study of water wave interaction with a submerged bottom-mounted compound porous cylinder in the presence of a porous sea-bed (PA0041)

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Abstract- The scattering problem of a submerged bottom-mounted compound porous cylinder located on a porous sea-bed is theoretically investigated under the assumption of linear potential flow theory. The compound cylinder is comprised of an impermeable inner cylinder and a porous outer cylinder. The boundary conditions on the porous boundaries follow Darcy's law by assuming fine pores in the porous structure. The whole fluid region is split into three bounded and an unbounded sub-regions, within which the individual velocity potentials are found by using eigenfunction expansion technique. Further, utilization of the matching conditions along the boundaries of individual successive regions leads to a

semi-analytical solution of the proposed problem. The impact of the non-dimensional porous-effect parameter of the cylindrical wall, the draft ratio, radius ratio and the sea-bed porosity on wave loads and free-surface elevation are studied. In addition, the wave power dissipation for the system is calculated by integrating the power absorbed by outer cylinder porous wall via direct method. Also, the far-field scattering coefficients are obtained with the help of asymptotic forms of Hankel functions in the plane wave representation form. Numerical results for the far-field scattering coefficient and power dissipation are investigated for various parameters. The results show that suitable consideration of porosity and structure parameters enhance the efficiency of the proposed compound cylinder in mitigating wave impact. Furthermore, the hydrodynamic wave load acting on the inner as well as outer cylinder can be reduced by the suitable positioning of the annular spacing of the system, which will provide explicit information for the purpose of engineering design in the offshore and coastal region.

Keywords- Porous cylinder, Porous sea-bed, Wave run-up, Hydrodynamic force, Moment.

Time-dependent wave motion in stratified fluid with permeable bottom(PA0044)

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Abstract- The general time-dependent problem associated with the initial transient response is solved using the Laplace-Fourier transform method and the method of stationary phase. The derived interface elevation and plate deflection are highly oscillatory in nature, so the asymptotic form of the interface elevation and plate deflection are derived using the method of stationary phase. The effect of different physical parameters like flexural rigidity, compressive force, ratio of upper and lower layer density, porosity parameter on interface elevation and floating plate deflection at a large time is discussed. Also, the general time-dependent problem associated with the initial Gaussian response is solved numerically using the spectral method and the simulation at a different time for floating plate deflection and interface elevation are presented.

Keywords- Gravity wave, Time dependent wave motion, Stratified Fluid, Porous bed, Current

Wave scattering by a partial flexible-porous breakwater moored in water of varying depth(PA0045)

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Abstract- This article investigates oblique surface wave scattering by a partial flexible-porous breakwater. The submerged flexible breakwater is moored to an uneven seabed through tethers and kept in tension. The boundary value problem is analyzed under the assumptions of small-amplitude water waves and Darcy's law for liquid flow past a porous medium. The problem is solved by using the Eigenfunction expansion in the region of uniform bottom and the Galerkin-

Eigenfunction expansion in the region of uneven bottom topography. Using Green's function technique, the structural deflection is obtained. The effect of clamped-moored flexible breakwater and refraction-diffraction due to uneven seabed on wave scattering is explored. The variations of wave reflection and transmission coefficients with wave, structure, and seabed parameters are illustrated. Parameter values are analyzed for optimum wave reflection and transmission.

Keywords- Flexible-porous breakwater, Mooring edge, Uneven seabed, Wave reflection, Wave transmission

Influence of dilating amplitude on the two-layered peristaltic driven flow in a catheterized tube: An application to Swallowing disorder.(PA0046)

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Abstract- Swallowing in a catheterized oesophagus is modeled mathematically by considering a mucous peripheral layer by duly considering mass conservation of the fluids independently in the peripheral and the core layers. Peristaltic waves governing the flow are assumed to have progressively dilating amplitude so that the distal oesophagus experiences higher pressure to ensure smooth delivery of gradually globular getting bolus into the abdomen through the cardiac sphincter [Kahrilas et al., 1995, Pandey et al., 2017]. To find solutions in terms of stream function, the long wavelength and low Reynolds number technique is applied. Mass conservation separately in the two layers is ensured by solving the interface as a streamline from an algebraic equation of the fourth-order. A similar attempt [Medhavi and Singh, 2012] for uniform wave amplitude had ignored mass conservation identically in the two layers by a wrong assumption of a fixed ratio between the layers. Due to unrealistic assumptions, those results cannot be accepted. Expressions for pressure, flow rate, and forces for the tube with the catheter are derived. A comparative analysis of introduced catheter and without catheter during oesophageal swallowing has been done. The interface between the two layers is discussed, and the results are obtained. Variation of pressure with flow rate over one wavelength and also distribution along the axial direction is studied. Even when the tube is catheterized, a linear relationship between pressure and flow rate is discovered. Flow rate increases with pressure. It is found that pressure increases with peripheral layer viscosity. It has also been observed that flow rate increases with increase in peripheral viscosity. It's also been discovered that the flow rate in a catheterized oesophagus increases for fixed pressure differences the peripheral layer gets thinner.
Keywords- Newtonian fluid, Catheter, Dilating amplitude, Swallowing disorder.

Modeling of Mexican Hat Wavelet Neural Network with L-BFGS Algorithm for Simulating the Recycling Procedure of Waste Plastic in Ocean(PA0048)

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Abstract- In the global economy, plastics are considered a versatile and ubiquitous material. It can reach to marine ecosystems through diverse channels, such as road runoff, wastewater pathways, and improper waste management. Therefore, rapid mitigation and reduction are required for this ever-growing problem. The marine habitats are believed to be the highest emitters and absorbers of O2 and CO2 respectively. As such, every day, the prominence of managing the litter in the ocean is growing effectively and efficiently. One of the most significant challenges in oceanography is creating a comprehensive meshless algorithm to handle the mathematical representation of waste plastic management in the ocean. This research dedicates to study the dynamics of waste plastic management model governed by a mathematical representation depending on three components viz. Waste plastic (W), Marine litter (M) and Recycling of debris (R), i.e., WMR model. In this regard, an unsupervised machine learning approach, namely Mexican Hat Wavelet Neural Network (MhWNN) refined by the efficient Limited-memory Broyden–Fletcher–Goldfarb–Shanno algorithm (L-BFGS), i.e. MhWNN-LBFGS model has been implemented for handling the non-linear phenomena of WRM models. Besides, the obtained solution is compared with the state-of-art numerical result to establish the precision of the MhWNN-LBFGS model. Furthermore, different global statistical measures (MAPE, TIC, RMSE, and ENSE) have been computed at twenty testing points to validate the stability of the proposed algorithm.

Keywords- Wavelet Neural Network, Mexican Hat, L-BFGS, Waste Plastic, Ocean.

Numerical soliton solutions of fractional Newell-Whitehead-Segel equation in binary fluid mixtures (PA0051)

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Abstract: In this work, the time-fractional Newell-Whitehead-Segel equation describing the occurrence of stripe patterns in two-dimensional systems has been solved numerically using the Kansa-radial basis function collocation method. Also, this equation describes the dynamic behavior near the bifurcation point of the Rayleigh–Benard convection in binary fluid mixtures. First, the finite difference approach is utilized to discretize the time-fractional derivative. Then, the Kansa method is employed to discretize the spatial derivatives. The stability and convergence of the time-discretized scheme are also established. Numerical experiments are performed to justify the theoretical results. Also, the obtained graphical representations demonstrate the accuracy and applicability of the proposed numerical technique. The investigations in this work can be useful in understanding the dynamic behavior of this model.

Keywords- Fractional Newell–Whitehead–Segel equation, Radial basis function, meshfree method.

Similarity Solutions for Cylindrical Shock Wave in a Low Conducting Gas Using Lie Group Theoretic Method(PA0057)

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Abstract- This paper aims to find the solution of a quasilinear hyperbolic system of partial differential equation describing one-dimensional unsteady, cylindrically symmetric flow of a weakly conducting perfect gas under the influence of axial magnetic field. It is assumed that the initial density and magnetic field has power law dependence on the distance in the undisturbed medium. One-parameter Lie group of infinitesimal transformations are used which leaves the governing system of partial differential equation invariant and give rise to a system of determining equation. By using the invariance surface conditions the infinitesimal generators of Lie group are determined. And four different cases of the solution have been discussed on the basis of the arbitrary constant present in the infinitesimal. Numerical solutions have been obtained for the power law shock path. The effect of the variation of the initial density, ratio of the specific heats of the gas and magnetic Reynolds number on the propagation of shock and the flow behind it are investigated. The patten of all flow variables behind the shock are analyzed graphically.

Keywords- Shock waves, Lie group of transformations, Similarity solution, weakly conducting gas.

Spatial-averaged conditional stress distribution over hemispherical rough bed (PA0058)

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Abstract - Most of the three-dimensional heterogeneous flow-field is observed due to the interaction of fluid flow with various kinds of rough obstacles in near-bed region. In this experimental study, some important flow-properties are discussed in term of spatially-averaged flow variables over various spacing (p/r = 2, 4, 6 and 8; p = pitch distance; r = height of the hemisphere) hemispherical rough bed arranged in regular pattern. In this purpose, a 3D Micro-acoustic Doppler Velocimeter (ADV) is used to measure the instantaneous velocity components for Reynolds number, Re = 64000. In the roughness region, the maximum spatially-averaged total stress indicates the conservation of immersive outward momentum flux which is mostly promoted for the bed condition p/r = 4. Quadrant analysis states that the stress-contributors conserves their immersive strength at the flow-depth ratio z/h = 0.07 compared to z/h = 0.14; which is decreases in such hemispherical spacing order p/r = 4 > 2 > 6 > 8. By using the

turbulent-kinetic-energy budget analysis, it is noticed that the production and dissipation rates are maximum at the starting zone of form-induced sub-layer and just below the upper boundary of interfacial sub-layer respectively. Again, these two regions are respectively treated as the zone of turbulence exploration and the zone of energy access.

Keywords: Rough bed, Turbulence, Spatial-averaged technique, Turbulent-kinetic-energy budget.

Effects of boundary absorption and wind on environmental dispersion for wetland flows(PA0059)

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Abstract- Wetland are characterised by flow and environmental dispersion which are necessary in water management system. When an instantaneous contaminant release into a wetland, there are both boundaries absorption and wind can large impact on contaminant dispersion process. Therefore, the present study performed to highlights the effects of wind and boundaries absorption on environmental dispersion, longitudinal mean concentration and velocity profile in a width-dominated shallow wetland flow. In this work, a multi-scale time period are considered to formulate dispersion model. By adopting this method, it is seen that the contaminant transport process is greatly influenced by various ecological parameters such as dispersion time, boundary absorption, tortuosity and vegetation drag. Also, the distribution of flow velocity, which is derived from basic equation of momentum for different wind intensity, is discussed. The significant effects of boundary absorption intensity on longitudinal and mean concentration are illustrated. Moreover, the effects of wind, the distribution of concentration would be complex for considering the existence of boundary absorption. It is observed that the effect of vegetation parameter and tortuosity (κ) in longitudinal concentration distribution is similar as in transverse concentration distribution. It is convey that the longitudinal concentration of contaminant gradually decrease for increase in vegitation parameter and tortuosity(κ). Keywords: Wetland, Boundary absorption, Environmental dispersion, Contaminant transport.

Keywords- Wetland, Boundary absorption, Environmental dispersion, Contaminant transport.

Wave scattering by flexible porous breakwater in the presence of step-type bottom(PA0060)

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Abstract- The problem of oblique wave scattering by thin flexible porous breakwater in the presence of step-type bottom is analyzed by employing eigenfunction expansion method. System

of equations is derived by applying matching boundary conditions. In the present problem, reflection and transmission coefficients are obtained by solving system of equation.

Keywords- Porous flexible breakwater, Mild-slope equation, Eigen function.

Uni-modal grain size distribution in a two-phase flow over a fine sand bed (PA0064)

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Abstract- Study of turbulent flow with suspended particulates in open-channel is a key topic of interest in fluid mechanics because it plays an important role in sediment suspension in rivers and many industrial processes. When the flow carries large amount of sediments in suspension, the properties of fluid mixtures are modified in terms of viscosity and density in suspension, and hence there is a change in flow properties. This study addresses the turbulence characteristics of sediment-laden flow and development of theoretical models for velocity and suspension concentration in sediment-mixed fluid. Variations of grain size distributions of suspension and bed load under the flow velocity and height of suspension above the bed are studied. A system of integro-differential equations of velocity and suspension concentration is developed, considering Reynolds shear stress in terms of mixing length of sediment mixed fluid for the formulation of vertical velocity distribution.
Keywords: Turbulence; sand bed; suspension; grain-size distribution.

Flexural gravity wave blocking in a submerged plate resting on a viscoelastic foundation(PA0066)

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Abstract- During the last decades, there is a rise in interest to study wave interaction with flexible submerged structures. For higher stability of the submerged plate with minimal structural vibration, one of the novel mechanisms is to allow the submerged plate to rest on a viscoelastic foundation. A recent study on wave interaction with floating structures has revealed that wave energy propagation ceases for two different frequencies in the presence of compressive force, which is referred to as wave blocking. In our study, the interaction of surface gravity waves with an infinitely extended submerged plate resting on a viscoelastic foundation is investigated in the presence of lateral compressive force. It is observed that no wave blocking occurs in the

submerged plate mode irrespective of the values of compressive force in the absence of elastic foundation. However, in the presence of elastic foundation without viscous damping, blocking occurs in the submerged plate mode and as a result, four propagating wave modes exist within the blocking frequencies, out of which one is at the surface mode and the others being at the submerged plate mode. Further, the study depicts that wave blocking does not occur in the presence of a viscoelastic foundation, which includes the effect of viscous damping, irrespective of the values of compressive force. Various results will be presented for different values of elastic and viscous damping constants associated with the viscoelastic foundation to understand the movement of the loci of the roots of the associated dispersion relation. Accordingly, the plate deflections are exhibited for different wave modes, which reveals the decaying pattern due to the presence of viscous damping.

Keywords- Flexural gravity wave, wave blocking, elastic foundation

An efficient explicit jump HOC immersed interface approach for transient incompressible viscous flows(PA0067)

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Abstract- We present a novel hybrid explicit jump immersed interface approach combined with a higher order compact (HOC) scheme for simulating transient complex flows governed by the streamfunction-vorticity (psi-$zeta$) formulation of the Navier-Stokes (N-S) equations for incompressible viscous flows. For the jump conditions at the irregular points across the interface, a new strategy of Lagrangian interpolation on a Cartesian grid has been used. This method, which begins with the discretization of parabolic equations with discontinuities in the solutions, source terms, and coefficients across the interface, is easily adaptable to simulating flow past bluff bodies immersed in the flow. The approach's superiority is reflected in the lower magnitude and faster decay of errors when compared to other existing methods. It is seen to handle several fluid flow problems with practical implications in the real world, including flows involving multiple and moving bodies, very efficiently. This includes flows past a stationary circular and a twenty-four edge cactus cylinder, as well as flows past two tandem cylinders, where one is fixed and the other oscillates transversely with variable amplitude in time. To the best of our knowledge, the last two examples have been approached for the first time using this method, which employs the psi-$zeta$ formulation in a finite difference setting. The extreme similarity of our computed solutions to existing numerical and experimental results exemplifies the proposed approach's accuracy and robustness.

Ketwords- Immersed Interface, Explicit Jump Conditions, HOC, Cactus, Oscillating tandem cylinder.

Water waves scattering by undulating bottom in the presence of current and surface tension in a two-layer fluid(PA0083)

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Abstract- In the present work, the scattering of water waves by undulating bottom in a two-layer fluid system is investigated by the inclusion of current and surface tension. The perturbation technique followed by the Fourier transform method is applied to solve the coupled boundary value problem and the associated velocity potentials, reflection coefficients, and transmission coefficients are obtained. A particular case of undulating bottom, namely sinusoidal bottom undulation, has been taken into consideration for showing the effects of current speed and surface tension.

Keywords- Water waves, Current speed, Surface tension.

Estimation of the coefficient of damping for sloshing in rectangular tanks using CFD (PA0085)

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ABSTRACT -The movement of a tank partially filled with liquid can result in sloshing, and cause a displacement of the liquid's free surface. Analysis of sloshing is important because it affects the dynamic stability of the tank containing the liquid. To minimize the effects of sloshing, the energy of the liquid should be dissipated. This can be done by installing a baffle within the tank to dampen the flow. In this work, the effects of a baffle's aspect ratio and its location on the sloshing dynamics are studied using OpenFOAM. The results are compared with existing experimental and numerical data. Here, we calculate the kinetic energy (KE) of the fluid as a function of time, after the removal of external forcing. Then, we fit a straight line to the logarithm of the nondimensionalized KE data and measure its slope to obtain the damping coefficient. For this purpose, we developed a separate code in OpenFOAM by modifying the interFoam solver. We find that the baffle located at the center of the tank results in the maximum damping rate.

Keywords- Computational Fluid Dynamics CFD, coefficient of damping, sloshing.

A deep learning-based numerical approach for the natural convection inside a porous media(PA0087)

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Abstract- A deep learning-based numerical method is employed to handle various simple and complex mathematical models associated with the natural convection fluid transport phenomena. The present work is dedicated to exploring the performance of the deep learning approach for various flow situations in porous media. The computational domain is discretized by the randomly sampled spatial and boundary points that are further utilized in training the feed-forward neural network. A loss function is formulated based on the governing equation and boundary condition, which value is further minimized through the backpropagation algorithm with a suitable optimizer. The finite element method is employed for validating the results of the deep learning method. The compatibility of results from the present work with FEM is outstanding. Therefore, the deep learning approach can be a potential alternative to the traditional numerical scheme for studying the natural convective study in the porous enclosure.

Keywords- porous media, deep learning, finite element method.

PROPAGATION OF BLAST WAVE IN A ROTATIONAL AXISYMMETRIC NON-IDEAL GAS: POWER SERIES METHOD (PA0094)

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Abstract- In this paper, the propagation of the blast (shock) wave in a non-ideal gas atmosphere in the rotational medium is studied using a power series method in cylindrical geometry. The flow variables are assumed to be varying according to the power laws in the undisturbed medium with distance from the symmetry axis. To obtain a similarity solution, the initial density is considered as constant in the undisturbed medium. Approximate analytical solutions are obtained using Sakurai's method by extending the power series of the flow variables in power of the ratio of the velocity of shock and speed of sound in undisturbed fluid. With the aid of that method, the closed-form solutions for the zeroth-order approximation is given as well as

first-order approximate solutions are discussed. Also, with the help of graphs behind the blast wave for the zeroth-order approximation, the distributions of variables such as density, radial velocity, pressure and azimuthal fluid velocity are analyzed. The results for the rotationally axisymmetric non-ideal gas environment are compared to those for the ideal gas atmosphere in non-rotational motion. It is determined that the shock strength reduces when the rotating medium is taken into account and increases with the adiabatic exponent and non-idealness parameter of the gas.

Ketywords- Shock and blast waves, Rankine-Hugoniot conditions, power series solutions, Non-ideal gas, Rotating medium.

Thermal Convection for Ferrofluid Layer with Different Boundary Conditions (PA0098)

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Abatract -The nonlinear stability analysis for convection in a magnetized ferrofluid layer heated from below is studied for free-free, rigid-free and rigid-rigid conducting boundaries. The eigenvalue problem is solved with single-term Galerkin method for the three types of boundary conditions. The ferrofluid is found to be more stable as compared to the ordinary viscous fluid and for free-free, rigid-free, rigid-rigid boundary conditions the effect of magnetic parameter is also analyzed at the onset of convection.

Keywords: ferrofluid, nonlinear stability, free-free; rigid-free; rigid-rigid boundary conditions, Galerkin method.

Waves past a rigid porous structure in stratified water of varying depth(PA0099)

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Abstract- Oblique wave scattering by a rigid porous breakwater in stratified water with undulated bottom topography is studied by using linear wave theory and Darcy's law for flow through the porous medium. The classical eigenfunction and Galerkin-eigenfunction expansion methods are used in flat and undulated bottom regions. The impact of surface and interfacial waves by bottom undulation has been taken into consideration. The scattering coefficients, such as reflection and transmission coefficients of the surface and interfacial waves for different wave and structural parameters are investigated. The study found that the wave reflection is high for incident surface and interfacial waves as the value of the porous-effect parameter G decreases. Moreover, wave transmission decreases with decreasing G.

Keywords- Stratified water, Porous breakwater, Varying bottom, Mild-slope equation, Reflection coefficient, Transmission coefficient

NUMERICAL INVESTIGATION OF HEAT TRANSFER IN A POROUS CHANNEL WITH SEMI-CIRCULAR HEATER/ COOLER AND Al2O3-Cu WATER-BASED HYBRID NANOFLUID(PA0100)

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Abstract-The combined implementation of porous medium and hybrid nanofluid with heaters/coolers can be a suitable technique to increase the effectiveness of various electric appliances. In this regard, the present study has been conducted to analyze the forced convection heat transfer of Al2O3 -Cu water-based hybrid nanofluid in a porous channel with a pair of semi-circular heater and cooler. The Peclet number ($25 \leq Pe \leq 200$), Darcy number ($10\text{-}6 \leq Da \leq 10\text{-}1$), porosity ($0.1 \leq \varepsilon \leq 0.9$) and volume fraction of hybrid nanoparticles ($0.1\% \leq \phi \leq 5\%$) are chosen as the operating parameters. The governing equations along with the suitable boundary conditions are solved by using the Finite element method. The thermal field is explored with the help of isotherm profiles, local Nusselt number, and average Nusselt number. The obtained results depict that the impact of Darcy number on isotherm contours magnifies as the value of the Peclet number increases. The highest heat transfer can be observed at the sharp corners of the heaters and coolers. The heat transfer from the heater/cooler is improved by diminishing the values of Darcy number and porosity.

