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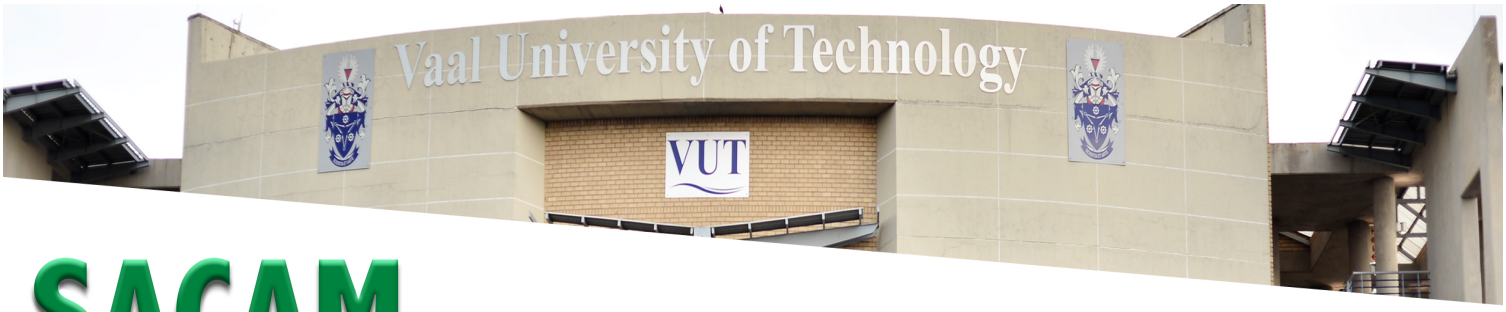

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INDUSTRIAL TRACK SUBMISSIONS
(Only Abstracts were reviewed)

ID: 185
Industrial Track
Keywords: Energy, Syn-gas, Pyrolysis, Bio-waste, Yield

Sygas yield comparison study on municipal waste and bamboo

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Energy in its different forms is an important asset to man's day-to-day activities from general house hold applications such as cooking and heating to large scale industrial applications such as power generation. However, the current reliance on fossil fuel based energy has become a central concern with respect to sustainable development. Fossil fuels are associated with greenhouse gas emissions and global warming which have been attributed to the dramatic weather and climate change patterns on the planet today posing significant threat to life. There is, therefore, a need to find more sustainable sources of energy for the planet. Biomass based energy has been used by humanity as a primary source of energy long before the episode of fossil fuel usage. Harnessing of this form of energy has become of overwhelming interest largely due to global warming. It has also been realized that producing renewable energy locally can offer a viable alternative, and facilitate socio-economic development in communities as evidenced by several sustainable energy production projects around South Africa. Biomass contributes 14% of the World's primary energy supply. About 75% of its usage is in developing countries. In this work, the organic fraction of municipal solid waste (OFMSW) was quantified at a landfill site in Johannesburg. This was part of a wider project to produce biogas from municipal waste. The potential of that waste to produce syngas by thermal decompositions needs to be investigated as an alternative to anerobic bio digestion. Furthermore, a bamboo species known as bambusa lacooa, which is currently being introduced for mine dumps rehabilitation in South Africa, was identified as a potential syngas production feedstock. If bamboo based mine dump rehabilitation succeeds, the economic value of the then widely available bamboo needs to be investigated. Production of syngas by pyrolysis becomes one such economic value chain. The aim of this work was therefore to investigate the optimum production of syngas from OFMSW and bamboo by pyrolysis. Specimens of these materials were prepared for thermal decomposition. Bamboo was categorised into wet and dry bamboo and dried in the sun for a period of 14 days. OFMSW made up of mixed food waste was collected from the waste dump landfill site and dried in the sun for a period of 24 hours. The candidate bio-waste materials were subjected to thermal decomposition in a specially designed pyrolysis reactor. Fumes produced during the thermal decomposition were collected at 100˚C temperature intervals from 0 ˚C to 700 ˚C. Dry bamboo produced the highest yield quality of syngas (24% - 23% quality) between 200 ˚C and 400 ˚C. Wet bamboo produced lower syngas yield quality than dry bamboo. The highest syngas quality of wet bamboo was 20.60% at 400 ˚C. OFMSW produced the lowest syngas yield quality of 19.12 % at 400 ˚C.

Bibliography
Bio-digester technology: Process selection through multi-criteria decision analysis
Summary-view: Biomass anaerobic respiration technology in South Africa

ID: 227
Industrial Track
Topics: Finite Element Modelling and Analysis
Keywords: FEA, Nonlinear, Convergence, Failure

Solving Nonlinear FEA problems

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Structures behave nonlinearly due to nonlinear material behavior, large displacement/large strain geometric effects and/or contact changes. Modelling such structures requires the relevant physics to be included in sufficient detail in the model. In addition, an iterative method like Newton-Raphson as well as convergence criteria and tolerances are required to find the solution.