Keywords- heater, cooler, hybrid nanofluid, porous channel, porosity

Comparative study of the scaling of sediment transport in a bifurcated channel with reference to the river Kangasabati(PA0102)

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Abstract- An experimental study on a scaled physical model of the bifurcation in river Kangsabati was conducted with the main objective to produce model-prototype similitude for the aspect of sediment transport and the approximate transport capacity. The approach that has been employed for physical model studies is based on a relationship between the dimensionless bed

shear (shield parameter) and grain Reynold number. The model was tested with different sediment sizes of varying densities with a set of predetermined discharges. In order to compare the applicability of the model to physical ones in river engineering applications, a thorough analysis and discussion of the results are presented in this article.
Keywords: Similitude, Shield Parameter, Grain Reynold Number

Scattering of oblique flexural gravity waves by an articulated floating elastic plate within the frame of wave blocking(PA0106)

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Abstract- In the present study, the scattering of oblique flexural gravity waves by an articulated floating elastic plate having structural heterogeneity is analysed with the inclusion of lateral compressive force within the reference frame of blocking dynamics. In the presence of a compressive force, group velocities vanish at two different periods where primary and secondary wave blocking occur. Furthermore, there are three propagating wave modes for each time period between the primary and secondary blocking points, two of which are associated with positive group velocities, and one of which is related to negative group velocity. In the case of single or multiple propagating wave modes, the energy relation associated with the flexural gravity wave scattering is then established using energy flux conservation. Concerning the two propagating wave modes with positive group velocities, the energy transfer rate corresponding to the mode with the largest wavenumber significantly contributes to the energy relation near the primary blocking point, whilst the other mode exhibits a close resemblance near the secondary blocking point. Additionally, to account for the principle of conservation of energy flux, the incident wave mode modulates between the primary and secondary blocking points. The study also demonstrates an inverse relationship between the rate of energy transfer and transmitted wave amplitude. Full-wave reflection occurs in the case of obliquely incident waves beyond a critical angle for a specific period of time. In addition, there are four removable discontinuities in the pattern of the reflection and transmission coefficients at the primary and secondary blocking points. However, there is a jump discontinuity at the location of incident wave mode conversion between the blocking limits. Additionally, irregular behaviour in plate deflection is perceived to be a consequence of the superposition of multiple wave modes that are propagating for a given period of time within the blocking limits.

Keywords- Flexural gravity waves, Wave blocking, Compressive force

Modal Analysis of Undamped MDOF Vibratory System(PA0108)

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Abstract- This paper deals with the numerical estimation of modal parameters such as natural frequencies and mode shapes using basic vibration theory for two and three Degree of freedom (DOF) vibratory system. The procedure can be extended to an 'n' DOF vibratory system easily. The equations of motion are dependent on each coordinate. The principle of orthogonality of mode shapes is used to convert the physical coordinate system into generalised coordinate system which give rise to an n–uncoupled differential equations. Response for free vibrations for each DOF can be obtained for different initial conditions to analyse the system. It can be realised that the response for an arbitrary initial displacement to the masses are the superposition of responses for each mode of vibration.
Keywords- Discrete systems, Modal analysis, Mechanical Vibration

Investigationofdilating/squeezingasymmetricchannelflowduetoMHDhybrid Nanofluidflow(PA0109)

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Abstract- An analysis has been carried out to investigate the effect of magnetohydrodynamic hybridnanofluid flow in dilating/squeezing asymmetric channel walls. Since, hybrid nanofluid boots the rate of heat transportations as compared to the conventional fluid flow.T herefore, this investigation is executed to study the flow behaviour of proposed model with hybrid nanofluid. Governing equations of the proposed model are adequately reframed to a set of ordinary differential equation by employing similarity variables and then numerically solved by Runge-Kutta-Fehlberg with shooting technique. Furthermore, graphs and tables of the physical parameter are illustrated with velocity and temperature profiles.

Keywords- Hybrid nanofluid; asymmetric channel; Heat transfer; MHD flow.

Comparative Study of CDP and JH2 Damage Model of Koyna Dam under Blast loading by CEL Technique (PA0110)

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ABSTRACT -Present study aims to analyze the dynamic response of Koyna dam with reservoir interaction under the influence of underwater explosion in ABAQUS/CAE. For dam water interaction, water in the reservoir is modeled by volume-of-fluid method in coupled Eulerian-Lagrangian (CEL) technique in which each element of material is meshed in Eulerian Volume fraction (EVF). Concrete is modeled as lagrangian mesh while the TNT, air and water are modeled as eulerian mesh. The response of a dam subjected to underwater explosion is studied for different targets with respect to stagnation and detonation point. Non-Linearity of concrete is considered using Johnson-Holmquist 2(JH-2) model and Concrete Damage Plasticity model. Results are evaluated and compared based on pressure history curves subjected to different TNT weight. Effect of foundation is neglected for the present study.

Keywords: ABAQUS, CEL Technique, Under water explosion, Concrete Damage Plasticity model and Johnson-Holmquist 2 (JH-2) model.

The general model of the outer size of the tropical cyclone(PA0112)

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Abstract- There are many analytical models of the tropical cyclone intensification and potential intensity which explain the existence of double exponential term as the reason for the rapid intensification of the tropical cyclonic winds. However, such framework has been unable to explain the evolution of the outer circulation. After a tropical cyclone reaches its lifetime maximum intensity, the increase in TC destructive potential can be explained mainly by the expansion of the outer size. An analytic growth model of the tropical cyclone outer size is derived from the angular momentum equation. The growth model fits a full physics idealized tropical cyclone simulation. The lifecycle composite of the best-track outer size growth shows a strong super-linear nature, which supports an exponential growth as predicted by the growth model. The climatology of outer size growth measured by the radius of gale-force wind in the North Atlantic and Eastern Pacific during the period 2004–2017, can be understood in terms of four growth factors of the model: the initial size, the growth duration, the mean growth latitude, and the mean top-of-boundary-layer effective local inflow angle. All four variables are significantly different between the two basins. The observed lifetime maximum size is in line with the law of the proportionate effect of this exponential growth model. The exponential size growth at a fixed time is approximately equal to the product of the Coriolis parameter and the mean effective inflow angle above the boundary layer. Further sensitivity experiments with the growth model suggest that the interannual variability of the global lifetime maximum size is largely driven by the variation of growth duration.

Keywords- Outer size, potential intensity, gale force wind, mean growth latitude, boundary layer, inflow angle, lifetime maximum size.

Riemann problem for a strictly hyperbolic system of conservation laws using self-similar vanishing viscosity method(PA0115)

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Abstract- We study the Riemann problem for a strictly hyperbolic system of conservation laws which occurs in gas dynamics and nonlinear elasticity. Existence and uniqueness of the solution of Riemann problem containing delta shock wave is established by employing self-similar vanishing viscosity method. We prove that delta shock is stable under self-similar viscosity perturbation.

Keywords- Riemann problem; Delta shock wave; self-similar vanishing viscosity; strictly hyperbolic system

The effect of chemical reaction on Stationary thermosolutal magneto-convection under non-equilibrium temperature conditions(PA0118)

MONAL BHARTY

Abstract- Under local thermal non-equilibrium temperature conditions, the effect of chemical reaction on the onset of stationary thermosolutal magneto-convection in a viscoelastic fluid saturated anisotropic porous material is investigated. The stability criteria is examined with the help of normal mode technique, and Rayleigh number for stationary convection is computed. Linear stability analysis is used to investigate the effect of different parameters on the onset of convection. It is shown that with increase in the value of Chandrashekhar number (Q) and interphase heat transfer (τ), minimum of Rayleigh number also increases, stabilizing the system. We consider viscoelastic binary fluid saturated anisotropic porous layer confined between two horizontal parallel planes. A constant magnetic field is maintained externally in the vertically upward direction and origin is picked in the lower boundary of Cartesian frame of reference. To account for the influence of density fluctuation, the oberbeck-boussinesq approximation is used. The stability criteria for the above problem are studied by the help linear stability analysis because linear stability analysis is useful to predict marginal thresholds.

Keywords- Porous media, Rayleigh number, Local thermal non equilibrium, Viscoelastic fluid

Influence of Chemical Reaction on the Stability of Double Diffusive Flow in a Vertical Channel filled with Porous Medium(PA0124)

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Abstract- The present study investigates the influence of chemical reaction on the linear stability of double-diffusive mixed convection flow of binary mixture in a vertical channel filled with porous medium. The walls of the channel are assumed to be at chemical equilibrium. The buoyancy-driven flow is induced by combined temperature and concentration gradients. The study shows that the chemical reaction parameter tends to stabilise the basic flow in a porous medium with high permeability whereas it tends to destabilise the basic flow in a porous medium with relatively low permeability.

Keywords- Porous medium, Mixed convection flow, Double-diffusive flow, Linear stability, Chemical reaction

Micropolar fluid moving peristaltically through porous media in a tube(PA0125)

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Abstract- The MHD flow of a micropolar fluid through a porous media caused by sinusoidal peristaltic waves travelling along the cylindrical tube walls is analysed and determined in this research. The nonlinear issue is solved in the closed form utilizing low Reynolds number and long wavelength approximations, and expressions for the axial velocity, and pressure rise per wavelength are derived using perturbation technique. By constructing graphs depending on the outcomes of the computation, the effects of relevant parameters on the aforementioned quantities are investigated. It is discovered that while permeability of the porous medium degrades, the pumping improves with Hartman number.

Keywords- Micropolar fluid, Peristalsis, Porosity

Numerical Investigation of Wave Forces on Large Rectangular Cylinder using REEF3D(PA0131)

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Abstract- From many years piles have been used in coastal structures. Due to the increase in the demand of renewable energy resources, the use of wind turbine and its applications have increased tremendously. Offshore wind turbine which are generally founded as a monopile up to 30m depth are termed as large piles. When we consider the large piles, diffraction plays an important role in the flow and scouring process along with the other parameters. In coastal contexts, new offshore constructions with rectangular cross-sections are appearing alongside those with circular cross-sections. When the waves interact with the huge rectangular shaped structure, it modifies the characteristics of the incident wave field. It even affects the wave-

hydrodynamics like wave radiation and diffraction. Flow processes such as wave run-up, reflection, and transmission are altered by the changing kinematics of the flow field. Although the KeuleganCarpenter number is the primary useful parameter for slender piles, it is believed that the diffraction parameter drag and inertia forces are equally effective for large piles. When the diffraction parameter, which is the ratio of the cylinder diameter (D) to the incidence wavelength (L), is more than 0.2 and the KC number is less than 2, inertia dominates the flow, and wave diffraction effects are significant. In this numerical model the Reynolds-averaged Navier– Stokes (RANS) equation with k-ω turbulence model closure gets solved by an open source model REEF3D. Hydrodynamics load is important for understanding the effect of the waves with these structures. The use of the Level-Set method is done to capture the changes in the free surface. The numerical model is verified by modelling the wave interaction with experimental results. Then, for various incident wave steepness, the wave interaction with a single large cylinder with varying aspect ratios of the rectangular cylinder is investigated.

Keywords- Wave Hydrodynamics, Wave Loads, Large Rectangular Piles, CFD

Numerical investigation of the effect of odd viscosity on the stability of the flow of thin liquid film on an inclined plane in the presence of a normal electric field (PA0138)

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Abstract- In this paper, we numerically investigate the dynamics of a thin liquid film with broken time-reversal symmetry flowing down an inclined plane in the presence of a normal electric field based on the earlier work of Bao and Jian (*J. Physical Review E, vol 103, 2021*). We perform the numerical analysis considering a fully nonlinear evolution equation in the periodic domain. Our results show that the electric field enhances the instability while odd viscosity stabilizes the surface waves caused by the electric field. These results are in good agreement with the results of the linear and weakly nonlinear analysis as reported by Bao and Jian.

Keywords: Thin film flows, instabilities, odd viscosity, electric field

Assessment of Turbulence Modeling for Gas Flow in a Two-Dimensional Plug Nozzle (PA0144)

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Abstract- The complicated flowfield phenomena (shock-pattern, shock-boundary layer interaction, high-speed shear layers and vortices, fluctuations), in which turbulence plays a prominent role that emerges in contoured rocket nozzles, make it difficult to simulate separated flows accurately by numerical analysis. Since many previous turbulence models intended for engineering applications have failed, it is evident that turbulence modeling is essential for simulation success, particularly for precisely predicting shock-induced flow separation. In this study, a steady-state simulation is performed for an in-house plug nozzle, and validation findings with the flow in the linear plug nozzle using different turbulence models are compared. It was found that the SST model produces more accurate results than the other model; However, the comparison with experimental data shows that it still somewhat predicts an earlier separation position.

Keywords- Turbulence model, RANS, plug nozzle.

Physical Model Study of Alluvial Bend Channel with and without Structural Measures(PA0151)

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Abstract-A meandering river changes its path continuously till it reaches a stable condition. Due to lateral erosion caused by this kind of river, different hydrological constructions get damaged, even though they are far from the watercourse. In this paper authors are going to see if any control measures may be taken for control this meandering process. A channel was constructed on an alluvial sand bed of 50 m long and a curvature of 1m radius was constructed at 5m after starting of the channel. The channel was run with a variable discharge of 0.004m^3/sec, for 14 hours. It was seen that the induced curvature of 1 m radius has changed its structure by erosional depositional process and also a meander pattern has formed after the constructed curvature. Again, the same channel was constructed with the initial dimension. Now some sand bags were induced at the curvature at some definite position and the channel was again run with a variable discharge of 0.004m^3/sec for 75 hours. No noticeable meandering pattern was formed and the curvature was in intact condition. So, it can be concluded that by applying necessary physical structures the process of meandering can be stopped.

Keywords- MEANDER, LATERAL MOVEMENT, STRUCTURAL MEASURES

Thermodynamical Properties of Statistical Associating Molecular fluids(PA0158)

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Abstract- The development of analytical expression for strongly homogeneous associating homogeneous fluids has proven to be difficult problems that have recently a great deal of attention. An exact statistical- mechanical treatment of homogeneous chain molecules is difficult owing to the large number of internal degree of freedom The equation of state for the hard – sphere homogeneous chain fluids have been obtained by Hall and co-workers. One approach is to introduce the possibility of molecular association into commonly used integral equation theories. Thus Cumming and Steel have solved the Percus-Yevick (PY) approximation for the chemical association by using a spherical symmetric bonding potential. The highly directional hydrogen bonding is introduced in fluids by the geometry of the interaction at an early stage of the theory. Wertheim's theory, however, is based on a resumed cluster expansion, which is made in terms of two densities, the total number of density ρ, and the monomer density ρ . Wertheim was able to simply the complex graphical expansions by assuming that the repulsive core of each molecule restricts the orientation ally dependent attractive site.. Key words: spherical symmetry, cluster expansion, associating monomer [1] Reference:[1]Jackson G., Chapman W.G. and Gubbins K.E., 1988, Mol.

Keywords- MOLECULAR FLUIDS

Multiscale modelling of flow and transport through porous media with porosity gradient(PA0164)

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Abstract- Flow and transport in heterogeneous porous media are ubiquitous in a wide range of engineering and natural settings. The macroscopic fluid flow and transport of solutes in porous media depends critically on pore structure. Due to the complexity of the microscopic problems, macroscopic effective medium equations, which can be used to obtain the macroscopic transport, are desirable. We have used homogenization via the method of multiple scales to upscale flow and transport problems through a graded porous medium.

Keywords- Porous media, homogenization, method of multiple scales, numerical simulations

Triads in a two-layer fluid involving flexural gravity waves (PA0167)

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Abstract- The study of the resonant interaction between waves propagating at the surface and the interface in a two-layer density stratified fluid system has increased dramatically during the last ten years. The interaction of two co-propagating/counter-propagating surface waves with an

internal wave and vice versa results in one of these resonances, known as a triad resonance. Depending on the kind of interactions, the triad resonances are divided into classes I, II, III, and IV. The goal of the present study is to understand the spectral distribution of wave energy by examining the formation of triads in flexural gravity waves in a two-layer density stratified fluid having a flexible plate-covered surface and an interface. The formation of triads is verified geometrically and analytically using the two-dimensional Cartesian framework. The study is based on the assumptions of finite-depth fluid and small-amplitude structural response. Further, the Euler-Bernoulli beam equation is used to model an elastic plate with lateral compressive force. In contrast to surface gravity waves, which can have a maximum of six triads, the present study evinces that flexural gravity waves exhibit a maximum of eight triads of three distinct classes before the threshold of blocking. The study reveals the occurrence of at most eight triads of three different classes in the case of flexural gravity waves before the threshold of blocking, in contrast to a maximum of six triads in the case of surface gravity waves. Further, for a certain frequency within the blocking limits, a maximum of thirty triads are formed. In addition, depending on the values of compressive force and stratification ratio, the class IV triad is found within the primary and secondary blocking points, which in general is not observed in the case of surface gravity wave under the assumption of the deep upper layer.

Keywords- flexural gravity wave, compressive force , wave blocking, triad resonance

Study on air flow profile in an indoor space using CFD(PA0172)

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Abstract- Most of the time we do live in an indoor environment. So, it is very important to have a good indoor environment especially in terms of air quality. One of the major factors affecting indoor air quality is ventilation. Computational Fluid Dynamics (CFD) can be used as a tool to simulate and analyze the indoor environment. In this study, the airflow profile in an indoor space has been simulated and analyzed using CFD. The velocity of air at different positions and heights was analyzed. The results were compared with available experimental data. The trend of the air flow profile was same as that of the experimental values. But in few positions, there is a difference in velocity values. It is due to variations in numerical errors like mesh quality, turbulence model, pressure-velocity coupling and order of discretization. The simulated values can be improved by further reducing numerical errors due to various sources.

Key Words: Computational Fluid Dynamics (CFD), Velocity profile

The effects of vertical heterogeneity on gravity current flows in porous media(PA0173)

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Abstract- Gravity currents are the type of flows driven primarily horizontally, due to the density differences between two fluids. In porous media, gravity currents occur during various applications that include carbon sequestration, seawater intrusion into groundwater, or geothermal processes. Problems relevant to gravity currents, therefore, have been active topics of research for the past several decades in the porous media community (Hesse et al. 2007, Ciriello et al 2016). Gravity currents have been studied both experimentally and theoretically, and most of investigations have focused on sharp-interface flows, which implies that the injected fluid does not mix with the ambient fluid. However, some recent laboratory experiments, for example by Huppert et al. (2013) and Sahu & Flynn (2017), show otherwise that mixing during a gravity current flow can be significant and in fact can alter the flow behaviour from what is found in a homogeneous medium. To understand the mixing dynamics of gravity currents, Szulczewski & Juanes (2013) studied this problem in a confined porous medium, where they found that mixing between the two fluids occur either due to diffusion or Taylor dispersion depending on the time scale of the flow. Extending this work, Sahu & Neufeld (2020) investigated a similar problem but in an unconfined porous medium. They showed that mechanical dispersion occurs vertically due to the horizontal velocity of the gravity current. Motivated from the laboratory experiments, Sahu & Neufeld (2020) also derived a theoretical model that predicts the amount of mixing in the gravity currents in porous media. Both these studies focused on homogeneous porous media, whereas the subsurface aquifers are usually heterogeneous in nature. In fact, the vertical heterogeneity in form of permeable strata is very common. In this work, therefore, we aim to investigate the behaviour of gravity currents in layered porous media, particularly focusing on the amount of mixing.
Keywords- Gravity current, Dispersion and Mixing, Porous Media.

A Mathematical Model of Plaque Growth in Early Stage of Atherosclerosis (PA0174)

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Abstract- Atherosclerosis is a chronic disease in which plaque is builds up inside our artery and can be model as an inflammatory disease. The inflammation process starts from the penetration of low density lipoprotein (LDL) in the artery and enters the intima to become oxidized LDL (ox-LDL). Subsequent immune response causes the migration of monocyte due to cytokines, differentiate monocyte into macrophage and phagocyte ox-LDL to become lipid laden foam cells. Consequently, plaque at early stage is formed which is mainly characterized by these foam cells and macrophages. Before appearing in the clinical site, plaque growth is almost asymptotic. Therefore, the understanding of plaque formation and its growth at early stage is very significant. In this article, we introduce a multiphase model that explores the growth of the plaque region at early stage with the assumption of the plaque moving boundary. The model incorporates two main constituents, macrophages and lipid laden foam cells that are key responsible for plaque growth. The impact of cytokines and ox-LDL in migration of macrophages and production of foam cells respectively are also included. Numerical simulations are carried out and a semi-

analytical method (perturbation technique) for the case of ox-LDL saturation are also presented. We investigate the cellular and biochemical mechanisms during the plaque growth and their impact on it.