A common problem in nonlinear analysis is that of non-convergence. This can be due to a surprisingly large number of reasons, most of them physical. In this presentation we'll discuss these sources of nonlinearity. We'll show examples of how and why they occur as well as how to model these sources correctly using FEA. Some examples of non-convergence will be shown together with methods how to solve these problems.

Finally, examples will be shown for some of the more extreme cases of nonlinearity such as welding (elements need to be added), machining (elements need to be removed), forging (extreme distortion requires remeshing and state-mapping), crack-propagation (fracture mechanics combined with remeshing) to name a few.

Bibliography
Gerrit Visser has been working as an FEA Engineer since 2000. He has completed B.Eng Mech in 1996 and honours in 1998 at the University of Pretoria. He has experience in structural and thermal FEA, specializing in nonlinear FEA for the last 12 years.

ID: 228
Industrial Track
Topics: Computational Fluid Dynamics, Fluid Mechanics
Keywords: CFD, Airflow, Ventilation, Healthcare

Balancing ventilation airflow of healthcare facilities against various duct systems

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The computation of airflow within the healthcare facilities (hospitals and clinics) is challenging. The balance of ventilation and infection control within the facilities geometries is primarily a concern that require detailed investigation. The objective of this work was to simulate airflow of various geometrical configurations of ducting system in building. The outcome being recommendations to air conditioning and ventilation designers for new healthcare buildings on placement of functional departments relative to airflow demands and quality. ANSYS® Fluent® 18.0 and ChemKin-PRO, two commercial packages, Computational Fluid Dynamic (CFD) and Chemistry Simulation were used to provide flow visualisation and the magnitude pollutant species in the airflow at the healthcare facility. The results were compared to experimental data from lab-built apparatus for various duct designs.

Bibliography
None

ID: 236 / POSTERS: 2
Industrial Track
Topics: Thermodynamics and Heat Transfer
Keywords: Indirect heated rotary kiln, Experimental tests, Temperatures, xx

Experimental Performance Assessment of an Indirect Heated Rotary Kiln

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ABSTRACT

The Indirect Heated Rotary Kiln (IHRK) is a device used for treating of powdery, granular, lumpy, dry or wet materials in the processing industry. Kilns are mainly applicable in cement production, drying of bricks, strengthening of petroleum coke for aluminum production, ceramics processing, glass processing and reclaiming of nickel from used batteries. The operation of IHRK is through transmitting of heat energy from outer surface of the kiln to the material to be treated by conduction without direct contact between the hot flue gases and the process material. Due to the complexity of this process, there is poor heat transfer between the combustion gases and the material. There is need to optimize the system to improve energy usage. In addition, incomplete combustion of fuel has led to harmful emissions of flue gasses thus exacerbating environmental pollution. To address these challenges, experimental tests were conducted on an industrial prototype using a ceramic material and LPG fuel. The temperatures achieved during the test were 587oC for the burner, 69oC for the ceramic material with exhaust gases exiting at 176oC. Such high exhaust temperatures represent significant energy losses which can be mitigated by optimizing the kiln process parameters.

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ID: 237 / POSTERS: 1
Industrial Track
Topics: Thermodynamics and Heat Transfer
Keywords: Direct heated rotary kiln, Experimental tests, temperatures, xxx

Experimental Temperature Profiling of a Direct Heated Kiln

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ABSTRACT

The Direct Heated Rotary Kiln (DHRK) is an industrial device used for the thermal treatment of powdery, granular, lumpy, dry or wet materials. Kilns are widely used in cement production, drying of bricks, strengthening of petroleum coke for aluminum production, ceramics processing, glass processing and reclaiming of nickel from used

batteries. The DHRK operates by generating heat energy to the material by Conduction, Convection and Radiation where hot flue gas mixes with the material. The study of kilns has shown that there are significant problems related to poor heat transfer. This leads to unfinished processing such as incomplete drying or chemical processes. Product reworks lead to increased costs. In addition, incomplete combustion of fuel leads to harmful emissions of flue gasses thus exacerbating environmental pollution. To investigate these challenges, experiments were conducted to assess heat flow in Direct Heated Rotary Kilns. Different experimental tests were conducted on an industrial prototype using a ceramic material and LPG fuel. The temperatures achieved during the test were 588oC for the burner, 87oC for the ceramic material with exhaust gases exiting at 273oC. Such high exhaust temperatures represent energy losses that could be due to velocity of hot gas and quantity of material in the kiln.

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ID: 257
Industrial Track
Topics: Computational Fluid Dynamics, Discrete element modelling, Engineering Education, Finite Element Modelling and Analysis, Fluid Structure Interactions, Mechanics of Materials, Structural Dynamics
Keywords: simulation, finite element analysis, non-linear, CFD

Student and Lecturer support offered by ESTEQ

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ESTEQ represents a number of International suppliers of hardware and software technologies and also makes their expertise and support available to students and lectures from local universities.

This presentation will provide a brief overview of all the technologies, support and assistance ESTEQ provides to students and lecturers in support of their teaching and research projects.

Bibliography

With degrees in both Civil and Mechanical Engineering, I have a “bigger picture with a focus on detail” approach.
I enjoy sharing knowledge on a practical basis rather than lecturing and like to do so live and through online tutorials and forums.
I also enjoy working with software developers to provide feedback with regards to ease of use and identifying software deficiencies. It is great to currently be closely involved with the development teams of MSC Apex and CivilFEM.

ID: 258
Industrial Track
Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer
Keywords: Newtonian heating, stagnation point, variable thermal diffusivity, plate, nonlinear

NEWTONIAN HEATING WITH VARIABLE THERMAL DIFFUSIVITY ON SECOND LAW ANALYSIS FOR MHD STAGNATION POINT FLOW OVER A FLAT PLATE

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This paper presents a steady magnetohydrodynamic (MHD) stagnation point flow of an incompressible, viscous electrically conducting fluid on second law analysis over a flat plate under the influence of variable thermal diffusivity and Newtonian heating. The nonlinear governing differential equations are transformed into nonlinear ordinary differential equations using similarity transformation. The shooting technique with Runge-Kutta fourth order scheme was used to obtain the numerical solutions of the transformed nonlinear equations and the computed results are validated for variations in velocity, temperature, skin friction coefficient and Nusselt number. The results of the various resulting parameters are presented graphically and discussed quantitatively. It was observed that thermal radiation parameter decreases the rate of heat transfer on the surface but increases the skin-friction coefficient. Increase in the viscosity and thermal diffusivity variation parameter increases both the skin-friction coefficient and rate of heat transfer.

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ID: 259
Industrial Track
Topics: Computational Fluid Dynamics, Finite Element Modelling and Analysis, Fluid Mechanics
Keywords: Discontinuous Galerkin Method, Finite Element Method, Symmetric Interior Penalty Galerkin Method, Mixed problem, \textit{hp} approximations

Error Analysis of the Discontinuous Galerkin Method of Finite Element Using Quadrilateral Meshes For Stokes Problem

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In this paper, we present the mixed formulation of the Discontinuous Galerkin Method for the Stokes problem using the primitive variables - velocity and pressure. In this formulation, non-overlapping conforming elements are used such that both velocity and pressure fluxes are considered to be discontinuous over the inter-elements interfaces. However, to enforce \textit{artificial} continuity we introduce a jump term, equipped with a penalty constant $\sigma>0$, which penalises the jump of numeric fluxes across elements. For the domain of the problem set, we demand that the velocity $u\in\left[H_0^1(\Omega)\right]^d $ and for the pressure, $p\in L^2_0(\Omega)$. Bilinear forms for both velocity and pressure are defined such that symmetry is ensured in terms of the numerical fluxes u and v, thus giving rise to our type of formulation known in literature as Symmetric Interior Penalty Galerkin (SIPG) Method. We will state and prove the in-sup condition, velocity and pressure error estimates. A simple case of lid-driven cavity flow in a square domain will be studied for our formulation and the results compared with results reported by others in the literature.

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Numerical Solutions To Two-Dimensional Navier-Stokes Equations
Honours Dissertation, Zululand University, 2015.

ID: 1124
Industrial Track
Topics: Discrete element modelling
Keywords: discrete element modelling, apple bruising, visoelastic behaviour, parameter calibration

A Discrete Element Model (DEM) for Predicting Apple Damage during Handling

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The Discrete Element Method (DEM) is used outside of its original purpose within the field of rock mechanics and applied to the agricultural sector. Apples are globally one of the most widely traded fruit and still suffer from significant mechanical injury in the form of bruise damage. Apple damage accounts for a significant proportion of financial losses in the postharvest handling of fresh produce.

DEM allows for individual particle contacts and the dynamic mechanical behaviour of a group of particles to be studied through collisions. Successfully applying this method to fresh produce, such as apples, allows for future investigations into postharvest mechanical damage to be performed on a range of fruit and vegetables.