Keywords- Atherosclerotic Plaque, Foam cells, Multiphase Mixture Theory

Semi-Analytical Approach to Study the Geophysical Korteweg-de Vries Equation with Coriolis Parameter (PA0175)

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ABSTRACT -This article examines the influence of the Coriolis constant on the explication of the Geophysical Korteweg-de Vries equation. The Adomain decomposition method (ADM) and ADM-Pade approximation technique have been implemented here to solve the nonlinear Geophysical Korteweg-de Vries equation. For validation purposes, the present solution obtained by ADM is compared with previously obtained results. Additionally, the ADM-Pade approach is also used to solve the governing equation, resulting in an approximate solution that is more accurate and closer to a solitary wave solution with a fast convergence rate. Based on these analyses, a direct relationship has been found between wave height and Coriolis constant, and an inverse relationship between wavelength and Coriolis constant.

Keywords- Adomain decomposition method, Geophysical Korteweg-de Vries Equation

Propagation of one-dimensional planar and nonplanar shock waves in nonideal radiating gas(PA0177)

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Abstract- The present study seeks to investigate a quasilinear hyperbolic system of partial differential equations (PDEs) which describes the unsteady one-dimensional motion of a shock wave of arbitrary strength propagating through a non-ideal radiating gas. We have derived an infinite hierarchy of the transport equation which is based on the kinematics of one-dimensional motion of shock front. By using the truncation approximation method, an infinite hierarchy of transport equations, which governs the shock strength and the induced discontinuities behind it, is derived to study the kinematics of the shock front. The first three transport equations (i.e., first, second and third-orders) are used to study the growth and decay behavior of shocks in van der Waals radiating gas. The decay laws for weak shock waves in non-radiating gas are entirely recovered in the second-order truncation approximation. The results obtained by the first three

approximations for shock waves of arbitrary strength are compared with the results predicted by the characteristic rule. Also, the effect of non-ideal parameters and radiation on the evolutionary behavior of shock waves are discussed and depicted pictorially.

Keywords- Hyperbolic equations, Shock waves, Whitham's characteristic rule, Non-ideal gas, Radiation

Effect of Confinement on Liquid-Liquid Droplet Flows in the Presence of Surfactant (PA0181)

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Abstract- Droplet microfluidics is an emerging technology that has applications in the field of chemical, biological, and environmental engineering. Microfluidics help in generating highly reproducible, mono-dispersed droplets with precise control of droplet volume and their reliable manipulation. Microchannels outperform conventional batch systems in applications such as liquid-liquid extraction. Often surfactants are added to stabilize the droplets formed. The presence of a surfactant renders the interface deformable and hence prevents droplets from coalescing. The presence of surfactant often leads to non-uniform distribution of surfactant at the interface resulting in Marangoni flows. The present study aims to numerically investigate the effect of surfactant on the droplet dynamics for two cases: case (i) an unconfined domain (mimicking a batch system) and (ii) a confined (microchannel) system. Previous experimental studies have revealed an enhanced mixing in the microchannel while a reduced mixing in the batch system in the presence of surfactants. This contradictory behavior of surfactants in the two systems warrants detailed investigation. Further, a clear understanding of how fluid properties, surfactant concentration, and operating conditions influence droplet dynamics is still lacking. Our study would constitute a comparative investigation of how unconfined and confined droplets behave with and without an insoluble surfactant. Here, a mathematical model based on the Level Set Method (LSM) is developed and validated with experiments reported in the literature. This study would help provide conclusive results on how Marangoni convection affects droplet dynamics (velocity, shape, vortex structures, mixing intensity) and surfactant distribution both in an unconfined domain and in a microchannel.

Keywords- Droplet Flow, Microchannel, Surfactants, Microfluidics, Mixing

Flow Visualization in Natural Convective Flow in Differentially Heated Cubical Cavity (PA0183)

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Abstract- Attention has been paid on the convective discretization schemes, like SUPERBEE and SFCD schemes to simulate the flow inside the cubical cavity, whose left wall is isothermally heated. These schemes are compared with respect to CPU time and the results available in the literature. The concept of energy pathlines is utilized to visualize the total energy flow. For energy pathlines hot wall always acts as source while cold wall acts as sink for energy pathlines.

Keywords- Natural Convection, Differentially heated cavity, Energy flux vectors

Prediction of bifurcation phenomenon inside a sudden expansion pipe using neural network(PA0186)

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Abstract- The current study investigates internal flow through a sudden symmetrical expansion pipe of different expansion ratios. The flow pattern is studied using Finite Volume based computational tool which trained a Neural Network to predict bifurcation phenomena at different expansion ratios and Reynolds number. This study focuses on the training of Neural Network using the dataset generated by the Finite Volume based computational tool and the predicted dataset is validated by comparing with the results of experimental investigation obtained from relevant literature. Latin Hypercube Sampling is used to generate random values of Reynolds Number, which is given as an input to the solver, from where we get outputs for vortex lengths. This process is repeated in a loop for the sample space of Reynolds Number and varying expansion ratios. A Neural Network is trained by the dataset generated by the solver using Reynolds Number as input and vortex lengths as output.

Keywords: Internal Flow, Sudden Expansion Pipe, Reynolds Number, Bifurcation Phenomena, Expansion Ratio, Neural Network

Effect of Initial Condition on Reactive Radial Viscous Fingering: a Numerical Insight (PA0190)

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Abstract- A chemical reaction plays a significant role in affecting the flow dynamics by modifying the viscosity profile of a system [1]. This may further induce a hydrodynamic instability, named viscous fingering (VF), which occurs when a less viscous fluid displaces a high viscous fluid in a porous medium [2]. The interface deforms into finger-like structures due to viscosity difference between the fluids and hence the instability is termed as VF. Such unstable displacements can be observed in several fields, viz., oil recovery, CO2 sequestration and pollution decontamination, to name a few [1]-[3]. Understanding the effect of chemical reaction on VF is of paramount interest in order to control the instability [4] and to gain insights into reaction dynamics. We aim to numerically understand chemical reaction induced VF for reactants undergoing radial displacement. For a radial flow, it is reported that an unfavorable viscosity contrast below a critical value is insufficient to trigger the instability when the reactants have same initial conditions [4]. However, the yield of a chemical reaction depends on the initial concentration of the reactants. The reactive VF dynamics for a planer interface between reactants have been investigated numerically [5]. Let a0 and b0 are the initial reactant concentrations, while Da and Db are diffusion coefficients of reactants. It is observed that when $Da a_0^2 \neq Db b_0^2$, the generated amount of product differs than the case with equal initial concentration and diffusion coefficients of reactants [5]. Further, for the radial flow, the flow velocity decreases with radial distance affecting the VF dynamics. Hence, it is worth exploring how the radial VF dynamics are affected when we consider the reactants to be in different concentration initially.

Keywords- Porous media flow, chemical reaction, Viscous fingering instability, radial displacement

Velocity Profiles in a Miscible Flow with Time-dependent Injections(PA0196)

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Abstract- The numerical simulations of viscous fingering instability in a homogeneous porous media under sinusoidal injection velocity, which is characterised by amplitude (Γ) and time-period (T), has been examined. Using Darcy's law, the continuity equation, and the convection-diffusion equation, the physical process is modelled. A finite element-based module in the COMSOL Multiphysics has been used for the numerical simulations. The total energy amplification and average velocity profiles are provided to demonstrate the influence of nonlinear dynamics. In contrast to the constant injection strategy, the time-dependent situation drastically reduces the rate of energy amplification, which has a substantial effect on finger dynamics.

Keywords- Viscous fingeirng, Sinusoidal injection, Porous Media

Influence of Porocoat beaded coating structure on bone ingrowth around the porous coated implant: A two-dimensional finite element study (PA0204)

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Abstract- The long-term biomechanical functionality of uncemented orthopaedic implants relies on bone ingrowth around porous-coated implants. The present study aims to numerically predict the spatial-temporal distribution of bone ingrowth around the Porocoat coated implant surface by employing the mechano-regulatory tissue differentiation algorithm using 2D Finite Element Analysis. Besides this, the influence of the porosity gradient from the substrate surface to the bone interface on bone ingrowth is also investigated. Two distinct 2D microscale models were developed and designated MODEL A and MODEL B. Both models have a three-layer beaded coating, with MODEL B incorporating the effect of a porosity gradient. Both models were assessed for bone ingrowth distribution. The percentage of bone ingrowth in the inter-bead spacing was predicted to be 66% for MODEL A and 45% for MODEL B after the attainment of equilibrium. The results of the simulation showed that a higher amount of bone ingrowth was predicted in MODEL A, which indicates a strong implant-bone interface. The presence of a porosity gradient appeared to weaken the interface through less bone formation. The findings of present study are well in corroboration with relevant studies which suggested that predicted results could be employed to predict bone ingrowth.

Keywords: Uncemented implants, Bone ingrowth, Porocoat coated implant, Mechano-regulatory algorithm, tissue differentiation, Finite element analysis, Microscale model, Micromotion, Inter-bead spacing, Porosity gradient.

Functionally Graded Materials Reduce the Stress Shielding in the Tibia Bone for Total Ankle Replacement (PA0207)

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Abstract- Metals, ceramics, and polymers are commonly used as orthopedic implant materials. Conventionally, Cobalt Chromium (CoCr) alloys, Titanium (Ti) alloys, Alumina (Al2O3) ceramic, Hydroxyapatite (HA), Polyetheretherketone (PEEK) are used. Bone resorption owing to stress shielding is one of the reasons for the failure of total ankle replacement (TAR). The stiffness mismatch between the tibia bone and the implant is responsible for stress shielding. It is hypothesized that stress shielding can be reduced by tailoring the implant material similar to the tibia bone by using functionally graded materials (FGMs). The aim of the study is to understand

the effect of FGMs on the stress shielding of the tibia bone for TAR. Finite element (FE) models were prepared for, the natural bone, the tibial component made from CoCr alloy, Ti alloy, Al2O3 ceramic, FGM of Al2O3 ceramic at the bottom, and PEEK at the top, and FGM of Ti at the bottom, and HA at the top. Material properties for FGMs were assigned using Ansys APDL code. The results indicated that the highest stress shielding was present in the Al2O3 ceramic model. Whereas, the least stress shielding was in the Ti+HA FGM model. This implies that the stress shielding and subsequently the bone resorption is reduced by using the FGMs. Thus, FGMs are advantageous when compared to conventional implant materials in order to reduce stress shielding.

Keywords: Total ankle replacement, tibial component, stress shielding, functionally graded materials, finite element method

MHD and viscous dissipation effects due to Graphene based nanofluid flow in concentric cylinders(PA0208)

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Abstract. Magnetohydrodynamic flow of graphene oxide nanofluid between two concentric cylinders is investigated in this article. A uniform magnetic field is applied and Buongiorno model is used to develop the flow of graphene nanofluids including the influence of viscous dissipation effects and nanoparticle characteristics such as thermophoresis and Brownian motion. The modelled equations are transformed and are numerically solved using linearization method together with Chebyshev's spectral collocation method under convective conditions. The impacts of embedded parameters on temperature, concentration and velocity profiles of the chosen nanofluid and their consequent impacts on the predominant cause for the generated entropy are studied. Finally, the obtained results are depicted and interpreted in detail. Furthermore, entropy generation is analysed and its irreversibilty is calculated. Also, the values of Nusselt number, Sherwood number and skin friction are tabulated.

Keywords: Graphene nanofluids, Buongiorno model, Entropy generation

MHD and viscous dissipation effects due to Graphene based nanofluid flow in concentric cylinders(PA0209)

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Abstract. The flow of graphene oxide nanofluid in an inclined channel is investigated in this paper under convective conditions. The impacts of embedded parameters on temperature, concentration and velocity profiles of the chosen nanofluid and their consequent impacts on the

predominant cause for the generated entropy are studied. Initially, the Newtonian behaviour of graphene based nanofluids at lower concentrations is modelled using Buongiorno model including the effects of nanoparticle characteristics such as thermophoresis and Brownian motion. The modelled equations are transformed and are numerically solved using linearization method. Finally, the obtained results are depicted and interpreted in detail. Furthermore, entropy generation is analysed and its irreversibilty is calculated. Also, values of Nusselt number, values of Sherwood number and skin friction values are tabulated.

Keywords: Graphene nanofluids, Buongiorno model, Entropy generation

A decomposition based Long short term memory model (LSTM) for reservoir inflow forecasting(PA0212)

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Abstract- Accurate forecasting of the reservoir inflow is crucial for operations and management of water resources. Due to the nonlinearity and nonstationarity of the real hydrological data, an empirical mode decomposition based long short term memory (EMD-LSTM) model is proposed in this paper for daily reservoir inflow forecasting upto 10 days lead time. The accuracy and performance of the model is analysed using the mean absolute error (MAE), root mean square error (RMSE) and Nash-Sutcliffe efficiency (NSE). The performance of the proposed EMD-LSTM model is compared with artificial neural network (ANN) and
long short term memory (LSTM) model for 3 days, 7 days and 10 days ahead lead time respectively. Daily inflow data from 2013-2022 of the Bhakra reservoir located on river Sutlej in Himachal Pradesh, India is used to demonstrate the proposed model. The overall results of the model were highly encouraging in terms of having Nash-Sutcliffe efficiency of upto 0.94 in validation stage for 10 days ahead forecast as compared to the ANN and LSTM models. Therefore, the model can provide useful information when the models are used for decision making and can ensure safe operations of reservoir systems.
Keywords: Reservoir Inflow, Artificial neural network, Long short term memory, Empirical mode decomposition

Study of parameters influencing aerodynamics of train-tunnel system(PA0214)

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Abstract- Various aerodynamic effects are produced as the train passes through a tunnel, especially when the train speed is high. These effects depends on a wide range of variables. For the safety of the train and the passengers, it is crucial to understand the relationship between these variables and the aerodynamic effects. The goal of the current study is to determine which

combination of these factors has the highest impact on the train-tunnel aerodynamics by analysing the pressure variation of these combinations. For different set of parameters, the pressure time history curves are plotted and analysed to obtain the critical combination of parameters. The aerodynamic loads and the passenger comfort criteria for this critical combination is also discussed.

Keywords: Aerodynamic effects, Pressure time history, Maximum pressure, Aerodynamical phenomena.

Plasma flow control on a pitching airfoil(PA0215)

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Abstract. The unsteady flow characteristics of a pitching airfoil are crucial in several engineering applications such as rotorcraft, rapid maneuvering in fixed-wing aircrafts, and MAVs. Beyond a critical angle of attack, the boundary layer (BL) separates over the airfoil. This results in a rapid decrease in the lift, deteriorating the vehicle's performance. Dynamic stall associated with the pitching motion adversely affects the performance and system safety. Hence, controlling the stall over an airfoil has been an active area of research. In recent years, researchers have been working toward exploiting the Dielectric Barrier Discharge (DBD) plasma actuators as active flow control devices. In the current work, we will present the high-fidelity simulations of a pitching airfoil and investigate the efficacy of DBD (Dielectric Barrier Discharge) plasma actuators in controlling flow separation. Simulations over a pitching NACA0012 airfoil with and without flow control are carried out using the high-order in-house solver COMPSQUARE. The solver has been enhanced with several plasma actuation models and with the numerics to handle dynamically deforming meshes to simulate pitching airfoils. The enhanced solver is exploited to carry out the simulations around a pitching airfoil and subsequently control the BL separation using plasma actuation. The plasma force field is modeled using the electrostatic model proposed by Suzen and Huang. In the final version of the manuscript, we will report the results of the plasma actuation on the pitching airfoil.

Keywords: Active flow control · pitching airfoil · unsteady flow · plasma actuators

Estimation of Wake Propagation in Horizontal Wind Turbines using Sparse Identification of Non-Linear Dynamics (SINDy) (PA0220)

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Abstract- Performing accurate modelling of non-linear dynamics measurement data is quite a challenging task prone to many idealized assumptions and sensitivity to noise resulting in not so reliable and accurate models. Several data-driven approaches, such as genetic programming,

artificial neural network, and others, could produce dynamic models with extended relations. However, such models often carry long and non-intuitive equations, thus becomes difficult to derive a linear representation of the non-linear dynamics. We propose an innovative application of the SINDy algorithm for deriving a dynamical model from the data obtained from measurements using an optical method called Particle Image Velocimetry (PIV). The methodology has been used to identify and model the non-linear dynamic of the downstream wind turbine wake. The application of the model analogy will have a great implication in wind farm modelling, where economic constraints related to available space and the turbine installation is of prime concern. The study helps in determining the optimal distance of placement of turbines to minimize the effect of wake interference and enhancement of performance.

Keywords – Sparse identification, wake modelling, particle image velocimetry, coherent structures, velocity of the flow field, vorticity vectors, proper orthogonal decomposition (POD), POD modes.

Stability of liquid film flow down an inclined anisotropic and inhomogeneous porous plane(PA0222)

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Abstract- We examined the linear stability of a Newtonian liquid film flow past a porous inclined plane. Falling film on inclined permeable planes displays three instability modes, out of which two are fluid modes (namely surface and shear modes) and one porous mode. Previous studies have examined the above-stated flow configuration for the case of an isotropic and homogeneous porous medium. In the present work, we focus on the effect of the anisotropic and inhomogeneous variations in the permeability of the porous medium on different instability modes. The generalized Darcy model is used to describe the flow through the porous medium along with the Beavers-Joseph condition at the fluid-porous interface. Our results demonstrate the exchange of the dominant mode of instability when anisotropic variations are allowed in the permeability of the porous medium. For example, for a given Darcy number, the dominant mode instability is the surface mode for isotropic and homogeneous porous media. However, when an anisotropic porous medium is considered, with high wall normal permeability compared to wall parallel permeability, the porous mode becomes the most unstable mode. We show a similar exchange of instability modes with respect to the inhomogeneous variations in the permeability of the porous medium.

Keywords- Film flow, porous media, Instability, Surface mode, shear mode, porous mode

Vapour Cloud Explosion Modelling using the Porosity Distributed Resistance (PDR) approach(PA0227)

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Abstract- Vapor cloud explosion modelling in confined and congested domains has been challenging for researchers for the past half-century. The wide range of length and time scales in these explosions make them complex to model. A cartesian-based solver, PDRFoam, is used to model unconfined/semiconfined and confined vapor cloud explosions. This premixed, turbulent combustion solver uses the Porosity Distributed Resistance (PDR) approach. The governing equations of mass, momentum, enthalpy and regress variable are modified using PDR fields and are solved using OpenFOAM utilities. This solver is validated against Standard Benchmarking Exercise Problems (SBEP). The present study compares results from simulations with experimental results for methane-air mixtures from the Shell Offshore Large Vented Explosion (SOLVEX) project and results for hydrogen-air mixtures from Hydrogen Safety for Energy Applications (HySEA) project. The numerical simulations predict over-pressure values (the maximum pressure value in an explosion), flame speed, and flame arrival time, which are directly compared to experiments. Overall, the deviation between predicted and experimental values is in the acceptable range. The flame wrinkling due to turbulence generated by obstacles in confined space is addressed using separate transport equations. It is split into flame wrinkling due to sub-grid obstacles and turbulence. Further, independent transport equations are solved for it. Challenges with computations for safety studies are large-scale domains and the mathematical modelling of complex physical phenomena. The Porosity Distributed Resistance (PDR) approach is presented as one of the practical solutions to overcome these challenges.

Keywords- Turbulent Combustion, hydrogen, PDRFoam, overpressure, flame acceleration

Study of effect of heat transfer nanofluid flow over parallel plates using homotopy analysis method(PA0230)

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Abstract- In this paper, the homotopy analytic approach(HAM) is used to conduct an analytical study of the heat transfer in a flow of nanofluids compressed between parallel plates. Copper has been considered in the form of nanoparticles, with water serving as the base fluid. Brinkman and Maxwell-Garnetts (MG) models are used to determine the viscosity of nanofluid and, effective thermal conductivity respectively. In a comparison with other numerical approaches, this one is shown to be in great agreement. Nusselt number is studied as a function of the nanofluid volume fraction, the squeeze number, the Eckert number, and δ. The results reveal that when the plates are kept apart, the Nusselt number is directly related to the nanoparticle volume fraction, δ , the

Eckert number, and the squeeze number, but when both the plates are brought together, the relationship is inverted.

Keywords- Heat transfer, nanofluid flow, parallel plates, homotopy analysis method.

Scalar and Directional Localized Artificial Diffusivity Methods to Capture Shock-Turbulence Interaction(PA0234)

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Abstract. The local artificial diffusivity (LAD) based methods rely on adding a grid-dependent artificial fluid transport coefficient (shear viscosity, bulk viscosity, and thermal diffusivity) to the physical fluid transport coefficients to capture the shock discontinuity in high-speed flows. Inthis paper, we demonstrate the performance of LAD when coupled with a high-order in-house solver COMPSQUARE, which uses central difference schemes (explicit and compact) for spatial discretization and an explicit 4th order Runge-Kutta scheme for time-integration. The efficacy of this method is tested on a variety of test cases which include a 1D stationary normal shock, 2D compression ramp, 2D incident oblique shockboundary layer interaction, and a 3D compressible turbulent boundary layer. We further examine the efficacy of the scalar and directional forms of the artificial diffusivity method. On highly stretched grids with higher aspect ratios, the scalar formulation of LAD adds excessive artificial dissipation to the governing equations. This results in smaller time steps due to increased numerical stiffness. In contrast, the directional artificial diffusivity approach outperforms the scalar LAD on higher aspect ratio grids, as will be demonstrated for the test cases of the incident oblique shock and supersonic turbulent boundary layer.