A contact model that is capable of closely replicating the viscoelastic nature of apples was developed and applied. The mechanical material parameters required for the implementation of the viscoelastic model were successfully derived through an error minimisation algorithm and the use of a pendulum impactor. The accuracy of the contact force model was dependent on definite representation of the effective damping constant and was less sensitive to the elastic stiffness.

Bruise damage models (in the form of bruise volume, bruise area and bruise depth) were coupled to the impact forces available through DEM. Bruise formations resulting from multiple impacts and variable time durations between impacts were studied. The resulting models were implemented in the numerical environment. A detailed particle shape representation along with a realistic contact point loading scheme was implemented in the DEM model. Overlapping bruises were studied and accounted for on a post-process level.

The resulting DEM model was successfully validated with the use of numerous physical experiments. Experimental validation commenced at a single specimen contact level and expanded into realistic situations, with up to 90 specimens, representative of conditions that may be experienced in practice. The model was extended to include run-time bruise visualisation during the DEM simulations.

Good correlation between the experimental and numerical results were achieved. Quantitatively, the model succeeded in accurately predicting the contact forces typically experienced by apples to within 11 %. The model predicted the mean bruise damage of a single apple for realistic situations within an accuracy of 50 % in terms of mean bruise volume, 35 % for bruise area and 30 % for bruise depth. Qualitatively good agreement of the dynamic mechanical behaviour predicted by the model and the experiments was achieved.

Bibliography
Student contribution

ID: 1161
Industrial Track
Topics: Mechanics of Composites, Mechanics of Materials, Nano-scale Mechanics
Keywords: Nanocomposites, Failure modes, SEM, xxx

Effect of surface treatment on the mechanical properties of a polymer clay nanocomposite

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Polymer clay nanocomposites consist of small amounts of clay particles dispersed in a polymer matrix to increase the mechanical performance of a polymer. The three levels of dispersion are phase separation, in which the polymer and clay do not interact; intercalation, when polymer fills the gaps between clay layers; and exfoliation, when the clay layers are completely surrounded by polymer. The effective dispersion of clay in a polymer is primarily determined by the interface between the clay and the polymer. Adding a surface treatment to inorganic clay assists the incorporation of clay into a polymer by increasing the compatibility between the clay and the polymer.

In this study, we investigate the effect of surface treatment on the mechanical properties of a nanocomposite consisting of layered double hydroxide (LDH) clay particles added to high-density polyethylene (HDPE). To improve the dispersion and intercalation of the clay in the composite, the LDH is coated in a compatibilizer. The yield stress and failure mechanisms of neat HDPE are compared to those of polymer clay nanocomposites containing LDH with and without compatibilizer coatings at 2.5%, 5% and 7.5% weight loading.

We note that neat HDPE has a significant amount of variability in the measured yield strength. The variability in the measurements decreases with the addition of clay inclusions. The addition of any amount of untreated clay to the polymer results in an immediate decrease of the yield strength compared to neat HDPE. The yield strength does not show a strong dependence on the amount of clay which is added. The failure mode of samples with 2.5% weight loading of clay is predominantly ductile, while for weight loadings greater than 5% the tensile test results in predominantly brittle failure.

The addition of a small amount of clay with an organic coating to HDPE does not reduce its yield strength, although the variability in the measured value decreases. Subsequently, the yield strength decreases with increase in weight loading. Tensile tests show that the failure mode of a polymer nanocomposite with coated clay will be predominantly ductile until weight fractions larger than 7.5% additional clay, where the failure mode will transition to brittle behaviour.

Scanning electron microscopy (SEM) was used to examine the fracture surfaces of freeze fractured samples. The neat polymer shows the most ductility, the surface treated composite shows decreased ductility, and the non-surface treated composite shows more brittle-like fracture. There is no evidence of intercalation and clay dispersion in both composites, and the non-surface treated composite shows agglomeration of clay particles. Both composites present with microvoiding, although the non-surface treated one shows more microvoid coalescence, increased polymer fibrillation and generally smaller fibrillar structures with less deformation. This indicates that less energy is absorbed by the non-surface treated composite during failure. These results are in agreement with the observed trends during tensile failure.

Bibliography

None

ID: 1175

Industrial Track

Topics: Solid Mechanics

Keywords: GPU, DEM, Civil engineering, contact models, milling, silo flow

Large-scale industrial GPU DEM simulations for civil engineering applications: focus on the history-dependent contact model effects

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Due to its approach at the particle scale, the Discrete Element Method (DEM) simulations have been shown to be able to capture the granular material responses. In the case of civil engineering applications, the DEM is suitable to tackle a large number problems involving granular materials in the several engineering sub-disciplines as for example coastal, construction, geotechnical, material or structural engineering. However, although DEM has been established as one of the key tools available to civil engineers, the DEM simulations remain mainly used for the field of the research due to particle number limitations [1].

These limitations are being lifted by the recent developments of high-performance computing (HPC) applied to DEM simulations bringing new opportunities for the engineers. In particular, previous studies with the use of the graphics processing unit (GPU) via the specific DEM environment BlazeDEM-3DGPU [2] have been carried on milling or granular flow applications [3-4]. These results have shown that it is possible both to tackle large-scale industrial applications by achieving millions of particles simulated within reasonable computing times on GPU platform and to envisage more complex DEM simulations with the modelling efficiently of more complex shape as polyhedral shaped convex and non-convex particles.

This study investigates the potential of a DEM code to model i) large-scale problem by using a large number of particles in typical civil engineering simulation ii) and to study the potential of GPU based simulations to be used in civil engineering applications by doing a particular focus on the history-dependent contact models. These history contact models are typically used for geomechanical applications with conventional DEM digital tools developed under central processing unit (CPU). This study focuses in particular on the mill and storage silo DEM simulations with French industrial examples.

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ID: 1207
Industrial Track
Topics: Mechanics of Composites, Micro-scale Mechanics, Nano-scale Mechanics
Keywords: Nanocomposite, homogenization, micromechanics, hierarchical materials, coupled problem

Elastic behaviour of gold-polymer nanocomposites and the simulation of a chemo-electro-mechanical coupled problem within nanocomposites.

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Nanoporous metals are of great interest due to their unique and appealing properties compared to their bulk counterparts. Nanoporous gold is of particular interest due to its ease of manufacturing. One of its most unique properties is its very high compressive strain capability. However, it has severe brittleness in tension which limits its usage. One means of addressing this limitation is to create a nanocomposite though the addition of a polymer into the voids of this nanoporous metal, resulting in a more ductile and stronger material.

In this work, the mechanical properties of a nanocomposite representative sample are studied numerically using the finite element method. Homogenization is performed using kinematic uniform, static uniform and periodic boundary conditions to calculate the linear elastic material properties which reveals an almost isotropic material.

Through simulation of the realistic structure the micromechanics of the nanoscaled structural features can also be further investigated. The stress–strain response within the composite is observed by studying the principal stresses and strains of each constituent along the centroid of the representative sample. Significant compressive and tensile stresses were observed within the gold constituent of the nanocomposite. The response of individual ligaments within the composite is also of great interest where the resultant forces, moments and torques acting on representative ligament cross-sections within the computational representative sample were investigated under compressive loading. Bending and normal forces dominated the loading modes within the ligaments while significant shear stresses were also seen.

Additionally, this gold-polymer nanocomposite creates an ionic metal polymer composite which opens the door to its use in applications such as sensing and actuation. Thus, to further the understanding of this behaviour the response within the gold-polymer nanocomposite is to be captured through the simulation of a chemo-electro-mechanical coupled problem using realistic RVEs. By simulating this nanocomposite with realistic models we can begin to understand the effects of certain structural aspects within the material.

As we begin to understand more about this nanocomposite material, the material can begin to be tailored to specific applications. Further functionality and areas of application of this material will certainly be expanded as more information is gathered about it.

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ID: 1215
Industrial Track
Topics: Mechanics of Materials, Solid Mechanics
Keywords: Virtual Element Method, VEM, Solid Mechanics, Elasticity, Transverse Isotropy

ANALYSIS AND APPLICATIONS OF THE VIRTUAL ELEMENT METHOD (VEM)

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The Virtual Element Method (VEM) [1] is a recent extension of the standard Finite Element Method in which elements in two-dimensional problems may be polygons having any number of sides. The method is well suited to problems involving complex boundary behavior, such as contact and friction, where the flexibility of the VEM allows for boundary conditions to be easily imposed at the interface of two bodies. Also, in problems involving adaptive mesh refinement, use of the VEM allows the refinement to be carried out without the need to keep track of common nodes across element boundaries.

The VEM is becoming a popular method, but as yet there little activity, and not much by way of software such as open-source codes.

The VEM has been applied to a range of problems in solid mechanics, including elasticity [2], contact [3] and large deformations [4]. This paper aims to apply the VEM to linear elasticity problems involving material inhomogeneity, such as transverse isotropy [5].

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Bibliography
N/A

ID: 1216
Industrial Track
Topics: Computational Methods in Mechanics
Keywords: Control system, Matlab, Simulink, hydraulic hybrid

The control algorithm of a hydraulic hybrid transmission for a heavy duty truck in a controlled environment such as Gerotek

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This paper will present the control system for the hydraulic hybrid transmission known as “Miser”. The technology was developed as a heavy-duty truck regenerative drive. This system uses a novel hydraulic system to harvest and store energy during braking and deliver when needed. Excess engine energy is also stored during this cycle. A robust control system is required to manage this process. The aim of the work, therefore, was to develop and test a control system for various useful drive cycles for heavy trucks and drive cycles. The objective was to measure savings and performance differences. The paper highlights the savings achieved from various drive cycles such as simulated city cycles, steady state and highway cycles. Furthermore, the theoretical basis of such fuel savings compared to the practical results achieved is also presented.