Keywords: Artificial diffusivity · Shock-turbulence interaction · Highorder schemes · Turbulent boundary layer.

Aerodynamic Performance Improvements of the Darrieus type Straight-Bladed Vertical Axis Wind Turbine with Gurney Flaps(PA0235)

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Abstract- The Darrieus type straight-bladed vertical axis wind turbines in the wind energy field are getting prime attention nowadays for power generation for various applications, mainly for low to medium wind speed. However, these wind rotors generate more power than other vertical axis wind turbines but produce less performance than horizontal axis wind turbines. Therefore, a numerical study is conducted by attaching a different Gurney flap (GF) at the trailing edge of the blade profiles to augment their aerodynamic performance. The GF is a small flat plate attached to

the trailing edge perpendicular to the chord line of airfoils. This study investigates three types of GF (GFin, GFout and GFboth configurations) with different heights, widths and mounting angles and compares their outcomes with the clean airfoil. The GFout configuration shows better aerodynamic performance augmentation as compared to the others. This configuration displayed maximum power coefficient and torque coefficient values of 0.52 and 0.324 at λ (tip speed ratio) of 2.0 and 1.6, respectively. An improvement of 9%, 13% and 6% is found from GFout configuration at λ =1.5 compared to clean, GFin and GFboth configurations. These GFs can be used in aeroplane wings and wind rotors for their power augmentation.

Keywords: Darrieus type SB-VAWT, Gurney flap, aerodynamic performance augmentation, tip speed ratio.

Higher Order Compact Numerical Simulation of Shear Flow Past a Circular Cylinder with an Attached Arc-Shaped Control Plate(PA0239)

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Abstract- This study presents a numerical simulation of an incompressible, unsteady, laminar shear flow through a circular cylinder with an attached arc-shaped plate. The radius of the circular cylinder is R_0 and radius of the circular arc is $(1.5*R_0)$ as shown in the schematic diagram of the problem. The Navier-Stokes (N-S) equations in cylindrical polar coordinates are considered as the governing equations . Using a higher-order compact finite difference technique, numerical simulations are carried out for the Reynolds number Re = 115 and the shear parameter (K) 0.0, 0.05. Through the use of vorticity contours, streaklines, lift and drag coefficients, phase diagrams, central-line velocity, and other techniques, the impact of shear rates on the vortex shedding phenomenon behind circular cylinder with attached plate is investigated. Finding out how shear rate and attached plate impacts the vortex shedding phenomena behind the circular cylinder is the aim of this study. To our knowledge, this is the first instance in which numerical simulations have been performed to analyse the phenomena of vortex shedding for the circular cylinder with an attached circular arc-shaped control plate.

Keywords- Higher order compact,shear flow, control plate, vorticity contours

Wave diffraction in a two-layer fluid by the submerged horizontal circular cylindrical pipe in front of a cliff as a vertical wall(PA0240)

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Abstract- The submerged cylindrical structure in front of a cliff gets affected by the waves reflected from the cliff which behaves as a vertical wall of infinite length. This makes the hydrodynamic results different from those for the cylinder in a horizontally unbounded fluid field. We investigated the wave exciting forces on the circular cylinder when it is submerged

below the interface in a density stratified two-layer fluid, in front of the vertical wall. Employing the image principle, the present cylinder-wall problem is transformed into an equivalent imaginary physical problem of wave diffraction in an unbounded fluid domain by two identical submerged horizontal cylinders placed symmetrically concerning the vertical wall in the original problem. We solved this using the multipole expansion method and obtained infinite systems of linear algebraic equations, which are solved numerically for the unknowns by truncation. Then, the wave exciting forces on the cylinder (sway and heave forces) are solved analytically and calculated numerically. They are depicted graphically against wave numbers in several figures and have been analysed to provide valuable results for engineering purposes.

Keywords*:* Wave diffraction, submerged cylinder, vertical wall, two-layer fluid.

Spiral Polar Plot (SPP) Analogy to Dictate the Two-Dimensional Depiction of Helical Vortex Lines (PA0242)

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Abstract- The article presents a unique methodology to represent the sequential pattern of the helical vortex lines (HVLs). The HVLs in the present study are the two-dimensional representation of the three-dimensional wind turbine's helical vortex dissipating from the blade tip. The rotor considered for the study is a horizontal-axis wind turbine, and a 2D particle image velocity (PIV) has been employed to assess the HVLs sequence within the near wake regime. The methodology introduced the combination of HVL sequence, helical analogy, and polar coordinates, named the spiral polar plot (SPP). Using SPP, one can easily define the sequence of HVLs at any given polar coordinate with respect to the blade position. Furthermore, the speed, velocity, and HVLs slope are obtained from the captured images by discretizing the same into the number of pixels. And on the basis of spatial and temporal response, the quantitative description of HVLs is defined and triangulated with the SPP to dictate the characteristics of HVLs, and wind turbine wake as a whole.

Keywords: Wind turbine wake, particle image velocimetry, helical vortex lines, spiral polar plot, Pitch of helical vortex.

Effect of Discrete Heat Sources on Natural Convection in a Corrugated Enclosure for Hybrid Nanofluid(PA0247)

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Abstract- In the present research work, natural convective heat transfer and entropy generation inside a square cavity with corrugated bottom has been studied. Three discrete isothermal heaters

are placed at the bottom of the cavity. The cavity is filled with aluminum water-based oxide (Al2O3)-silicon dioxide (SiO2) hybrid nanofluid. Higher order compact (HOC) finite difference method for stream function-vorticity formulation has been used for solving the set of conservation equations along with the proposed boundary conditions. The study has been conducted numerically for nanoparticles volume fraction (ϕ) ranging from 0%-4% at Rayleigh numbers (Ra) ranging from 1000 to 1000000. The effect of the aspect ratio (AR) of the heaters (AR = 0.2, 0.4, 0.6 and 0.8) has been presented graphically in terms of streamlines, isotherms, entropy generation contours. Besides, average Nusselt number and Bejan number values for different aspect ratios are also analyzed.

Keywords- Natural convection, entropy generation, hybrid nanofluid, corrugated enclosure.

Characterization of Impinging Liquid Jet Injectors at Subsonic and Supersonic Air-Crossflow(PA0253)

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Abstract- In this work, an injection strategy that can be used in turbojet, afterburner, ramjet, and scramjet is explored. Two liquid jets are made to impinge on each other at different angles in presence of air crossflow to enhance atomization. The liquid jets are always injected from an injector into a subsonic and supersonic crossflow. The liquid jets are made to impinge each other, such that the plane of injectors will be perpendicular to the direction of air crossflow. In case impinging injector in crossflow, atomization of jet happens due to hydrodynamic force of two liquid jets on collision and due to aerodynamic force of crossflow. As the impinging angle is varied, the distance between injector nozzle exit and point of impinging between liquid jets will also change. Due to this hydrodynamic force of jets, at point of impinging also varies and this could significantly affect the breakup length. In addition to above-said effect, liquid jets would bend down in the direction of crossflow by the aerodynamic force of the air. This also ends in the variation of interaction point of liquid jets and varies spray characteristics. This work aims to compare penetration height and jet trajectory of the impinging jet (plane of injectors will be perpendicular to crossflow) and single injector in case of without crossflow, with subsonic crossflow and supersonic crossflow. Jet breakup and spray formation would also be studied.

Keywords- Impinging Injector; Penetration height; Crossflow; Momentum flux ratio; Twin injectors.

Magnetohydrodynamic nanofluid flow over stretching sheet problem using homotopy analysis method(PA0254)

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Abstract- In this paper, the study of the magnetohydrodynamic flow of nanofluid over stretching sheet has been carried out with nanoparticles such as Cu and Ag. The system of partial differential equations is transformed into a system of ordinary differential equations using similarity transformation. The robust technique called homotopy analysis method has been applied to understand the behavior of the velocity profile and the temperature profile at different amounts of volume fraction of nanoparticles, magnetic parameters, Eckert number.

Keywords- Magnetohydrodynamic flow, nanofluid, heat transfer, stretching sheet, homotopy analysis method.

ON THE STABILITY OF MATHEMATICAL MODELLING OF INFLUENZA (PA0258)

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Abstract. In this work, a non-linear mathematical model is considered containing susceptible, Infected, vaccinated and recovered classes for influenza. Positivity and Boundedness is established for the model. The basic reproduction number is found for different equilibrium point and its effect on stability is established for disease free and endemic equilibrium point. An attempt has taken for global stability of the model also. Numerical simulation has been done for establishing the mathematical claim. The model without vaccination ($S-I-R$) and the interactive model between susceptible and Infected ($S-I$) is also considered here. The role of Basic Reproduction Number is also portrait here for these sub models and stability analysis have been done with respect to that.

Keywords: Modelling, Influenza, Stability Analysis, Basic Reproduction Number

Impact of Time-Periodic Pulsating Temperature on Heat Transfer in Airflow from an Unconfined Circular Cylinder with Re=180(PA0259)

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Abstract- The two-dimensional laminar, unstable, incompressible airflow over a pulsating heated cylinder, is studied in the paper. The HOC scheme, with an accuracy of at least 3rd order in space and 2nd order in time, is used to discretize the governing equations. Non-uniform polar grids are used for this method. The solution is obtained from the discretized system by using the BICGS method. The range of parameters considered under the current scope is Re=180; Pr=0.7;

a=0.5,1,1.5; and P=1,10,100. The investigation is solely based on the isotherm contours and local, surface-average, and period-average total Nusselt numbers. The results are verified with existing work. A comparison is made between the isothermal cylinder and the pulsing temperature cylinder. The investigation reveals that the time-periodic pulsating temperature has a significant impact on the heat transfer mechanism. The increasing amplitude of the time-periodic pulsating temperature increases the rate of heat transfer. Also, the average Nusselt number goes up with the increasing period of the time-periodic pulsating temperature goes up. The presence of backward heat transfer is found and discussed. In the end, we can say that the current study on airflow shows some interesting properties about how heat is transferred.

Keywords- backward heat transfer, heat transfer, HOC, navier-stokes equations, time-periodic pulsating temperature

Similarity solutions using group invariance method for spherical shock wave in a non-ideal gas under the influence of gravitational and azimuthal magnetic fields: adiabatic and isothermal flows(PA0266)

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Abstract- In the present work, we have applied the group invariance method to discuss the propagation of spherical shock wave using the concept of Roche model in a non-ideal gas under the influence of gravitational and magnetic fields for the adiabatic and isothermal flows. We have obtained the similarity solution with power law shock paths in both the ideal gas and non-ideal gas cases by the different choice of the arbitrary constant values appeared in the expression for infinitesimal generators. Numerical solutions are obtained for both the isothermal and adiabatic flows. The effect of the gravitational parameter, Alfven Mach number, non-idealness parameter and adiabatic index on the shock strength, the density ratio across the shock front, and on the flow variables are studied. An increase in the gravitational parameter or non-idealness parameter or Alfven Mach number or adiabatic index increases the density ratio across the shock front and decreases the shock strength.

Keywords- Shock wave; Similarity Solutions; non-ideal gas; Roche Model; Group invariance method; Adiabatic and isothermal flows.

Fabrication and Thermal Characterization of a Coaxial Thermal Probe(PA0278)

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Abstract- The information about the surface heat flux is the most crucial parameter, required for designing high-speed vehicles such as re-entry vehicles, intercontinental missiles etc. Due to the constraints imposed for real-time experiments of such vehicles, ground-based test facilities (e.g. shock tubes and shock tunnels) are used for performing the experiment by creating a transient environment. The finding of surface heat flux values using steady state thermal probes in transient environments is a challenging task. Therefore, in the present study, an in-house fabricated thermal probe has been tested and characterized for its suitability in the transient environment. A specially designed fast response coaxial surface junction thermal probe (CSJTP) has been fabricated in-house. The CSJTP mostly contains two metal alloys (chromel and constantan) and insulation. The constantan wire (of length 13 mm and diameter 0.81 mm) is put inside the chromel wire (of length 8 mm and diameter 3.25 mm) with insulation in between them. Bothe the wires are connected at the surface through abrasion technique. The calibration process has been performed by using an alumina bath to get the sensitivity value of the thermal probe. Later on, it is used to measure transient temperature, when it is swiftly exposed to a hot water bath (plunging process). The sensor responded in the form of a nearly step signal which indicates its fast response. The temperature has been used as an input parameter to get the heat flux information analytically by suitably modelling the sensor (semi-infinite substrate) and also through numerical simulation. There observed a nice agreement between the analytical and numerical heat flux values. Hence, the thermal probe (CSJTP) can be used as a transient fast response sensor in real time experiment.

Keywords- Coaxial surface junction thermal probe, calibration, transient environment, sensitivity, heat flux.

Prediction of Drag Force over a Blunt Bicone Model with Accelerometer force balance at high speed environment using Vibration SDOF Technique (PA0280)

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Abstract- Prediction of aerodynamic forces is challenging in a high-speed environment, i.e., hypersonic flow. As per researchers, there are so many recovery techniques have been imposed to increase the accuracy of the force recovery for better design of space vehicles. So, here, a new numerical algorithm has been employed for the prediction of aerodynamic forces, and it is also compared with previously used recovery techniques. For this, a bluff bicone-shaped aluminum model along with a three-component accelerometer force assembly has been tested in IITB-Hypersonic Shock Tunnel (HST) at 0° Angle Of Attack (AOA) with and without hemispherical spike to estimate the coefficient of drag, respectively. Initially, a multi-point calibration methodology is implemented to evaluate a pure axial as well as a normal force by employing a Genetic Algorithm (GA). Further, these time histories signals have been used to evaluate an impulse response function (IRF) or system parameters for De-convolution along with newly

developed recovery algorithm i.e. Vibration SDOF (Single degree of freedom). This optimized value of IRF, as well as system parameters, are employed for the recovery of aerodynamic forces from acquired acceleration signals during shock tunnel experiments. Testing of these acceleration signals at 0° angle of attack with and without hemispherical spike experiments showed a good fit for the recovery of drag force with accelerometer force balance theory based recovery. But, it has been noticed that Vibration SDOF has a very encouraging agreement with conventional accelerometer force balance theory for each shock tunnel experiment i.e. with or without a hemispherical spike. Similar, drag reduction has been observed for the vibration SDOF technique in shock tunnel experiments with the spike. Moreover, it is recommended that these newly developed recovery algorithms can also be applied for the prediction of lift and moment coefficient.

Keywords- Hypersonic, Bluff bicone, Accelerometer force balance system, Vibration SDOF, De-convolution.

Computational Analysis of Performance and Flow Field of Airfoil in Low Reynolds Number Regime (PA0281)

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Abstract- A computational study is conducted on the S5010 airfoil to estimate the aerodynamic performance and flow characteristics in order to provide guidance for the design of low-speed vehicles such as MAVs. Regarding this, steady simulations are carried out in Fluent for pitch angle from 0° to 16° and Reynolds number from 30 × 103 to 60 × 103. The results reveal that the influence of the Reynolds number on the lift and drag coefficients is less significant for the pre-stall angle, while it is a more prominent factor for the stall or post-stall region. With an increase of Reynolds number from 30 × 103 to 60 × 103, the maximum lift coefficient rises up to 7%, and the corresponding stall angle improves from 10° to 12°. In contrast, the magnitude of the drag coefficient falls at high pitch angles as the Reynolds number increases. Furthermore, flow field analysis demonstrates that laminar separation occurs at the suction side of the airfoil surface, and a separation bubble is detected in all cases. As the angle of attack increases, the separation bubble travels from downstream to upstream. In addition, the size of the separation bubble reduces with improving Reynolds number.

Keywords: Low Reynolds number, S5010 airfoil, Fluent, Aerodynamic coefficients, Separation bubble.

Momentum, heat and mass transfer in the hydrodynamic electrically conducting fluid flow over a stretching sheet (PA0284)

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Abstract- This study looks at the numerical results of magneto hydrodynamic liquid flowing across a stretching sheet at its stagnation point while also experiencing chemical reaction, viscous dissipation, thermal radiation and variable magnetic field. The fundamental partial differential equations that regulate physical phenomena are converted into non-linear ordinary differential equations by using the appropriate similarity transformations. Later, resolved by numerically using the Mathematica. Results of the effect of the non-dimensional parameters like Velocity ratio parameter (λ), Porosity (k), Magnetic parameter (M), Radiation parameter (R), Chemical reaction parameter (γ) etc. on velocity, concentration, and the temperature profiles for their various values were analysed and presented graphically. The numerical evaluation of the physical quantities was provided in tabular form for the various values of the relevant stream parameters.

Key words: Magnetohydrodynamics, Chemical reaction, Velocity ratio parameter, Boundary layer flow, Stretching Sheet.

Numerical Investigation on Flexural Performance of Trough-shaped FRP Beams(PA0286)

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Abstract- Although FRP has many advantageous properties, structures made of FRP alone face several problems that include high costs and sudden catastrophic failures when they are used exclusively. Even though the initial cost of the fibers is high for concrete composite structures, the fact remains that maintenance costs are lower while the strength is increased, there is no doubt that there is a great economic interest in FRP concrete composite structures. Due to the anisotropic properties of the FRP, the I-sections used in the steel structures cannot be directly used in FRP structures, it is due to low inter-laminar shear strength at the web-flange junction of I-sections. Therefore, FRP box sections are highly used in construction, and the trapezoidal box section has high flexural resistance due to the truss action of the inclined webs. In this study, flexural response of FRP trough-shaped sections is investigated with different web inclination, curvature of soffit of the beams for different L/d ratios. It is observed that optimum web inclination for high stiffness of beam is 21 degree and curvature of the soffit is 3 degrees.

Keywords- Numerical Investigation on Flexural Performance of Trough-shaped FRP Beams

Estimation of Wake Propagation in Horizontal Wind Turbines using Sparse Identification of Non-Linear Dynamics (SINDy) (PA0288)

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Abstract- Performing accurate modelling of non-linear dynamics measurement data is quite a challenging task prone to many idealized assumptions and sensitivity to noise resulting in not so reliable and accurate models. Several data-driven approaches, such as genetic programming, artificial neural network, and others, could produce dynamic models with extended relations. However, such models often carry long and non-intuitive equations, thus becomes difficult to derive a linear representation of the non-linear dynamics. We propose an innovative application of the SINDy algorithm for deriving a dynamical model from the data obtained from measurements using an optical method called Particle Image Velocimetry (PIV). The methodology has been used to identify and model the non-linear dynamic of the downstream wind turbine wake. The application of the model analogy will have a great implication in wind farm modelling, where economic constraints related to available space and the turbine installation is of prime concern. The study helps in determining the optimal distance of placement of turbines to minimize the effect of wake interference and enhancement of performance.

Keywords – Sparse identification, wake modelling, particle image velocimetry, coherent structures, velocity of the flow field, vorticity vectors, proper orthogonal decomposition (POD), POD modes.

Augmenting Data in Scarce Regions helps Accurately Upscale Water Volume of Inland Waterbodies (PA0289)

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Abstract -The water volume of Inland Water bodies (IWBs) is crucial for understanding biogeochemical and earth system processes. However, the water volume measurements are scarce and poorly documented. The scarcity of IWBs water volume data results in a poor understanding of various earth system processes such as nutrient dynamics, food chain dynamics, sediment trapping, and waterbody interaction with the environment. Studies have attempted to estimate water volume globally through regression-based modeling to fill this knowledge gap. For example, Hakanson & Karlsson (1984) developed a regression model to estimate the lake volume using only lake area as a prediction variable. Improvements were made to this method by including surrounding topography as the second prediction variable as it reflects the lake's topology (Heathcote et al., 2015; Hollister et al., 2011; Sobek, 2011). Messager et al. (2016)

mapped (>10 ha) and estimated various features like water volume, mean depth, and residence time of lakes globally. Similarly, Pekel et al. (2016) conducted high-resolution mapping (30m) of global surface water for 32 years (1984-2015). These improvements in IWB's water spread estimates can improve water volume estimates. Recently, machine-learning methods have become popular for understanding and modeling non-linear complex scientific data. Khazaei et al. (2022) estimated the bathymetry of around 1.4 million lakes using the trained ML model on geometric variables like area, volume, perimeter, and slope. The significant limitations of these approaches were broad generalizations in terms of input used, lack of dependable and accurate datasets, and data scarcity. The effect of such abstraction is least explored, and the suitability of these models for data-scarce regions is still ambiguous. Therefore, to test the upscaling possibilities and check the suitability for data-scarce areas, we developed a new upscaling approach to predict the water volume of IWBs through machine learning (ML). We simulated the scarcity of water volume data by sub-setting (choosing states to represent country) the global water volume dataset – HydroLAKES. The obtained water volume data along with their input parameters, i.e., lake surface area, length of shoreline, shoreline development, average lake depth, and average slope, were sub-setted for states of West Bengal, Tamil Nadu, Madhya Pradesh, Gujarat, and Uttar Pradesh for predicting all the water volumes of Indian IWBs. The data was filtered from outliers by removing values above the ninety-nine percentile and less than one percentile using the pandas and NumPy libraries in *python 3.9.3*. The filtered data were split into 60% for training and 40% for testing. We trained linear regression, polynomial regression, decision tree, and random forest models on the simulated-scarce data (state-level data) using the *sci-kit learn* library in python. We augmented the input parameters through product, squares, and division and arrived at an optimal combination for predicting volume, i.e., Lake Area × Average Depth × Shoreline Development. The models were validated and performance-tuned by optimizing the coefficient of determination (R2). The trained models were then made to predict the Indian National level water volume (upscaling) estimates and evaluated for accuracy.