Bibliography
none

ID: 1218 / POSTERS: 6
Industrial Track
Topics: Computational Methods in Mechanics
Keywords: hydraulic hybrid, xxx, yyy, zzz

Going from Mathematical model to the real world: translating a Matlab/Simulink control algorithm onto a fixed time step controller

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This paper will show some of the relevant results achieved regarding a novel hydraulic hybrid truck transmission system known as “Miser” but will focus on the difference between a mathematical (Matlab/Simulink) simulation and the practical implementation of a control algorithm. The main purpose is to show that simulations are very valuable but limited in use and hence a practical model must be developed. The real world system had numerous minor additions to deal with issues at the edges of the performance envelope of the vehicle that had not been captured by the mathematical model. Pitfalls such as the slower computational speed typical of a microcontroller compared to a mathematical model that can reduce step size and not operate in real time are presented. Similarly, other issues arose when converting to a fixed time step controller that operates in the Hz range compared to the much smaller step size possible in a simulation model. This study also serves as a guide and warning for engineers to consider such pitfalls in the development of control systems.

Bibliography
none

ID: 1226
Industrial Track
Topics: Mechanics of Materials, Micro-scale Mechanics, Nano-scale Mechanics
Keywords: Strain-gradient Plasticity, non-proportional loading, elastic gap, xx

Numerical Investigation of strain gradient theories of plasticity

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Strain gradient(SG) theories of plasticity take account of size-dependent effects at the microscale by incorporating dependence on gradients in the plastic strain. There has been intensive investigation of one model, viz the dissipative theory, in which the gradients appears in the flow reaction. The objective of this work is to explore theoretically and computationally the response of the combination of the dissipative and energetic theory to non-proportional loading, with a view to gaining further insight into the phenomenon of the 'elastic gap’: this refers to elastic behaviour following plastic deformation and a non-proportional change in loading. This unexpected response has been observed in numerical explorations of the dissipative theory [1].

For this project, Gurtin's distortion gradient plasticity theory [2] is implemented as a user-element(UEL) in the commercial Finite Element software ABAQUS. Various numerical examples are used to explore the response due to non-proportional loading.

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N/A

ID: 1233
Industrial Track
Topics: Finite Element Modelling and Analysis, Mechanics of Composites
Keywords: Composites, DIC, FEA, xxx

Updating finite element models of composite aircraft structures using full field digital image correlation

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The anisotropic nature of composite materials presents a challenge when modelling them in a finite element analysis. By using full field digital image correlation the strain response of any material can be captured in real time as the material deforms. This work describes updating of finite element models for composite materials typical of the aircraft industry. The application of such updating techniques to improve the finite element models of composite aircraft structures, specifically those which often suffer from bird strikes, will enable a more accurate prediction of their elastic and plastic behaviour due to impact loading. This contributes to the furtherment of damage tolerant designs.

In this research laminate composite specimens will be subjected to impact forces from projectiles travelling at various speeds. The strain responses of these specimens, measured through high speed digital image correlation will then be used to determine how to best model the composite such that the simulation results reflect reality.

This work explores the formulation of an optimization problem, using the strain equation (a function of material properties) to minimize the error in strain values between those produced by the equation and those from the digital image correlation.

Bibliography
None

ID: 1251 / Session 2: 2
Industrial Track
Topics: Biomechanics
Keywords: coupled heart electromechanics, bidomain equations, arrhytmias, cardiac resynchronization therapy, virtual heart models

Virtual heart models: finite element based patient-specific analysis

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Today, cardiovascular diseases are considered as one of the most serious health issue of humanity because of its high prevalence and morbidity, impairment of life quality and economical side effects. Developed technological devices enable us to partially monitor electromechanical activity in a patient's heart on macroscale and evaluate the current status of the cardiac function. However, working mechanisms of the heart as well as disease development have not been fully comprehended due to the difficulties in vivo experiments. Besides, unique properties and conditions of each patient's heart make demanding to establish general consensus on diagnosis and treatment methods. The disease identification and its treatment strategy for a specific patient are determined via avalaible monitoring tools and physiologist's experience, which is naturally subjective and does not neccessarily guarantee the best outcome. For instance, one-third of patients do not respond to cardiac resynchronization therapy. On the other hand, It is believed that a huge amount of people are subjected to misdiagnosis leading to serious health problems, deaths and additional costs that could have been prevented. Therefore, we need robust diagnostic tools and precise patient-specific treatment strategies.

On that account, the mathematical modelling of the heart electromechanics can noninvasively assist cardiologists to develop effective and inexpensive personalized treatment techniques.

In this presentation, our novel numerical tools simulating the cardiac electromechanics will be introduced. We will demonstrate the performance and feasibility of the numerical tools through multi-field initial-boundary value problems based on real heart geometries. We will compute left ventricular (LV) volume-time curves, pressure-volume curves and electrocardiograms which are frequently used diagnostic tools by cardiologists in order to asses the cardiac function. The simulation results will be compared with real clinical data by means of LV motion characteristics, e.g. displacement, rotation, torsion and the importance of boundary conditions on LV motion will be discussed. Additionaly, we will simulate life-threatening arrhythmia, e.g. fibrillation, and its termination, i.e. defibrillation.

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ID: 1253
Industrial Track
Topics: Biomechanics, Finite Element Modelling and Analysis, Micro-scale Mechanics, Solid Mechanics
Keywords: cardiac mechanics, heart modelling, micromorphic theory, finite element method, active tension

Micromorphic cardiac mechanics: modelling the active contraction of cardiac muscle tissue

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Computational modelling allows one to study the mechanical behaviour of complex biological structures, such as the heart. With the use of cardiac simulations, we can investigate the biomechanics of the heart and so improve our understanding of its physiology on an organ, tissue and cellular level, particularly under pathological conditions.

In this work, the finite element method is used to investigate the biomechanics of the left ventricle. A full heartbeat of a patient-specific left ventricle is modelled. The total ventricular wall stress is additively decomposed into an active and passive stress component. To model the passive behaviour of the heart, cardiac tissue is treated as a micromorphic medium. The micromorphic theory may be regarded as an extension of the classical continuum theory. Within a micromorphic continuum, particles are endowed with extra degrees of freedom that describe the deformation of a director attached to each continuum particle. The director represents the micro-deformation of the particle, which is independent of the macroscopic displacement field. In the case of cardiac mechanics, the director is chosen such that it represents the deformation of the cardiac fibre. This allows the heart fibres to experience deformation relative to the extracellular matrix. The active tension in the heart is taken to be a function of the sarcomere length, peak intracellular calcium concentration and the time after the onset of contraction. Contraction takes place in the fibre direction, described by the director field, and all the heart fibres are assumed to contract simultaneously.

To elucidate the effects of micromorphic modelling, the results obtained are also compared to a cardiac simulation that uses a classical continuum formulation.

Bibliography
NA

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MAJOR CORRECTION-Academic Revised Manuscript
Topics: Computational Methods in Mechanics
Keywords: hydraulic hybrid, pump-motor, Matlab simulink, algorithm

Simulation of a hydraulic-electrical hybrid compared to a conventional Electric vehicle

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This paper presents the concepts behind a hybrid drive using a hydraulic-electric drive versus a conventional electric vehicle. Matlab/Simulink models of the vehicle with and without the hybrid drive operational are compared over a given drive cycle to predict performance of the vehicle and the resulting electrical and hydraulic system parameters. The advantages of this combined-hydraulic electrical system are that the hydraulic drive can be used as a launch assist to reduce peak electric loads and accomplish higher overall regenerative braking efficiency. The combination of electrical and hydraulic systems has the potential to significantly increase the range of any given battery vehicle as well as increasing the life of the batteries.

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none

ACADEMIC TRACK SUBMISSIONS
(Full papers double blind reviewed and full papers to be included in conference proceedings)

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Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Fluid Mechanics, Fluid Structure Interactions, Micro-scale Mechanics, Nano-scale Mechanics, Stochastic Mechanics
Keywords: Nanoparticles size, spatial distribution, morphology, surface tension and surface energy.

The stochastic effects of nano-particles size, morphology and spatial distribution on surface energy

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For over decades now more research efforts on the wettability of Oil/water separation membranes have been focused on surface tension driven separability. Little or no major effort has been focused on surface energy driven separability, which is the focus of the current article. Surface tension mainly quantifies wetting characteristics of a solid surface with respect to the contact angles. This fails to examine the bulk properties that may be a as result of morphology and spatial distribution of particles that affect the surface properties. As a result, a study that does not only look at the contact surface may yield more insightful results. Since these characteristics that influence the bulk property or surface energy arise from the stochastic nature of the membrane constituent such as random particle size, random pore morphology and random spatial distribution of membrane channels/pores, it is important to employ the tools of stochastic theory to study this characteristics and the impacts on surface energy. .