Contributory Paper(SM: Solid Mechanics)

Design and analysis of piezoaeroelastic energy harvester using a torsional spring from aeroelastic flutter(PA0017)

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Abstract- In this paper, the research efforts have been focused towards investigating the potential of considering the pitch motion using torsional spring with the piezoelectric layers for energy harvesting from piezoaeroelastic system. A mathematical model is presented to simulate the potential of the piezoaeroelastic energy generation from the pitch motion. Here, a curved PZT strip is mounted over the curved surface of the torsional spiral spring. It was found that the pitch motion can generate a significant amount of power in addition to the attachment of the piezoelectric coupling with the plunge motion for energy harvesting.
Keywords: Piezoelectricity; Aeroelastic excitation; Energy harvesting

Generalized homotopy perturbation approach: an application to wave partial differential equations(PA0028)

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Abstract- In the present study, we employed an analytical technique in order to determine the approximate/exact solutions to the distinct kind of partial differential equations (PDEs) (especially wave equation). Generalized homotopy perturbation method (GHPM) depends upon He's theory of homotopy perturbation and basic theory of least square method (LSM). The GHPM has been proved beneficial in obtaining the convergent solutions with ease. Applications of the method are presented by considering some examples.

Keywords- Wave equations, Least square method, Homotopy pertuebation method

Mechanical Characterization of Iron Flakes Filled Polyurethane Composites(PA0031)

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Abstract- In this work, a micron-thick composites film filled with iron flakes and polyurethane (PU/Iron-Flakes) was developed using the hand spray method. These composite films were prepared of various thicknesses ranging from 0.18 mm to 0.37 mm using various weight fractions of iron flakes (20, 30, 40, 50, and 60%) at room temperature. The densities, Young's modulus, tensile strength, and fracture toughness measurements of the composites were examined. The experimental densities of neat-PU and iron-flake-filled PU composites with varying weight fractions were determined using the Pycnometer method. While theoretical densities were obtained by the rule of mixture. In tensile testing of soft and thin polymer composites, when specimen elongation is determined from crosshead motion, the inaccuracy associated with system compliance might be substantial, and measurements such as young's modulus and elongation will be inaccurate. Therefore, we have considered the compliance correction procedure in tensile testing. The stress-strain response of various types of iron flakes filled polyurethane composites developed in this study are shown in figure 1(a). The Fracture Toughness of PU/Iron-flakes composites is characterized by the mode I tensile method using Single Edge Notch Tension (SENT) test. As indicated in Table 1, increasing the iron-flake filler content in PU matrices increased the densities, tensile strength, and Young's modulus.

Keywords- Iron Flakes composites, Polyurethane composites, Pycnometer method, Fracture toughness, Hand spray coating.

Maximization of Fundamental Frequency for Laminated Composite Shells Using Metaheuristic Techniques(PA0036)

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Abstract- Composite Shells structures are widely used in civil, aerospace, mechanical, and marine industries. Because laminated composite cylindrical shells are widely used in engineering, optimizing their design is critical. In this study, three metaheuristic optimization techniques are proposed to find the optimum stacking sequence to maximize the fundamental frequency of the shells. For the vibration analysis of the shells, first-order share deformation theory and a nine-node isoparametric element with five degrees of freedom per node is considered. The fiber angle orientation of the shells is considered as the design variable. The present approaches are compared with the previously published results using layer-wise optimization theory (LO), the Ritz method, and classical lamination theory. The optimum fiber angle orientation of the shells carrying distributed mass for various boundary conditions and shell types is calculated. Lastly, a comparison study is conducted for GA, GWO, and SSA

Keywords- Optimization, FSDT, Composite, Finite Element, GA, GWO, SSA

Free Vibration Analysis of Functionally Graded Plates with Elliptic Cutouts(PA0037)

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Abstract- Functionally graded materials (FGM) are superior to the conventional composite materials in their mechanical behaviour because of the smooth and continuous variation of the material properties making it free from stress concentrations and crack initiation due to absence of interface. The main objective of this paper is to find out natural frequency and mode shapes of the moderately thick FGM plates with central cutout of elliptical shape. Eight noded isoparametric serendipity element using first order shear deformation theory has been applied. The results have been validated with the existing literature. Parametric studies have been carried out to study the effect of size of elliptical cut-out, length to thickness ratios, boundary constraints and power law indices. It is shown that the frequency parameter and mode shape depend on the said parameters.

Keywords: Functionally Graded, Free Vibration, Finite Element, First order shear deformation, FGM plate with cutout

Free vibration analysis of laminated composite plate resting on two-parameter elastic foundation using Finite Element Method (PA0043)

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Abstract: A 9-noded plate bending isoparametric finite element formulation is presented for the free vibration analysis of laminated composite plates resting on elastic foundation of Winkler and Pasternak type. The plate equations are derived using the first-order shear deformation theory (FSDT), incorporating the effects of transverse shear using a shear correction factor, and the principle of virtual work. The formulation is validated with existing results obtained using the Fourier series method and Reddy's higher order shear deformation theory. The effect of elastic foundation on the laminate composite plate is discussed and new results are obtained for laminated composite plates having various stiffness parameters, number of ply-layers, different fibre angle orientation.

Keywords: Two-parameter elastic foundation, Laminated composite plates, First Order Shear Deformation Theory, Finite Element Method

Identification of Stiffness Parameters of Generalised Multi-Storey Frame Structures in Fuzzy Environment (PA0047)

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Abstract- Main aim of this work is to solve the inverse problem for generalised multi storey frame structures in an uncertain environment. Triangular fuzzy numbers are used in this work to handle the uncertain parameters. Forward problem may be solved to find the natural frequencies and mode shapes of the original structure using uncertain stiffness and mass of the system. Further, procedure has been given to use known uncertain form of natural frequencies and mode shapes to estimate the stiffness matrix in fuzzy form. In this regard, double parametric approach has been used to handle the fuzzy parameters. Bounds of the stiffness parameters are obtained corresponding to different values of the two parameters.

Keywords- Fuzzy numbers, Parametric form, Double parametric form, Global stiffness matrix

Dispersion of torsional surface waves in a threefold concentric compounded cylinder with imperfect interface(PA0049)

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Abstract- The present paper investigates the torsional wave propagation in a threefold concentric pre-stressed compounded cylinder with imperfect contact conditions. The three-dimensional linearized theory of elastic waves and the piecewise homogeneous body model has been employed to formulate the problem. The mathematical modelling has been carried out in two independent cases. In the first case, a solid cylinder encased in a hollow cylinder embedded in an infinite elastic medium has been considered as shown in figure 1. Whereas the second case comprises of a hollow cylinder of finite thickness in place of a solid cylinder. By means of Murnaghan potential, the mechanical characteristics of the three materials have been used [1]. Further, the dispersion relations for both the cases have been obtained in terms of the Bessel and modified Bessel functions. In order to validate the present findings, two particular cases have been derived that matches with the previous works [1-2]. The first case is obtained by removing the outermost cylinder, while the second case has been derived by removing the imperfection in addition to that. To summarize the computations, a complete numerical simulation has been carried out, and graphical illustrations have been shown to aid the mathematical analyses.

Keywords- Torsional wave, imperfect interface, pre-stressed, infinite elastic medium

Optimal Partial Safety Factor Calibration of Structure Considering Series System Failure(PA0050)

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Abstract- In India, the reinforced concrete structures are designed using code IS 456. Partial Safety Factors (PSFs) given in the code are same for Live Load (LL) as well as for Dead Load (DL) for all load cases and all limit states. But it is obvious that uncertainties in LL is more in comparison to DL. Hence, PSF of LL should be more than that of DL. However, this fact is not reflected in the present version of IS codes. So, proper calibration of code is required to reveal effect of uncertainty more realistically. In this work, considering well-established uncertainty levels in LL and DL, PSFs are re-calculated using First Order Reliability Method (FORM). PSFs are calculated for flexure and shear limit states under static loading as well as dynamic loading for a simply supported beam. The multivariate normal distribution concept is adopted to combine the PSFs of flexure and shear limit states, which constitute a series system of failure. The obtained safety factors are observed to vary with different levels of DL, LL, and their ratios. Thus, an optimization is performed using Baker's approach, to evaluate unique PSF, which is optimum for all considered levels of DL and LL. With the proposed set of PSFs in this study, a design comparison is made with that by the IS:456-2000. The results show that using the PSF sets proposed one will have more economical design, maintaining desired target reliability requirement. The present study yields PSF for DL as 1.2, and PSF for LL as 1.3 for all the static and dynamic load cases, except for the point load case. The PSF for LL is 1.4 for the point load case. Based on these findings, a design comparison is made with that by the IS:456-2000. The results show that using the PSF sets proposed in this study, one can have more economical design, maintaining desired target reliability requirement. The depth requirement of the beam also becomes almost 25% less than the conventional design approach.

Keywords- Partial Safety Factor, Series System, Uncertainty, First Order Reliability Method, Optimization

A Design Guideline of Laminated Composite Plate Roof with Cut-out(PA0055)

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Abstract- Due to its excellent stiffness to weight ratio, laminated composite has become immensely popular in the various weight-sensitive disciplines of engineering. In order to accommodate various utilities, opening or cut-out in the plate has become an essential requirement in various industrial structure. This paper intends to conduct a detailed study of the stress behavior of composite plates with various locations of opening in them for uniformly distributed load intensity. Parametric studies are carried out to determine the stress, strain and deformation for the cross and angle ply orientations considering simply supported boundary conditions to find out the most suitable position of cut-out.

Keywords: Laminated composite plate, cut-out, uniform load

Effect of crack position on remote stress for crack propagation and stress field near the crack tip(PA0056)

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Abstract- This study focuses on the role of the relative position of crack from the boundary on the stress required for the crack propagation for silicon. The crack propagation process is implemented on diamond cubic silicon crystals with central cracks under tensile load normal to the crack plane. The primary simulation method adopted was molecular dynamics using the Stillinger-Weber potential. Effects of different model sizes and different crack positions with respect to the surface on the boundary stress have been extensively investigated. Molecular Dynamics simulations are performed on silicon models of 217.2 nm width and 217.2 nm and 543 nm height respectively and the depth is kept periodic to replicate a plane strain condition, and the lattice vectors are kept along principal directions. The boundary velocity and timesteps are optimized to hinder any kind of local deformation. The results show that when we start shifting the crack from the mid position towards the surface, the boundary stress required to propagate the crack decreases, but the effect of the boundary can affect up to a depth of about 230.775 nm. It is shown that from the mid position to 230.775 nm from the surface the boundary load required to propagate the surface remains mostly constant. It is further demonstrated that when the crack enters the region of depth, the boundary stress required for propagation starts decreasing linearly. Finite element simulations of the near crack tip region have also been carried out where the J-integral method is considered in a plane strain sample of similar dimensions to obtain the stress field along the crack tip. The results of both simulations reasonably agree on the profile of stress fields, however, the minima obtained by the stress field from MD calculations show a lesser value compared to the boundary stress.

Keywords- Crack propagation, Molecular Dynamics simulation, Silicon structure

Fixed-time stability of nonlinear impulsive dynamical systems and its application to memristor neural networks(PA0061)

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Abstract- This present study is mainly concerned with the fixed-time stability (FXTS) analysis of nonlinear dynamical systems with impulsive effects. The novel criteria have been derived to achieve fixed-time stability of the non-autonomous dynamical system under the effects of stabilizing and destabilizing impulses. For the case of destabilizing impulses, the fixed-time stability of nonlinear dynamical systems has not been investigated in the previous literature. Therefore, some sufficient conditions have been derived to achieve the fixed-time stability of nonlinear dynamical systems under the effects of stabilizing impulses and destabilizing impulses using the concept of the average impulsive interval and the comparison principle. It has been shown through theoretical derivation and numerical simulation that the estimated fixed-time in this study is less conservative and more accurate as compared to the existing fixed-time stability theorems. Further, the theoretical results are applied to delayed memristor neural networks to realize fixed-time synchronization of the considered systems in the impulse sense. Finally, numerical examples are given to validate the effectiveness of the theoretical results.

Keywords- Fixed-time stability, Lyapunov stability, Nonlinear systems, Impulsive systems, Memristor neural networks.

Modeling and Analysis of Inflated Air-Spring(PA0062)

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Abstract- This article presents a compact design for finding the analogical behavior of an inflated air spring. Air springs ensure enhanced comfort, ride quality, and support load in the desired range. Unlike the more common pneumatic cylinders, air-springs have no moving parts inside the bellow. Moreover, air springs are more elastic and flexible than other types of conventional isolators used in machinery and automobiles. In the present formulation, the modeling considers two cylindrical hyperelastic membranes based on the Mooney-Rivlin material model fixed on the top and bottom sides of two rigid annular plates in an undeformed state. Upon inflation, the bellow of the air spring is created, and then the inflated bellow is pressed by the top annular rigid plate. The problem is axisymmetric; hence, independent of the circumferential coordinate. The inflated membrane profiles are assumed to be symmetric about the mid-plane of the inflated bellow. A computational solution scheme is adopted, and obtained results are validated using a finite element-based software package (ANSYS). The inflated air spring's pressing is a quasi-static process; hence, isothermal pressing is assumed. Increasing the press level, the stiffness of the air spring increases, against the displacement of the rigid plate is observed.

Keywords: Air-spring, hyperelasticity, gradual pressing, rubber bellow.

Study of Impact induced response of simply supported laminated composite conoidal shell by Finite Element Method(PA0065)

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Abstract- Significant improvements in the utilization of composite materials in structural applications have been made over the last few decades. In spite of different advantages of laminated composite material its low transverse shear capacity due to impact load has compelled researchers for further investigation. Impact induced damage remains suppressed within the lamina and eventually causes total failure of the structure. Conventional contact law proposed by Hertz, initially applied for isotropic material, proves to be insufficient for laminated composite material and being modified in due course of time. Conoid being a preferred shell geometry among the different industrial sectors, civil engineers too, picked up the shape to use it as a roofing entity. Due to its non-developable configuration, it offers huge stiffness, ease in fabrication and allows huge entry of north light, conoidal shell roof became popular as a roofing entity. This study aims to investigate the impact induced response of laminated composite conoidal shell for simply-supported boundary condition being struck by an isotropic steel impactor at the centre of the geometry. A parametric study consisting contact force history, deformation, stress and stain for two different ply-orientations, namely cross and angle ply.

Keywords: composite; conoid; shell; ball; steel; graphite/epoxy; laminate

Free vibration characteristics of braided rotating Plate via 3D Finite Element Method (PA0068)

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Abstract- The 3D braided composite is one of the new classes of composite materials in the twenty-first century. The notable applications of 3D braided composites are already found in numerous industries and engineering fields like mechanical, aerospace, defense, naval architecture, automobile, civil, etc. It has distinct advantages over laminated composites, such as anti-delamination capability, high damage tolerance, superior in-plane stiffness, high strength-to-weight ratio, high impact resistance, etc. In 3D braided composites, some fibers are oriented in the thickness direction, which not only improves strength but also works against de-laminations. The standard four-step stable braiding procedure is used to manufacture 3D braided composites.

The equivalent material properties of 3D braided composites are calculated based on bridging methods using the average volume technique. The fiber bundles and the matrix are deemed transversely isotropic and isotropic material, respectively. A third-order shear deformation theory (TSDT) with twelve degrees of freedom per node and an eight-noded isoparametric finite element has been used to model the geometry of 3D braided composite plates. The transverse displacement is a function of thickness coordinate, which is the unique advantage of this theory. Therefore, to predict the accurate response of thick plates, it has more capability compared to the other plate theories. In this theory, the shear correction factor is not needed. The generalized dynamic equilibrium equation of the present models is derived from Lagrange's equation of motion. For moderate rotational speeds, the Coriolis effect is neglected. Several comparison studies are investigated to judge the accuracy and correctness of the present models. Numerical results are obtained by varying various geometrical and material parameters.

Keywords: Plates; Vibration; Braided composite; 3D Finite Element; Rotation.

Analysis of Unidirectional Polyethylene-Glass Fiber Reinforced Phenolic Polymer Composite Laminate(PA0074)

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Abstract: Fiber-reinforced composite materials have become popular for items that need to be lightweight yet strong enough to sustain challenging loads. In this work, phenolic composite plates reinforced with polyethylene and glass fiber are statically and dynamically analyzed. With partly polymerized Resol/VAC-EHA, unidirectional hybrid laminates made of glass fibers (GF) and polyethylene fibers (PEF) are explored. The static response of polyethylene-Resol/VAC-EHA and glass-Resol/VAC-EHA reinforced composites has been studied first using finite element technique. ANSYS 2022 is used to model the plates at varying volume fractions of fibers, and the findings are compared to published results. The modal analysis of the hybrid plates is presented next. The lay-up order and relative percentage of PEF and GF in laminates are varied keeping the overall volume fraction of fibers in the hybrid plates constant at about 35.6%. In both static and dynamic studies, the boundary condition is considered to be simply supported.

Keywords: Finite Element, Polyethylene Fiber, Glass Fiber, Resol/Vinyl Acetate-2-ethylhexyl Acrylate (VAc-EHA).

SH-wave in multi-layered poroelastic composite structure based on Eringen's nonlocal elasticity theory (PA0075)

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Abstract- The present study investigates SH-wave propagation in a multi-layered initially stressed nonlocal poroelastic composite structure. Based on Eringen's nonlocal elasticity theory, constitutive relations and equations of motion for a nonlocal poroelastic medium are developed. Using Haskell's matrix method, the dispersion relation of SH-wave propagating through the multi-layered structure is derived. For particular models, the dispersion relations are then matched with standard Love wave equation to ensure the validity of the problem. For *n=2,3* numerical computations and graphical illustrations are performed to observe the effect of porosity, initial stress and nonlocality on the phase velocity of the SH-wave.

Keywords Haskell matrix method, Nonlocal elasticity, Poroelasticity, SH-wave, Dispersion relation

Haskell matrix method and Love-type waves propagating in multi-layered elastic media containing voids(PA0080)

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Abstract- Love-type surface waves propagating through a multi-layered elastic solid half-space containing evenly distributed pores/voids are investigated. Using Haskell matrix method, the dispersion relations are derived when the topmost boundary is: (a) stress-free, and (b) rigid. Two wave fronts may exist in both the models propagating with distinct speeds. One of them, is independent of the presence of void parameters in the model and is analogous to the classical Love-type surface wave. However, the second wave front is new and has appeared due to the presence of voids in the model. The numerical computations are performed by taking a particular numerical data for 2-layered and 3-layered models with stress-free boundary. Comparison for the dispersion curves of both the wave fronts is plotted for the considered models. The effect of presence of voids on the speed of second wave front is significant for 2-layered model. The variation of wave speeds of both fronts with the thickness of layer is plotted graphically.

Keywords- Voids, Haskell matrix method, Love-type waves

Dynamics of MFC actuated composite plate using reduced Models(PA0084)

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Abstract- In this work, first-order shear deformation theory (FSDT) is used to develop a linear dynamical model for an MFC actuated plate. Subsequently, two reduction techniques are implemented namely SEREP (system equivalent reduction and expansion process) and POD (proper orthogonal decomposition) to reduce the number of degrees of freedom. The developed full-scale model and the reduced order models have been validated using numerical simulations in ABAQUS. The use of the aforementioned reduction techniques for modelling smart structures can be immensely useful for designing accurate and highly efficient control systems.

Keywords- Reduced order model, MFC actuated plate, POD, SEREP

Analyzing machine learning approaches for Lamb wave based damage detection(PA0086)

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Abstract- The data-driven approach to structural health monitoring (SHM) has emerged as one of the most promising techniques to automate the SHM process. It requires a data acquisition system, preprocessing techniques for turning the data into useful features, and a machine learning (ML) algorithm for creating a correlation between the structure's final condition and the extracted features. In this study, a variety of ML classification algorithms including, 'Support Vector Classifier (SVC)', 'Random Forest Classifier', 'Extra Tree Classifier', 'Extreme Gradient Boosting classifier (XGB Classifier)' and 'Artificial Neural Network (ANN)' have been analyzed to determine the best algorithm for damage detection in a thin aluminium plate. SVC, Random Forest classifier and Extra Tree classifiers have achieved the accuracy of 50%, whereas XGBoost classifier has achieved the accuracy of 58%. It is observed that ANN is able to successfully differentiate between the Lamb wave responses of damaged and undamaged thin aluminium plate.

Keywords- SHM, ANN, SVC, XGB, Random Forest classifier, damage detection

Isogeometric Analysis of beam structures(PA0089)

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Abstract- Finite Element Method (FEM) is a commonly used numerical procedure to solve PDEs for simulating various engineering problems. The design domain of any problem is created using various CAD tools. The domain is discretized into simpler shapes like rectangles, triangles in 2D and hexahedrons in 3D. The discretized form of the domain is termed as mesh. Making use of the mesh data, FEM approximates the unknown field in the discretized domain using Lagrange polynomials. In case of complex geometries, the mesh fails to represent the exact domain. An

attempt is made to approximate the unknown field using the basis functions of CAD. This eliminates the need for a separate meshing tool, and the time taken for designing, analysing and redesign is greatly reduced. The procedure later named as Isogeometric Analysis (IGA), since the same geometry is used for the analysis.

Keywords- Isogeometric Analysis, large deformation, NURBS, FEM, nonlinearity

Analysis of surface wave vibration in FGPM composite: WKB approximation (PA0090)

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Abstract- Present research paper illuminates the Love-type surface wave transference in a functionally graded piezoelectric plate resting over a homogeneous elastic substrate. The material properties of the piezoelectric plate are assumed as a linear function of depth. Rigorous analytical techniques have been utilized to solve the coupled electro-mechanical field equations. Using proper boundary conditions, the dispersion relations are obtained for both electrically open and short circuit cases. By using a particular example, graphical demonstrations are given for phase velocity which expatiate the influence of functional grading and other relevant parameters on the dispersion of wave. The salient outcomes may be utilized as guidelines for the theoretical study of optimization of the performance of surface acoustic wave devices.

Keywords- FGPM composite, Surface waves, WKB approximation

Analyse effect of interfacial layer on current – voltage characteristics of Schottky diode(PA0092)

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Abstract- We analyse effect of interfacial layer on I-V characteristics of Schottky diode using simulation method . Based on thermionic emission diffusion (TED) theory. The current through Schottky diode as function of applied voltage. The data collected are simulated using TED taking into account the interfacial parameters. The calculated current – voltage data are fitted into ideal

TED to observe the apparent effect of interfacial parameters on current transport. Results shows that presence of interfacial layer at the metal – semiconductor interface the schottky contact behave as an ideal diode of apparently high barrier height but with the same ideality factor and series resistance as considered for a pure schottky contact without interfacial layer . This concludes that apparent barrier height decreases linearly with decreasing temperature.

Key words: Schottky diode, simulation method ,thermionic emission diffusion

Analyse effect of interfacial layer on current – voltage characteristics of Schottky diode(PA0093)

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Abstract- We analyse effect of interfacial layer on I-V characteristics of Schottky diode using simulation method . Based on thermionic emission diffusion (TED) theory. The current through Schottky diode as function of applied voltage. The data collected are simulated using TED taking into account the interfacial parameters. The calculated current – voltage data are fitted into ideal TED to observe the apparent effect of interfacial parameters on current transport. Results shows that presence of interfacial layer at the metal – semiconductor interface the schottky contact behave as an ideal diode of apparently high barrier height but with the same ideality factor and series resistance as considered for a pure schottky contact without interfacial layer . This concludes that apparent barrier height decreases linearly with decreasing temperature.

Key words: Schottky diode, simulation method ,thermionic emission diffusion

Study of Ferromagnetic character in Semiconductors(PA0095)

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Abstract- Rapid development of information technologies originates from the exponential increase in the density of information that can be processed, stored, and transfer by the unit area of relevant devices. There is, however, a growing amount of evidences that the progress achieved in this way approaches its limits. Various novel ideas put forward to circumvent barriers ahead are described. Particular attention is paid to those concepts which propose to exploit electron or

nuclear spins as the information carriers. Here, ferromagnetic semiconductors of III-V or II-VI compounds containing a sizable concentration of transition metals appear as outstanding spintronic materials.

Key words : ferromagnetic semiconductor , transition metals , spintronic

Electronic and Magnetic Properties of Diluted Ferromagnetic Semiconductor (PA0096)

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Abstract- Ferromagnetic systems obtained by doping transition metals into semiconductors have generated extensive studies since early 1990s because of their potential use for spin-sensitive electronics (spintronics) devices. In proto-typical systems based on III-V semiconductors, such as (Ga, Mn)As and (In, Mn)As, substitution of divalent Mn atoms into trivalent Ga or In sites leads to severely limited chemical solubility. Because of this, the specimens are chemically meta stable, available only as thin films , and their material quality exhibits high sensitivity on preparation methods and heat treatments.This substitution dopes hole carriers together with magnetic atoms, which prohibits electron doping to obtain n-type systems necessary for formation of spintronics p-n junction devices. We have investigated the electronic structure and magnetic properties of Mn-doped LiZnP using density functional theory within the generalized gradient approximation (GGA) +U schemes. We have shown that the ground state magnetic structure of Mn-doped LiZnP is anti ferro magnetic. LiZn is the most plausible acceptor among several candidates for p-type doping and hole-mediated Zener'sp-d exchange are responsible for the origin of the Li (Zn,Mn) P ferromagnetism.

Keywords: electronic and magnetic properties, first-principles calculation.

Computation of molecular Dynamics in diffusion of liquid semiconductors(PA0097)

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Abstract- We study an extensive molecular-dynamics for computation of diffusion in liquid semiconductor (ℓ -Si and ℓ -Ge, and of impurities in ℓ -Ge) using empirical Square Well (SW) potentials models with different fitting parameters. With an application of numerical algorithm in which the three-body part of the SW potential is decomposed into products of two-body potentials, thereby permitting the study of large systems. One important choice of SW parameters agrees very well with the observed ℓ -Ge structure factors. The diffusion coefficients D(T) at melting are found to be approximately 6.4×10^{-5} cm^2/s for ℓ -Si, in good agreement with previous calculations. We briefly discuss possible reasons why the SW potentials give D(T)'s substantially lower than ab initio predictions.

Keywords: Molecular Dynamics , Diffusion , Liquid semiconductor

Identification of Structural Nonlinearities from Aircraft Structural Coupling Tests(PA0103)

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Abstract- Nonlinearities in an aeroelastic system can affect the response of aerospace vehicles and lead to complex phenomena such as flutter, limit cycle oscillations (LCO), bifurcation and chaos. These phenomena are associated with structural and aerodynamic nonlinearities and results in performance degradation, structural damage and material fatigue. Generally, the structural nonlinearities such as freeplay, wear and tear contact nonlinearities are progressive in nature as the aircraft structures subjected to repetitive aerodynamic, inertial and gravitational loads. The earlier methods predicted this variation on a simple model by means of analytical and not attempted the actual variation of the stiffness and damping on real aircraft. This paper presents a methodology used by Denigri, for predicting the frequency and damping trends from the transfer function of vibration responses obtained for different excitation amplitudes during the structural coupling ground test (SCT) with a stepped sine sweep signal conducted on a typical fighter aircraft. The variation of frequency and damping trends are extracted and compared for adding different stores there by changing the actual mass of the aircraft. An attempt has been made for the prediction of these nonlinear parameters in terms of stiffness and damping from an actual aircraft structural response and this actual variation of stiffness and damping will be implemented on the existing mathematical models for more accurate prediction on the aeroelastic and other vibrational problems.

Keywords- Nonlinear Aeroelasticity, Flutter, LCO, Dynamic Decomposition, Structural Coupling Test, Freeplay, Wear and Tear, FRF, Transfer Fuction

On use of plain washer for prevention of self-loosening in bolted joint subjected to transverse cyclic load(PA0104)

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Abstract- Bolted joint subjected to transverse loading undergoes self-loosening due to several reasons like vibrations, thermal cycles, transverse slip. Self-loosening leads to an increase in the rotation of the nut, resulting in preload decay and eventually joint failure. Many researchers have studied the loosening mechanism of bolted joints subjected to various types of loading. However, numerous parameters are affecting self-loosening, and monitoring all of them is more challenging. This study is based on the use of plain washer for studying prevention of self-loosening by evaluating the effect of friction between contact surfaces on loosening. Numerical simulations are carried out by creating the CAD model of a bolted joint assembly with appropriate boundary conditions. The values of coefficient of friction between contact surfaces of nut and washer and washer and plate are varied to study the effect of friction. The simulation results show that for a nut-bolt threads contact friction coefficient, the presence of a washer deters the loosening for lower values of coefficient of friction between the washer and plate. Further, the effect of the coefficient of friction between nut-washer contact surfaces does not seem to affect the preload decay. The stick-slip phenomenon is observed in between contact surfaces and threads which gives an opportunity for the loosening reaction thread moment to cause rotation of the nut in the loosening direction leading to preload decay.

Keywords- Loosening of bolted joints, transverse load, cyclic load

Explicit Finite Element Simulation for Failure Prediction(PA0105)

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Abstract- Simulation can be defined as the imitation of real-world system. Developing a model which shows behaviours, functions and characteristics of real-world physical system is the first and foremost step of simulation. Simulation involves heavy use of finite element method.

Prediction of failure in the real-world physical event makes the simulation technology to implement before carrying out costly tests and experiments. Most of the real-world physical problems are nonlinear dynamic event. These transient structural dynamic problems are solved by using time integration methods. The explicit integration method is one of the integration methods which uses the known solution from previous time step to find unknown solution at next time step. This method can be used to simulate drop test event. In this paper, a mechanical component is dropped from certain height on floor and impact study has been carried out for three different orientations using ANSYS 2021 R2 software to determine the failure locations and failure intensity. Geometry has been subsequently modified and simulation has been carried out on worst case scenario. Reduction in stress values at earlier failure locations after modification implemented in the next simulation ensures the improvements. The distinct characteristics of simulations is that these are carried out for end time of simulation ranging from 1 to 2 second to observe the overall failure of component from the time when first impact occurs to the time when component stabilizes on the floor.

Keywords- Explicit FEA, Failure prediction, Simulation

Nonlinear Dynamics of Bistable Piezoelectric Harvester with Symmetric Elastic Constraints (PA0113)

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Abstract A nonlinear vibro-impact piezoelectric energy harvesting system is analysed in the present study. The harvesting system comprises of a bistable inverted cantilever beam with tip mass impacting a rigid frame. The governing equations of non-smooth system are developed using Lagrange's method. The dynamics and harvesting performance are analysed using numerical simulations. The results show that the proposed vibro-impact model for energy harvester has the potential to harvest from ambient vibration more efficiently as compared to conventional linear piezoelectric energy harvesters.

Keywords: nonlinear dynamics, energy harvester, vibro-impact, piezoelectric materials

Influence of axial constraints on the chemo-mechanics of the first lithiation of crystalline silicon(PA0126)

Amit Bhowmick and Jeevanjyoti Chakraborty

Abstract- A chemo-mechanical model incorporating kinetics of addition reaction, which creates lithium-rich and lithium-poor zone along with an alloying-dealloying reaction, is presented for the first lithiation of crystalline silicon. A two-way coupled diffusion of lithium through the lithium-rich zone is considered. The lithiation-induced deformation is modeled through the multiplicative decomposition of the total deformation gradient under the finite deformation framework. Thus, the current model can mimic the non-uniform distribution of concentration and non-uniform stress. Additionally, the vis-co-plastic behavior of amorphous silicon is considered in the current model. The influence of the different geometric and mechanical constraints on the characteristics of two-phase lithiation is studied.

Keywords- Lithium-ion battery, Silicon anode particle, Interface velocity, Reaction–diffusion, Crystalline silicon.

Influence of governing parameters on the molecular dynamics study of Boron Nitride Tube(PA0127)

PIYUSH BHATT VIKAS KUKSHAL

Abstract - Molecular Dynamics (MD) simulation has gained popularity due to increasing computational power in recent years to determine the mechanical and physical properties at the atomic scale. However, incorrect use or misuse of parameters may lead to inconsistent MD results in comparison to the experimental result. Parameters like interatomic potential, force field, cut-off distance, time increment, and many other parameters are needed to be chosen properly otherwise actual reality won't be captured due to the sensitivity of the results. Boron nitride tubes (BNT) attracted much research attention over carbon nanotubes as these possess strong hardness, chemical and thermally stability, and excellent piezoelectric properties. In this paper, a thorough study has been conducted by choosing different values of these parameters and their contribution

while simulating the Boron Nitride Tube (BNT). The investigation is done by taking different parameters and their effect on the properties of the composite. Various intermolecular potentials like TERSOFF, EXTEP, and other potentials are employed in MD to calculate properties with these potentials. Similarly, a different cut-off distance for Lennard-jones potential is deployed and crosschecked. The Time step is also compared by deploying different values of time integration in MD simulation. In the end, a comparison of the present parameters is made with the existing experimental results and their closeness with the actual reality is done. So that, those parameters can be directly used for further investigation in the future.

Keywords: Molecular Dynamics, Boron nitride tube

The study of effect of shear wall on building resting on hill slopes(PA132)

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Abstract- Due to asymmetry of plan and elevations, structures in hilly areas are more susceptible to earthquake forces. Due to increase in population in few decades, there is shortage of land in flat grounds. Due to rapid urbanization, economic growth and climatic conditions, migration towards hilly areas is increasing day by day. In the Indian context hilly areas are more vulnerable to earthquakes. In such circumstances, it is very important for the researchers to examine the responses of structures subjected to any impact load such as earthquake. As the height of entire building is not same due to elevation, responses of structure changes in case of earthquake loading. Use of shear wall in reinforced cement concrete multi storey building provides solution to many challenges. Shear walls are very effective against lateral loads in multi storey buildings. Shear wall ensures the safety by neglecting the displacement. Shear walls brings solution to many complex problems by reducing the dynamic responses in case of earthquake. A G+5 multi-storey building in seismic zone IV in hilly slope of approximately 200 is taken for the analysis in finite element software. Shear wall was placed across the slope at different location on different models. Effect of shear wall is considered and concluded that shear wall enhances the integrity of structure in case of earthquake. From the analysis it was shown that the intensity of shear force and bending moments significantly reduces across the slope direction of buildings on hill slopes. Results shows that addition of shear walls reduces the base shear. In the building resting on hill slopes the major concern for structure designer is to reduce the short column effect because of column located at different levels by providing the shear walls the short column effect can be minimized.

Keywords: Shear wall, hill slope, Building on hill slopes, Staad pro, earthquake force,

irregular building.

Design of a Bone-Inspired Composite(PA0136)

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Abstract- In the current paper, a 2D numerical model based on XFEM, designed in Abaqus 6.14, has been used to characterize the mechanical behavior of bioinspired composites. A 3-point bending test on the sample following ASME standard dimensions was carried out. Initially, a comparison between a normal composite and a bio-inspired composite was made with regard to properties like flexural stress, bending strength, young's modulus, and fracture toughness. The effect of change in the shape of osteons and increase in the osteon density were analyzed to understand their effects on various material properties. The presented model was able to mimic the crack deflection and twisting mechanisms thought to be the main contributors to bone fracture resistance using the microstructure of cortical bone as inspiration and increase fracture toughness over frequently used lightweight composites like laminates.

Keywords- Bio-inspired, fracture toughness, XFEM, Osteons, bone

Stochastic RBFN-based reliability estimation of variable fiber spacing composite plates under thermal loading (PA0139)

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Abstract- Stochastic reliability analysis is performed in the present work for variable fiber spacing composite (VFSC) laminates. The finite element model here is developed with third-order shear deformation theory (TSDT) to estimate buckling performance under thermal loading. The reliability analysis is performed with the first-order reliability method (FORM) and with the radial basis function network (RBFN) model as well. Further RBFN-based surrogate model is utilized for stochastic analysis, which is highly efficient and possesses a close match with traditionally used Monte Carlo simulation (MCS). The sensitivity of each input parameter is investigated, out of which the thermal expansion coefficient of the matrix ( ) is found to be the most sensitive one. m □

Keywords: Stochastic thermal buckling, variable fiber spacing composite (VFSC), First-order reliability method (FORM), Radial basis function network (RBFN), Monte Carlo simulation (MCS).

Bending Analysis of Functionally Graded Plates Under Mechanical and Thermal Environment Using Non-Polynomial Shear Deformation Theory(PA0143)

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Abstract- In recent years, spectacular technological progresses have led to tremendous requirements form engineering materials. These higher expectations from the structural elements to perform under different challenging conditions have led to the development of advanced structural materials such as composites, which have been extensively used in aerospace, mechanical, and other engineering applications for many years because of their excellent strength-to-weight ratios and stiffness-to-weight ratios. However, these composite materials are incapable to withstand high-temperature environments. To overcome all these limitations and to fulfil these demands of efficient advanced engineering materials by various emerging fields, a new class of material has been developed, known as functionally graded material (FGM). The FGMs are inhomogeneous materials with varying properties over a dimension. These materials are composed of two or more phases with continuously varying composition distribution in the preferred directions. FGM eliminates the sharp interfaces existing in composite materials, replacing them with a gradient interface to produce a smooth transition from one material to the next. They are usually made from a mixture of ceramics and metals to attain the significant requirement of material properties. In this present study, the linear bending analysis of the FGM(Al/Al2O3) plate is analyzed under mechanical as well as thermal environments under different boundary conditions and load conditions. Also, the present studies are performed by varying the aspect ratio, side-to-thickness ratio, and power law parameter.

Keywords- Bending Analysis, Functionally Graded Material Plates , FGM , TSDT

Kinematic Analysis based Comparative Study and Development of Modified Theo Jansen Linkage (MTJL)(PA0145)

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Abstract- In the field of leg robotics, the Theo Jansen Linkage is widely popular due to its scalable design, and deterministic foot trajectory. In this article, the author has modified and

analysed the Theo Jansen linkage to achieve better step height and stride length. The proposed Modified Theo Jansen Linkage (MTJL) consists of two ternary links and five binary links compared to the Conventional Theo Jansen Linkage (CTJL) which consists of twelve binary links including a crank link. In order to identify the optimized step height and stride length, several iterations are performed by varying the dimensions of the links, and each iteration is analysed for smooth foot locus trajectory, step height, and stride length to conclude the result. The iteration showing smooth foot locus trajectory, and maximum step height and stride length are selected for further study where it is compared with the CTJL and Theo Jansen linkages (JLs) developed by the other researchers. The result shows that the MTJL has a better step height and stride length compared to JLs as well as CTJL.

Keywords: Theo Jansen Linkage, Modified Theo Jansen Linkage, Path Analysis, Motion Analysis, Step Height, Stride Length, Foot Locus Trajectory

Propagation of Rayleigh-type wave in a microstretch elastic solid with voids (PA0147)

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Abstract- The propagation of Rayleigh-type surface wave is investigated for an isotropic, homogeneous microstretch elastic solid half-space containing voids. For the two-dimensional problem, the dispersion relation is obtained for the propagation of the Rayleigh-type surface wave by using the appropriate boundary conditions. It is found that the dispersion relation is dispersive, attenuating and complex in nature. The phase speed and corresponding attenuation coefficient of the Rayleigh-type wave are found to be affected by the voids and stretch parameters. The variation of phase speed and the attenuation coefficient against the frequency, voids and stretch parameters is depicted graphically for a Gauthier composite material. Some special cases are also discussed.

Keywords- Rayleigh wave, Microstretch, Voids, Phase speed

Study on strength evaluation of Bamboo-composite laminates for its use in low to medium scale structural components(PA0150)

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Abstract- Harmful destruction of the ecosystem and government strict laws and regulation has encouraged the incorporation of natural fiber composites which are entirely biodegradable. The utilization of bamboo fibers in the polymer industry is increasing tremendously as response to increasing demand for developing sustainable, and reusable material. India comprises 13 commercial bamboo species, of which standard qualities are reported from the Northeastern region. Though the potential of bamboo in this region is quite promising but the proper utilization and development of bamboo based products are lagging due to the absence of proper knowledge on the mechanical properties and acceptable building regulations. Various published articles have highlighted the physical and mechanical properties of bamboo composites, with less focus on finite element analysis about how this material would structurally behave under certain load application. The primary objective of this work is to develop composites from bamboo procured from the local markets of Assam. Composites are manufactured using – vacuum assisted resin transfer molding (VARTM) and compression molding. The strength single laminated bamboo composites and [0/90] laminates are evaluated and studied for its further study in FE (finite element) analysis. The composite's mechanical properties are evaluated and compared with traditional materials. The strength parameters of these composites are further incorporated to model small wind turbine blade to analyze its structural strength in low windy condition.

Keywords – Sustainable, Bamboo composites, Laminates, Finite element, Mechanical properties, Wind turbine blade

Novel Fringing Field Model for MEMS Resonators (PA0152)

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Abstract- Electrostatically-driven microelectromechanical systems (MEMS) devices are mathematically modelled using one dimensional approximation to study the nonlinear dynamics of the resonators. It is observed that the electrostatic fringing field affects the pull dynamics of MEMS resonators. The existing fringing field models are developed under assumption of infinitely wide rigid grounded beam as compared to the deformable beam. These models considered parameters which depends upon the thickness and the width of the elastic beam. In general, the MEMS resonators which are used for practical applications cannot have infinitely wide rigid grounded beam. In this work, a new fringing field model is developed to take into the account the finite width of the rigid beam electrode. A new parameter γ which accounts the fringing field effect due to the finite width of deformable and grounded rigid beam electrodes is introduced. The performance of the new fringing modelled is compared with the existing fringing models for different cases. It is observed that the new fringing filed model performance better for all test cases.

Keywords: Fringing field effect, Electrostatic force, MEMS actuators, Parallel plate capacitor

A spectral scheme to study elastodynamic fracture problem at the interface of a layer and a half-plane(PA0155)

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Abstract- A spectral scheme for 2D antiplane elastodynamic fracture problems at the interface between an elastic layer and an elastic half-plane is presented. In this scheme, the boundary integral equations (BIE) between the tractions and resulting displacement discontinuity along the interface are taken in the spectral form. Primary advantage of current scheme is its numerically efficiency due to evaluating field quantities over fracture plane only, rather than computing them in entire domain. Prior studies have used BIE where unbounded domains of elastic solids are considered to adjoin the sliding interface. BIE for the material interface of unbounded domains were first given by Budiansky and Rice [1979] and Kostrov [1966]. Their spectral form was given by Geubelle and Rice [1995] for 3D and Ranjith [2015, 2021] for 2D, respectively. To illustrate the application of above proposed scheme, an interfacial cohesive law is applied to study fundamental problems of the mechanics of dynamic ruptures at the interface of a layer and a half-plane.

Keywords- Friction, Boundary Integral Equation, Rupture Propagation, Elasticity

Probabilistic Fracture Mechanics studies using GraFEA and HDMR(PA0161)

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Abstract- Recently a tool, graphical Finite Element Analysis (GraFEA) is developed for fracture/damage growth analysis using non-local criteria. Studies based on GraFEA have been

done regarding the crack propagation for structures with deterministic material properties; however, the response of structure in the presence of different uncertainties in the system has not been studied. The current study examines the possibilities of extending GraFEA formulation in probabilistic linear elastic fracture mechanics problems. For the probabilistic analysis a response surface method based on high dimensional model representation (HDMR) is used. The probabilistic characteristics of load at which unstable crack growth occurs has been evaluated using the proposed HDMR based GraFEA simulation. Further, for the validation of results direct Monte Carlo simulation of system of equations has been employed. The probabilistic analysis is further extended to identify the safe load, at which the probability of failure is minimum.

Keywords: Probabilistic Fracture Mechanics, Fracture, Graphical Finite Element Analysis, High Dimensional Model Representation.

A Deep Learning Based Approach to Estimate Unbalance of a Flexible Rotor(PA0162)

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Abstract-The present work proposes a method for unbalance identification of single and double disc rotors using the method of deep learning. The magnitude and phase of rotating unbalance are intended to be determined from the measurement of horizontal and vertical displacements of the rotor at the location of the disc(s). A three layered model is trained and tested with appropriate dataset. In place of an actual rotor, a numerical model of the same is considered. In order to account for the possible error in measurements and other uncertainties in an actual rotor, a random error is deliberately introduced in the numerically computed results.

Keywords: Unbalance, Artificial Neural Network, Displacements of shaft

Modified Model for Soft Filler Polymer Nanocomposite to Predict the Mechanical Behavior(PA0163)

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Abstract- Dielectric elastomers (DEs) are recognized for electromechanical actuation performance that holds their applications in flexible electronics to construct actuators, sensors, and energy generators. In preparation for DE-composite, the use of soft fillers rather than rigid fillers is found feasible to improve the electromechanical performance of DE-based devices. Although it is relatively easier to determine the electrical properties of soft fillers, difficulty in the prediction of mechanical properties hinders the complete understanding of fillers effects towards overall performance. In this paper, attempts were taken to propose a modified model for the evaluation of the mechanical properties of fillers. The obtained mechanical property (elastic modulus) of soft filler is verified for the DE-composite having higher weight percentage (soft filler) by comparing with existing experimental data. The modified model predicts the mechanical compliance of soft polymer composite with enhanced accuracy and thus shows its efficacy. It is expected that known fillers properties may be helpful to use materials efficiently for enhanced the performance of DE.

Keywords: Dielectric elastomers, soft fillers, dielectric properties, mechanical compliance.

Study of Lightweight Armour Solutions for Shipboard and Marine Structural Applications(PA0168)

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Abstract- Lightweight armours are being exploited extensively as protective materials against ballistic and fragment hazards launched from explosions or small arms. Specific applications of these armour system include personal clothing (Bullet proof jackets), helmets, components and interiors of aircraft cockpit, combat vehicles and ships. While the lightweight armour solutions have been extensively presented in the open source, very limited information related to lightweight ship armour has been published. This review paper brings out the performance of conventional monolithic structural and armour grade steel against fire arms. Design configurations and ballistic performance of multilayer armour system have also been highlighted. Various techniques used for undertaking design of lightweight structural armour for helping a Naval Architect in design of protective structures susceptible to attack by small/ medium calibre projectiles and fragments have been briefly described.

Keywords: - Ship Armour, Marine Grade Steel, Composites, Impact Analysis

Free Vibration Analysis of Thin Membranes using EFGM(PA0176)

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Abstract- Vibration of thin membranes under tension is a topic of very high physical significance. One of its most common application is in a typical western percussion instrument where a uniform membrane under tension is used to produce sound. Some classical Indian percussion instruments use a variable density membrane to generate complex modes of vibrations. Present work is aimed at developing an efficient computer program based on Galerkin scheme, a particular case of Mesh Free Methods, to solve the basic wave propagation equation for the specific case of a thin rectangular membrane fixed along the perimeter. A MATLAB code is written to extract its first few modes of vibration. Starting from the basic wave equation, a weak form for the governing differential equation is formulated, followed by the formulation of discrete equations, as prescribed by Element Free Galerkin Method (EFGM). It is observed that the code can produce accurate mode shapes associated with the vibration. A convergence study is performed to determine the minimum number of nodes required to produce accurate results. It was observed that the results converged in a relatively low number of nodes in comparison to a traditional FEM technique. The error plots produced by EFGM method also proved that the results obtained from the meshfree method were much more reliable than the traditional FEM results. The work has future scope to be developed into a full-fledged 3-D capable tool to analyses complex geometries and composite cavities.

Keywords- EFGM, Free Vibration analysis, Thin structures, Membrane, Meshless method

Failure analysis of quasi-brittle materials using CZM based floating node method(PA0189)

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Abstract- Initiation and propagation of a crack in engineering structures require critical attention, which may otherwise lead to structural failure. In this work, numerical analysis of quasi-brittle materials is performed using the Cohesive Zone Model (CZM) based Floating Node Method (FNM), and the nonlinear behavior of material inside the fracture process zone (FPZ) in front of the crack tip is modeled by intrinsic CZM approach. FNM is used to represent the kinematics of crack and the crack front inside the domain without the requirement of remeshing. The proposed method is applied for the patch test of a 2D specimen under mode I and II loading conditions.

The effectiveness of the proposed model is checked by comparing the results with the available literature data.

Keywords- CZM, FPZ, FNM

A study of stress profiles in cyclic bending of an elasto-plastic beam(PA0192)

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Abstract- In complex bending applications, quite often elasto-plastic deformation is experienced in structures. To model this elasto-plastic deformation, elastic perfectly-plastic stress-strain model is generally considered. In the case of elastic bending problems, it is well known that moment –curvature based constitutive law is over the stress-strain law, for ease of solving the governing deflection equations. However, in the case of inelastic bending, a nontrivial transformation occurs between stress-strain model and moment-curvature based model. In the process of obtaining the moment-curvature law, a detailed through thickness stress profile is necessary for any given curvature. In this paper, a study is presented on stress profiles along the depth of the beam at different stages of cyclic loading subjected to elasto-plastic deformation. The results indicate interesting stress profiles which are observed at points of zero moment and curvature in an elasto-plastic loading cycle.

Keywords: Moment-curvature, stress-profile, beam bending, elastic-perfectly plastic

An Efficient Enrichment Approach for Fracture Simulations using Element Free Galerkin Method (PA0193)

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Abstract - In the current work an approach to enhance the computational efficiency of element free Galerkin method (EFGM) has been proposed by modifying the usage of enrichment functions along with regional nodal density. Effective use of linear basis and fully enriched basis function has been proposed such that area near to tip utilizes fully enriched basis function which subsequently changes to linear basis function in a well-defined proposed way in moving away from the crack tip. Similarly, the regional near crack is discretised for high nodal density than the remaining region. This newly proposed scheme has been validated by evaluating the stress intensity factor for crack problems under thermoelastic loads. Obtained results from proposed scheme show good agreement with the results from literature and relatively took 58% less computational time thereby enhancing its computational efficiency. Also disadvantage of

traditional EFGM in evaluating field variables inaccurately for non-convex domains has been overcome by the proposed criteria.

Keywords*:* EFGM, Fracture, Crack, MLS Basis function.

Estimation of the residual stresses in thermal autofrettage of hollow disk using von-Mises yield criterion (PA0194)

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Abstract: This work presents a numerical elastic plastic stress and strain analysis in the thermal autofrettage of a disk based on von Mises criterion. The solution for elastic plastic stresses and strains and the residual stresses induced by thermal autofrettage due to von Mises are obtained for elastic-perfectly plastic material and for plane stress condition. The numerical evaluation of the stresses and strains in a typical mild steel disk undergoing thermal autofrettage is carried out and the corresponding solution is compared with the existing analytical solution employing Tresca's yield criterion.

Keywords- Thermal Autofrettage, von Mises criterion , residual stress, thin disk

Simulation of Functionally Graded thermal barrier coating (TBC) over Al-Si Piston using Finite Element Method (PA0197)

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Abstract- The piston is an essential part of an internal combustion engine which transfers force from gas expansion in cylinder to the crankshaft. Owing to its functionality, piston is subjected to high thermal gradients due to expansion of gases which often leads to development of high thermal stresses. Use of coating on engine components has been found to yield the efficiency of the engine as it entraps unwanted heat transfer to the engine components. Over the years functionally graded materials are gaining importance as thermal barrier coating owing to its spatial variation of constituent. FGM consists of metallic and ceramic phases which vary in composition from one end to other in a well-defined way. The effort to increase the performance of piston using thermal barrier coatings in form of Functionally graded materials have been the main aim of current work. Spatial variation of constituents in FGM has enabled it to be used as thermal barrier coatings as its ceramic constituent exposed to high-temperature acts as a barrier to heat transfer due to its lower thermal conductivity. Functionally graded Thermal barrier coating enhances high-temperature durability of the components by reducing heat transfer between the underlying piston metal. Current work focuses on finite element analysis of Al-Si piston using

ANSYS workbench having different type of FGM coatings (MgZrO3 + NiCrAl, YSZ + NiCoCrAlY, NiCrAlY + YSZ, La2Zr2O7 + NiCoCrAlY). The major aim of this study is to predict the most suitable FGM coating after comparing the outcomes of the analysis performed using the Finite element method.

Keywords: Functionally Graded Material, Finite Element Method, Piston, Coating

Detection of edge crack in beam like structure modeled as rotational spring by using Bayesian filtering(PA0198)

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Abstract- Numerical beam is an important structure type for replicating and idealizing several different real structures, e.g. bridges, high-rise structures etc. Towards development of damage detection approaches/ algorithms for bridge structure, present study has idealized it as a prismatic beam and an instance of localized structural damage is replicated as a through crack at the beam. The objective of this study is further to precisely localize the extent and location of such damages under severe ambient and model uncertainties. Particle filtering based structural health monitoring (SHM) approach has been employed in this study. Typical of such model-based algorithms, the real structural domain is discretized into finite elements with the damage attributed to any of these elements, rendering the localization precision being dependent on the discretization resolution. Current study modelled the damage as a independent massless rotational spring in the beam attributing the local stiffness deterioration of the real structure through the decay in the spring stiffness. To localize and quantify the real damage in the beam, the goal of present estimation approach is therefore set as to locate the position of such spring and further estimate its residual spring stiffness. This enables localization of the damage with a resolution much beyond the discretization density, and thereby helping the algorithm to be supported with much less compute-intensive models. The algorithm is validated for its sensitivity against noise and damage severity. The results demonstrate the algorithm to be efficient, prompt and precise in detecting damage in a structure.

Keywords- Particle filtering, Structural health monitoring, Beam like Structure, massless rotational spring ,finite element model, model-based algorithm

Multi-pass weld influence on the microstructure of gas tungsten arc welded Ti-6Al-4V alloy (PA0199)

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Abstract- Aircraft applications make use of Ti-6Al-4V for almost 50% of all alloys used in. Owing to their high tensile strength to density ratio, high corrosion resistance, and ability to withstand moderately high temperatures without creeping, titanium alloys are used in aircraft, armor plating, naval ships, spacecraft, and missiles. aircraft engines and frames which frequently fabricated using welding technology that often involves multiple passes that has direct impact on alloys metallurgical properties. Therefore, the aim of the present work was to investigate the effect of weld pass on the metallurgical properties of 7 mm thick Ti-6Al-4V alloy. Ti-6Al-4V weld joint in the butt-welding position were fabricated using 3-pass and 4-pass welding procedure using Gas tungsten arc welding (GTAW) process. Heat input control becomes essential in such critical applications and can have far reaching consequences as far as service performance of welded structures is concerned. The results of this work show that Ti-6Al-4V alloy is sensitive to welding heat input caused via procedural variation. Further, welding procedures can be designed according to the microstructural and hence mechanical requirements of Ti-6Al-4V alloy by controlling heat input per weld pass suitably.

Keywords: Ti-6Al-4V, GTAW, Microstructure, Hardness, Multipass weld.

Transient analysis of graphene reinforced FG-porous sandwich plates subjected to underwater blast (PA0200)

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Abstract- The present study performs the transient analysis of sandwich plates subjected to underwater blast loading. The sandwich plate is composed of two isotropic face sheets and a functionally graded (FG) porous core which is reinforced with graphene nanoplatelets (GnP). The effective properties like Young's modulus and mass density of the reinforced core are obtained using the Halpin-Tsai model and rule of mixture, respectively. The distribution of porosity and GnP employs continuous functions to accomplish gradation along the thickness direction. The governing equations based on the higher-order plate kinematic model are developed using a variational approach. The transient response in terms of nondimensional center displacement has been accessed by the finite element method along with Newmark's time integration approach and the influence of various parameters such as porosity index, GnP's weight fraction, type of distribution, etc. is also explored.

Keywords: Finite element method, functionally graded porous core, graphene reinforcement, sandwich plate, transient analysis, underwater blast.

Specific heat and magnetic effects in orthotropic piezoelectric micropolar medium under three-phase-lag thermoelastic model(PA0205)

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Abstract- This research work aims to investigate the nature of physical variables and the phase speed of elastic waves using normal mode analysis and appropriate boundary conditions in the heat conducting orthotropic magneto-micropolar piezoelectric material under the three-phase-lag model. It is observed that five elastic waves propagate through this material continuum.The appropriate boundary conditions at the plane interface (z = 0) are the vanishing of normal stress, tangential stress, couple stress, dielectric displacement and temperature gradient.The effect of specific heat and magnetic intensity on the phase speed (c□, c□, c□, c□, c□) and physical variables are investigated using graphical analysis of 2D graphs plotted against
increasing angular frequency (ω). Also 3-dimensional graphs of physical variables consisting of displacement components, normal and tangential stress, couple stress, dielectric displacement and temperature are plotted against both components of distance.The value of phase speed (c□) decreases, while all the other phase speeds increase with the increase of frequency (ω). With the increase of specific heat the values of c□ increase, while those of c□and c□ decrease. All the physical variables when plotted against increasing distance component (x) represent sinusoidal form of graph for different values of magnetic intensity. 3D representation of the physical variables indicates curves are moving harmonically along x −axis and dying along z −axis.

Keywords: Piezoelectricity; Magneto-thermoelasticity; micropolar; orthotropic; stress.

Effect of the internal length scale parameter in gradient damage mechanics (PA0210)

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Abstract-Gradient enhanced continuum damage mechanics is one of the best methods to remedy the mesh sensitivity and mathematically infeasible results usually obtained in the numerical implementation of continuum damage mechanics theories. It involves the introduction of internal length scales through nonlocal averaging. In the present study, we investigate the effects of the internal length scale parameter on the structural response. A half model of a single-edge notched specimen is analyzed with large and small length scale parameters using an in-house MATLAB code assuming isotropic damage and plane strain conditions. A scalar damage variable with exponential evolution law is considered. The results demonstrate that with increasing internal length scale parameter, the damage spread increases and its maximum value decreases; hence, its selection should be made considering the experimental responses of a material. A detailed

description of finite element formulations and implementation algorithms for solving the nonlinear problem is elucidated.

Keywords: Gradient Damage Mechanics, Internal length parameter, Nonlinear Finite Element Methods

Subdomain boundary forces estimation of bridge structure under vehicle loading using interacting Ensemble-Particle filtering(PA0213)

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Abstract- Vehicle-induced vibration may cause fatigue in bridge structures leading to sudden failure causing loss of economy and human lives. Structural fatigue estimation is however a complicated proposition since the entire structure needs to be monitored irrespective of the fatigue proneness of different parts of it. This eventually invites huge computational cost due to high dimensional modelling and also dense instrumentation for precise estimation of the fatigue related properties or parameters. It has been perceived that only a certain specific locations are fatigue prone and standalone fatigue monitoring of only that subdomain is possible provided the forces acting on to it is available. To isolate the subdomain of interest from the entire structural domain, one needs to compensate with boundary forces at the domain boundaries which is never possible to be measured. This study proposes a subdomain estimation based approach powered by interacting Ensemble-Particle filtering approach (IP-EnKF) that monitors only a subdomain of interest (fatigue prone) independently for its structural and damping properties while estimating the boundary forces in parallel for subsequent fatigue life estimation. This allows employment of computationally inexpensive predictor models for any model assisted health monitoring approach while reducing the required cost and effort of instrumentation. The approach has been validated on a bridge structure excited by a 4-degrees-of-freedom half-car model and subsequently unknown boundary forces are estimated for the fatigue life assessment. The proposed method is investigated for its noise sensitivity and has been found to be effective and reliable.

Keywords- subdomain, vehicle, boundary forces, particle filter, interacting filtering.

Nanoindentation of Nano-crystalline Cu-Ni Alloy Thin Films employing Indenter Dynamics and Parameter Variation - A Molecular Dynamics Approach(PA0216)

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Abstract- In the present work, nanoindentation simulation has been carried out for poly-crystalline Cu-Ni alloy thin films in nanostructured form, using molecular dynamics (MD). We aimed to investigate the effects of varying speed of indenter, indentor position and indentor size on hardness and Young's modulus. The simulation of nanoindentation was performed employing loading, holding and unloading of spherical indenter.

Keywords- Molecular Dynamics, Nanoindentation, Cu-Ni alloy, nano thin film

Electromechanical response of partial nano unimorph beams considering surface and flexoelectric effects (PA0218)

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Abstract- In this work, we have shown the electromechanical behaviour of rotationally restrained cantilever nanobeam of partial unimorph structure considering flexoelectricity and surface effects. The differential equation of the beam is solved from the methodology developed from the Gurtin-Murdoch Continuum theory. For the partial unimorph structure we have considered Silver as passive material and Functionally Graded Piezoelectric Material (FGPM) with different distribution patterns as active material. For endpoint load, the results revealed a strong dependence on the sign of residual surface stress and how several distribution patterns in FGPM can influence the electromechanical behaviour of nanobeams. The model can be extended to energy harvesting aspects in future.

Keywords: Flexoelectricity, Surface Effects, FGPM, Residual Surface Stress.

Programming in-plane and out-of-plane auxeticity in metamaterials through exploiting hybrid unit cells(PA0219)

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Abstract- Engineering materials used for structural applications have a limited tendency to only expand in the lateral directions when subjected to a compressive force applied longitudinally commonly known as the Poisson's effect. Based on the bending-dominated behaviour of elementary beams with variable curvature, we illustrate diverse auxeticity following the framework of multi-material unit cells. The 3D connected double loop (3DCDL) unit cell and hybrid unit cells (formed based on their clusters) are capable of achieving partially auxetic,

purely auxetic, purely non-auxetic and null-auxetic behaviour. The open cell structure of engineered auxetic materials results in a lower density. Using an analytical approach to characterise multi-directional auxeticity would be efficient and physically informative. Extensive finite element validation have been performed to establish appropriate confidence in the conclusions obtained using the established analytical technique. Auxetic materials have applications in technologically demanding industries, including defence, aerospace, mechanical, and biomedical engineering, based on their increased mechanical capabilities.

Keywords- Multi-directional auxeticity; 3D lattices; Fully auxetic; Fully non-auxetic; Zero Poisson's ratio; Finite Element Validation

Mechanics of Inflatable Aerospace Structures(PA0221)

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Abstract- Inflatable structures are made up of highly thin membranes and have the ability to take complex shapes upon deployment. Due to their lightweight and low mass, they have become an obvious choice over rigid solid structures and are extensively used in the aerospace sector. In the present work, we have presented the analytical expression of the deformation of an inflatable beam element using the vector mechanics approach. Further, we have validated the presented formulation by comparing it with the expression of beam deformation obtained using the energy method. These inflatable structures have brought about a revolutionary paradigm shift in the aerospace industry because of compact storage, easy deployability and low cost of aero-specific missions.

Keywords: Inflatable structures; internal gas pressure; vector mechanics

Multiscale Simulation and Experimental Approach to Design Carbon Fibre Reinforced Epoxy Polymer Composites (PA0224)

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Abstract- Carbon fiber reinforced polymer composites (CFRP) have significantly improved mechanical properties over conventional metallic composites. Due to this, they have been used in the manufacturing of different structural parts in aeronautical industries, such as fuselage sections and cock-pits. For heterogeneous materials like CFRP, the determination of a large number of properties through an experimental process is a time taking and expensive process. So homogenization techniques are used to predict the elastic properties of the composites in terms of the elastic properties of the constituents (matrix and reinforcements). Homogenization techniques are based on more and less accurate microstructure modeling and are called micromechanics

modeling. The mechanical properties calculated from micromechanics are used to calculate the mechanical properties at the laminate level. Elastic properties calculated from the micromechanics model roughly follow the rule of mixture. An experimental test of CFRP has also been done to validate the simulation data. A good agreement was found between simulation value and experimental results.

Keywords- CFRP, Micromechanics, Finite Element Method, Homogenization

Motion control study in energy-saving electrohydraulic system for RCGA-based identification of valve-cylinder parameters

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Abstract- It is quite challenging to improve the motion tracking performance in the emergent energy-efficient type of high-power electrohydraulic systems with applications ranging from slow-response excavators to fast-response automobile steering. A simulation study of motion tracking by a low-cost high-friction double-acting single-rod cylinder DASRC with control of the flow from an energy-efficient variable-displacement pump VDP by a low-cost large-deadband proportional valve PV has been performed. An experiment-assisted identification study has been carried out for the parameter estimation of a novel order-separated feedforward formulation developed to tackle the nonlinear effects of variable supply pressure of VDP, oil compressibility, friction in DASRC along with leakages and deadband in the PV. With respect to the motive incompressible flow that sustains the piston motion demand, the feedforward formulation assumes other effects to be of lower-order. A PI feedback voltage has been added to minimize the effect of these approximations. Alternately engaged and disengaged phases of spring loading on the reciprocating piston has been considered to cater to simulate typical real-life load profile. A number of simulation runs have been executed to estimate the feedback gain setting for achieving good tracking response along with taking care of the stability issue for the fourth-order high linearized error dynamics.

Keywords- DASRC, RCGA, Variable Displacement Pump, Feedforward-PI Controller, IAE, Electrohydraulic Systems

Force tracking in an electrohydraulic system with variable-displacement pump by a novel feedforward controller with PI feedback(PA0228)

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Abstract- The challenge of mitigating pressure transients in the cylinder chambers in closed loop has restricted the growth of force control application with respect to motion control by electrohydraulic system. Such transients could get aggravated in a pressure-compensated

variable-displacement pump, or VDP, which is used for energy saving with respect to that achieved by using a fixed-displacement pump. In this context, a real-time force-tracking experiment under feedforward-PI feedback, or FFPI, controller has been carried out in a laboratory setup shown in Fig. 1. The setup has of a VDP and a low-cost pair of a proportional valve, a high-friction double-acting-single-rod cylinder DASRC loaded by a spring. There is a load cell for measuring the output force in excess of the friction. Notable contributions of this work are the FF formulation for tracking of force instead of motion by a compact DASRC of different flow areas in the two cylinder chambers instead of equal areas in a double-acting-double-rod cylinder and flow variation at the VDP delivery. A significant achievement of the order-separated formulation is a generalized frame involving multiple nonlinear aspects like the dominating oil flow through the metering valve orifices sustaining the piston motion against the external force together with the friction between the piston and the cylinder along with the lower-order effects of variable pump pressure, oil compressibility and flow leakage mostly ignored in the existing motion-tracking formulations. A significant outcome of the work is the realization of the need of employing more detailed friction model for its compensation in executing the force control especially during the reversal of the demand. By changing the feedback gains, the modelling limitations of the FF formulation could not be compensated in real-time experiments by PI feedback

Keywords- DASRC, RCGA, Variable Displacement Pump, Feedforward-PI Controller, Electrohydraulic Systems, Force Control

Heave tracking by an electrohydraulic serial-parallel manipulator(PA0229)

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Abstract- Electrohydraulic manipulators are used to avert coupler failure in rotary motor of electrical actuation systems in high-power applications with uncertain and sudden load changes typical in harvesters and excavators. However, the control emerges as more challenging due to the flow and friction nonlinearities in the valve-cylinder pairs. Hence, good motion tracking response has been achieved in excavators only up to 0.05Hz despite the use of advanced feedforward-PID, or FFPID, controller. In this context, a novel order-separated FF formulation has been developed together with transformation of the kinematics of the output motion demand to the actuation space. In the formulation, the effect of the valve-cylinder leakage flow sustaining the piston motion is taken care of by assuming the effect to be dominated by the motive flow in the cylinder modelled by considering oil as incompressible. Additional PID feedback has been employed in the real-time experiments to take care of the limitations of the formulation. The efficacy of the FFPI controller has been demonstrated by accomplishing successful heave tracking up to 0.2Hz for a manipulator platform supported on four legs in parallel arrangement and each leg in the form of a serial manipulator with three valve-cylinder pairs having cylinder axes inclined to the limb axes. In comparison to PID-only controller, the tracking performance and disturbance rejection capability of the FFPID controller is clearly seen as superior. Since the experiment has been executed at 9MPa delivery pressure of the gear pump set by the pressure

relief valve, higher settings of 20MPa or higher that are usual with axial-piston pumps would indeed yield even higher speed of response.

Keywords- Electro-hydraulic Serial Parallel Manipulator, Heave Tracking, Electro-hydraulic Systems, FFPID, Harvesters, Excavators

On the natural frequency of shear deformable FGM plates with symmetric and asymmetric porosity distributions(PA0232)

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Abstract- This paper investigates the natural frequency of shear deformable functionally graded material (FGM) plates with symmetric and asymmetric porosity distributions. The distribution of porosity is considered using cosine functions and the gradation by composition is accomplished by employing power law along the thickness direction of the plate. The ceramic and metal are taken as the constituents and the effective material properties are obtained by the rule of mixture. The variational approach is adopted to drive the governing equations based on C0-continuous higher-order shear deformation theory (HSDT) with 7 degrees of freedom. The natural frequency of the FGM plate is found using the finite element method considering a nine nodded isoparametric element. The parametric study is also given which demonstrates the effect of various parameters like volume fraction index, porosity coefficient, and side-thickness ratio on the natural frequency of FGM porous plates.

Keywords: Finite element method, free vibration analysis, functionally graded materials, higher-order shear deformation theory, porous plates.

Influence of different wave characteristics on the propagation of surface waves in a piezo-thermoelastic half-space (PA0233)

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Abstract- Recently, one of the smart materials named piezoelectric is applied in various fields of engineering, science, and technology. Piezoelectric materials may be used in extreme temperature conditions, so thermal effects should be considered in mathematical models. The prime focus of this study is to investigate the propagation of surface (Rayleigh type) waves in a homogeneous, transversely isotropic, piezo-thermoelastic half-space subjected to stress free, electrically open, or shorted, and thermally insulated or isothermal boundary conditions, based on three-phase-lag thermoelastic models. Expressions for mechanical displacements, electrical potential, and

temperature change have been derived with the aid of plane harmonic wave solutions. In view of these expressions, stresses, electrical displacement, and temperature gradient have been formulated. Based on different boundary conditions, four secular equations have been discussed in the considered half-space. A pre-established analysis is discussed as a particular case of this study. The influence of various wave characteristics (namely, phase velocity, attenuation coefficient, and specific loss) has been depicted by means of graphs. This mathematical framework may be utilized to design and develop temperature sensors, and other piezoelectric surface acoustic wave (SAW) devices.

Keywords: Thermoelasticity, piezoelectric materials, surface waves, three-phase-lag model, specific loss.

Assessment of intra-laminar macro damage in textile composite using gradient enhanced continuum damage mechanics method(PA0237)

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Abstract- Although, textile composites have been popular over the laminated composites, their complex fiber architecture pose hurdles in modelling and predicting material behaviour under various static and dynamic conditions. Also, development of effective methodology for capturing material response to macro-damage onset and evolution is even challenging. The present work discusses the intra-laminar macro-damage initiation and evolution in plain woven textile composite. A two-step homogenization approach is employed to deduce the effective properties of the composite material which are then used in developing the strain-damage coupled constitutive equations. Gradient enhanced continuum mechanics technique is used to tackle the localization issues due to mesh sensitivity in otherwise vastly efficient and popular continuum damage mechanics method. The numerical solution is evaluated with the help of ABAQUS user element subroutine (UEL) via nonlinear finite element solution techniques. The material response to macro-damage initiation and evolution is observed to be consistent with the experimental data thus validating the efficiency and accuracy of the present work.

Keywords- Macro-damage, Gradient Enhanced Continuum Damage Mechanics, Regularization, Textile Composite, Two-step Homogenization, Nonlinear Finite Element Method.

Molecular dynamics simulation for phase transformation of Ti-50 atom% Nb alloy(PA0243)

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Abstract- Now-a-days Ti-Nb alloy become prominent in biomaterials field for its biocompatibility in human body. Rapid prototyping (3D printing) took the limelight since past few years for the fabrication of bio implants. For study of modelling and simulation of rapid cooling, can be executed in molecular dynamics (MD) simulation, involves in 3D printing process during solidification. In this study Ti-50 atom % Nb has been simulated and analysed by the help of molecular dynamics simulation in LAMMPS package. A calculated lattice parameter of Ti-(50 atom %) Nb alloy by the help of MD simulation has been taken for this study. A modified embedded atom method (MEAM) potential file from NIST potential has been used during programming. A periodic boundary condition of a 100×100×100 Å3 box size for single crystal and npt ensemble for thermal equilibrium condition at higher temperature of 673 K followed by heat extraction at 50, 70 and 100 eV/ps at nve ensemble up to room temperature have been studied. During rapid cooling calculation of temperatures of phase transformation by the help of total energy at each steps and crystal structure analysis and verified at both higher and room temperature by the help of radial distribution function have been analysed.

Keywords- Molecular Dynamics, Phase transformation, Alloy

Investigation of Composite Materials for a Remote-Sensing Cubesat Structure: An Alternative to Traditional Aluminium Alloys(PA0246)

Adesh S. Phalphale, Nishita Sanghvi, Subhamoy Sen and Sunil V. Dingare

Abstract- Satellite miniaturization and CubeSats have encouraged the development of smaller sensors that could be accommodated in smaller launch vehicles to comprehensively address most Earth Sciences needs. The positive spiral emanating from this development has resulted in lower costs, shorter mission development times, and an accelerated absorption of contemporary technologies and commercial off-the-shelf components for space applications. CubeSat architecture demands materials that can withstand all static and dynamic loads encountered during its launch and operational life, while effectively meeting all size, weight, and power constraints. A CubeSat's integrity and stability are directly related to its structural design and configuration, and thus, it is essential to optimize the structure. Typically, a CubeSat structure facilitates simple load paths, simplified interfaces, and easy integration, with a strong emphasis on minimum weight, vibrational interactions, and material selection considerations. The structure must achieve its goals for the static and dynamic loading of the testing and the launch phase, and finally in the zero-gravity operational environment. The structural and mechanical parts of a satellite generally represent a large percentage of its mass, and therefore, it is essential to choose the proper material and structural configuration to minimize mass. The primary choice for structural systems is Aluminium alloys, the most common being 6061 or 7075 and respective grades. This paper focuses on the design and verification by thermal and structural analysis for a remote sensing CubeSat structure in sun-synchronous near-polar low-earth orbit. It also presents

the results of the investigation of the use of suitable and feasible composite materials in structural design. The research explores the feasibility of designing and qualifying a 'hybrid' CubeSat structure made of both composite materials and aluminum alloy.

Keywords- CubeSat Structural Subsystem, Thermal Analysis, Composite Structures

Design and Structural Optimization of a 1U Cubesat(PA0256)

Rahul Dada Sharmale, Adesh S Phalphale

Abstract- By adopting fewer restrictions and incorporating commercial technology, a quickly expanding small satellite sector has made it possible for space missions to become more capable and affordable during the past few decades. In space exploration, cubesats are replacing larger satellites. It is crucial to maintain the structural integrity of satellites during challenging space environment. The integrity and stability of a satellite are intimately correlated with its configuration and design. As a result, it's important to optimise the architecture for the specified space requirements. The structure is one of the primary satellite components for cubesat missions. The structural subsystem's main goal is to provide a straightforward, durable structure that can withstand launch loads and create an environment that is conducive to the proper operation of all other subsystems. A small, light CubeSat must have a precise geometrical design in order to be launched into space. When developing a cubesat, there are numerous factors to take into mind. These factors include simpler and more affordable production, cubesat dimensions, and materials that will be employed. The structure will meet all performance objectives if these factors are incorporated into a design specification. A standard requirement while designing a cubesat's structure is to include considerable stiffness and strength to withstand both static and dynamic loads acting on the cubesat. This research paper aims to study different cubesat structures as the structure of cubesat plays an important role in determining the outcomes of many investigations that have been done on them. This would provide us a succinct ideology regarding several structures that might work well for our cubesat. Followed by this, structural, modal as well as transient analysis would also be performed which would give us an outcome about different structures and its durability in harsh space environment.

Keywords- CubeSat, Optimization, Analyses

Deep Learning Model to Predict the Stresses in Polymer Composite Materials(PA0261)

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Abstract- Polymers are used in various engineering sectors for their effective and efficient mechanical properties, anti-corrosive nature, and high strength-to-weight ratio. The particulate polymer composites (PPC) of short carbon-filled epoxy are focused on in this study for their

macroscopically isotropic behavior and easy fabrication. PPC is used for its customized applications, thus requiring a very precise estimation of the mechanical behavior of the material used in the fabrication of the composite. In order to obtain precise stress-strain behavior of the composites, a lot of labor-intensive and time-consuming efforts are required in performing the experiments and expensive computational simulations. With the purpose of reducing these cumbersome efforts of engineers and researchers, the training data model of Machine Learning (ML) is implemented and it tends to examine the mechanical behavior of PPC accurately and expeditiously. The results for the training model are examined on the basis of accuracy obtained in terms of L2 Norm and correlation factor. The L2 norm is found to be lesser than 0.15 and 0.005 for most stress-strain estimations in the 2D micromechanics-based model. The Deep Learning (DL) framework is found to effectively and efficiently predict the mechanical behavior of PPC. It is observed that the results attained from finite element analysis software and the predictions from DL are proficiently generating valid outcomes for the given input in training the Convolutional Neural Network (CNN).

Keywords: Micromechanics; Machine Learning; Mechanical Behavior, Convolutional Neural Network (CNN)

Influence of alloying elements on mechanical deformation of AlCoCrFeNi High-Entropy Alloy(PA0272)

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Abstract- In the present study, a set of molecular dynamics (MD) simulations are carried out to investigate the effect of individual alloying elements on the mechanical deformation of AlCoCrFeNi high entropy alloy (HEA). Different HEA system configurations were considered by varying the atomic fraction (at.%) of the individual alloying elements. The shear strain-shear stress responses are recorded during the mechanical deformation of the individual HEA system. In addition to that, the microstructural deformation evolution of the HEAs is also investigated under the shear loading. This study proposes a bottom-up design approach for the synthesis of High-Entropy alloys based on the desired characteristics.

Keywords- Molecular Dynamics, High Entropy Alloy, Alloying Elements, Mechanical Deformation, Shear Strength

Experimental and numerical investigations of cyclic plastic deformation of cryorolled AA 5754 (PA0273)

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Abstract- The objective of the present work is to study the influence of cryogenic deformation on strain controlled low cycle fatigue (SC-LCF) properties of Al-Mg (AA 5754) alloy. AA 5754 is rolled at cryogenic temperature (-196oC) for maximum of 40% thickness reduction. XRD analysis substantiates the ultra-fine grain formation during cryorolling. A series of uniaxial SC-LCF tests are executed at three strain amplitudes from 0.4% to 0.6% for parent and cryorolled (CR) condition of alloy. Majority of the fatigue life span for cryorolled alloys shows cyclic softening behaviour except cyclic hardening at initial 30–40 cycles. In contrast, only cyclic hardening behavior is depicted by parent specimens. Chaboche model is used for simulating the SC-LCF hysteresis loops. The present study reveals good superimposition of experimental and simulation hysteresis loops.

Keywords: Al -Mg alloy, cryorolling, low cycle fatigue, hysteresis loop, Chaboche model

Numerical investigation of crack propagation in industrial pipeline using extended finite element method (PA0274)

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Abstract- The objective of the present work is to numerically simulate the crack propagation in the cylindrical pipelines. Pipeline industries frequently getting damage caused by crack formation and its propagation during manufacturing and installation process. Due to this fitness-for-service deteriorates and service life of pipelines will get decreased. In this work, a cylindrical pipe having a circumferential semi-elliptical surface crack is considered and its crack growth mechanism has been investigated numerically. A novel numerical approach extended finite element method is used to simulate the crack growth mechanism. The critical stress intensity factor (SIF) is calculated for different shapes of the cracks present in the domain. Simulation results show good agreement with the experimental results which can be further utilized for practical reference for defect evaluation in pipeline industries.

Keywords: extended finite element method; fracture mechanics; crack growth; stress intensity factor.

Importance of Separation Gaps for Asymmetric Tall Buildings under Earthquakes (PA0275)

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Abstract- The poor performance of structures under strong ground motion can be attributed to structural asymmetry. Asymmetry strongly contributes to translational-torsional coupling in the seismic response, which can result in higher lateral deflections, increased member forces, and eventually collapse. During large earthquakes, structures with asymmetry cause structural damages or the collapse of the entire structure. This paper aims to investigate the seismic response of horizontal asymmetric buildings with and without separation gaps. Three asymmetric building plans ("T" shape, "+" shape and "L" shape) have been chosen in order to investigate the beneficial effects separation gaps. Comparative study has been carried out in terms of developed horizontal and vertical forces; moments and reinforcement required in columns. The analysis results show that the amount of reinforcement is significantly reduced when separation gaps at strategic locations are introduced.

Keywords- Asymmetric building, Earthquake analysis, Separation gap, Seismic resistant design

Programming shape based on mechanics of origami (PA0282)

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Abstract- Patterns created with Miura rigid origami are finding more and more applications in fields like engineering and technology. However, the techniques to do geometric analysis that is employed in this research study are, in most cases, unplanned. In this paper, in order to acquire the various geometric forms, kinematic analysis and geometric analysis are both utilized. Kinematic analysis is performed using the D-H matrix approach in order to acquire the dihedral angle, and then these angles are incorporated into the geometric modelling in order to generate a wide range of different geometrical tessellations. In addition to this, it is demonstrated how the geometric correlations have the potential to be combined into programmable geometric tessellations.

Keywords- Origami, Miura - ori pattern, kinematic analysis, Rigid foldable geometry 1. INTRODUCTION & OBJEC

Multiple Impact Responses of Bending stiff Composite Plates – A Finite Element Approach (PA0283)

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Abstract- The paper presents the multiple impact responses of laminated composite plates. Based on finite element (FE) formulation, the governing equations are framed considering eight-noded isoparametric elements with each node having five degrees of freedom. Newmark's time integration scheme and the modified Hertzian contact law are employed to solve the time-dependent governing equations. The defining input parameters of the impactors are considered

for the low velocity multiple impact responses of the composite cantilever plate. The parametric study is conducted for maximum contact force portraying the effects of multiple impact at three different location of impact on the plate at equal time interval with equal initial velocity of impactor (VOI). The finite element discretization with (8 × 8) mesh plan is considered. The FE code developed is validated for an eight layered bending stiff [0º/0º/30º/-30º/-30º/30º/0º/0º] composite plate, each layer is considered with material properties.

Keywords- Composite, Multiple impact, Bending Stiff, Contact law

Influence of Induction Heating on Thermal Characteristics and Residual Stress for Plasma Arc Welding of Structural Steel Plate(PA0285)

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Abstract- Structural steels are widely adopted in offshore structures, high-rise buildings, bridges, storage tanks, and construction machines because of their low cost and toughness. However, structural steels are encountered various problems, such as cracking, residual stress and distortion during the arc welding process, leading to early failure of the weld joint. Currently, a finite element based analysis is conducted by adopting a high-frequency induction heating (HFIH) source as a preheat source to relieve the residual stresses. HFIH is a non-contact, environmentally friendly heating process suitable for the scanning heating of the weld line. The present study finds that the addition of HFIH significantly affects the final residual stress distribution and improves weld penetration.

Keywords: Welding residual stress, Electromagnetic-thermal analysis, Thermo-mechanical analysis, Induction preheating, Arc welding

3D Sloshing Frequency Analysis of Partially filled functionally graded Cylindrical Containers (PA0287)

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Abstract- A 3D finite element approach is presented for the free vibration analysis of partially filled functionally graded cylindrical containers, emphasizing direct coupling between a flexible composite container and fluid sloshing. For the motion of small amplitude, the fluid is assumed to be inviscid and linearly compressible. The fluid domain is modeled based on the Helmholtz wave equation, derived from the Navier–Stokes equation, using 20 noded brick elements. The structure domain is modeled by using the degenerated solid elements based on Reissner–Mindlin assumptions. Thus, in terms of mid-surface nodal variables, the 3D field has been reduced to a

2D field by taking into account shear deformation and the rotating inertia effect. A direct-coupled analysis is performed for the fluid-structure interaction to obtain a coupled response. A MATLAB code has been developed, and the results have been validated with results available in the open literature and found to be in good agreement. Results from the parametric study indicate the significance of power law ratio, and a dimension ratio of the composite container while finding the coupled sloshing frequencies of the coupled system

Keywords- Functionally graded tank, sloshing, cylindrical tank, direct coupling