The random nature of nanoparticles size, spatial distribution of nanoparticles and their morphology impact surface energy driven separability of oil/water. It was also observed that the smoother the membrane surface, the better surface energy driven separability when compared with rough membrane surfaces. It was also observed that surface energy increases as the nanoparicles size decreases. The continuous increase in nanoparticles size did not lead to continuous increase in surface energy.The influence of network of pores or spatial distribution of pores on wettability or surface energy was also revealed.

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9.The effect of different approaches of measuring grain size on nanomaterials mechanical properties.
10.Conceptual model based on nanoscience and nanotechnology in design of smart home for energy efficiency.

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Academic Track _ Resubmission of Revised Full Paper
Topics: Fluid Mechanics, Fluid Structure Interactions, Nano-scale Mechanics, Stochastic Mechanics
Keywords: Nanoparticles size, morphology, spatial distribution, surface energy and flow rate

The stochastic effect of nano-particles size, morphology, spatial distribution on flow rate through a nanostructured membrane surface

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Several inefficiencies in oli/water separation membrane design have been reported to be due to poor characterizations of nanoparticle sizes, morphology and their spatial distribution apparently because they are random in nature.This has resulted in poor flow of water through the membrane surfaces leading to the current inefficiency in oil/water separation. In this study the random nature of nano-particles size, morphology and their spatial distribution are modeled by employing stochastic theory and their impacts on flow rate are tested during oil/water separation. The modeling results revealed the following fact which agree with experimental observations.

The obtained results revealed that flow rate varies with the variation in nanoparticle sizes, pore morphology and the spatial distribution of the nanostructured membrane pores. It was also revealed that there is an optimal nanoparticles size, morphology and spatial distribution of membrane channels that offer better separation of water from oil. Thus, a proper characteristaion of the nanoparticles sizes on the oli/water separation membranes, the proper characterisation of por morphology and the spatial distribution of the network of pores or membrane channel would lead to design of membrane that offer better oli/water separation

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9.The effect of different approaches of measuring grain size on nanomaterials mechanical properties.

10.Conceptual model based on nanoscience and nanotechnology in design of smart home for energy efficiency.

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Keywords: Surface tension, surface energy, separability, nanostructured membrane

Relationship between surface tension and surface energy in oil/water separation process

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The relationships between surface tension and surface energy are vital in oil/water membrane technology. Most research findings on oil/water separation membrane focused on surface tension whereas surface energy has not be given a major attention. Surface energy mainly relates to the work spent in creating a new surface why surface tension mainly relates to the work spent in stretching a solid surface. When considered as a force not energy, the force on the membrane is called "surface tension". The force depends on the temperature of the separating particles, as increase in temperature affect the separated particles due to reduce binding forces on the particles. Surface energy depends on the total inward force, and therefore surface energy decreases with rise in temperature. There is a clear relationship between surface energy and surface tension that need further investigation.

This relationship has not been investigated in details as more efforts are only focus on surface tension. The characteristics that influence surface tension and surface energy are random in nature due to the membrane constituent random nature, such as random pore sizes distribution, random pore morphology and random spatial distribution of membrane channels/pores, and this necessitate the importance to employ the tools of stochastic mechanics to study this characteristics and their impacts on surface energy and surface tension. The random nature of nanoparticles size, spatial distribution of nanoparticles and their morphology revealed different results on surface tension and surface energy driven separability of oil/water. These research findings suggest the possibility to reformulate the behavior of surface tension, and surface energy separability in terms of dislocation theory in a more acceptable way than, the previous way it has been done.

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10.Conceptual model based on nanoscience and nanotechnology in design of smart home for energy efficiency.

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Keywords: Surface tension, surface energy, flow rate, nanoparticles.

Relating the parameters of flow rate, surface tension and surface energy to nanoparticles

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In oil/water separation technology nanoparticles are affected by their shape, size, morphology, particle loading and temperature. Several attempts has been made to relate the parameters of nanoparticles to flow rate, surface tension and surface energy without taking into account the relevant statistical distribution on the nanoparticles. In this study the relevant measure are taken into consideration by using the relevant tools of stochastic mechanics since it offers the characteristics of a random phenomenon. The flow of water on a membrane surface are random in nature and therefore their surface tension and surface energy are also random. The relationship between these parameters have not been invested in details since studies only focus on surface tension and little on surface energy.

The relationship between surface tension, surface energy, pore size distribution and pore spatial distribution of the porous structure of the nanostructured membrane were determined by matching or relating the experimental data with the theoretical obtained results from pore sizes network, spatial distribution, surface tension and surface energy model simulations. Good agreement between theory and experiment study is found. Different relationship are revealed between flow rate on a membrane surface, surface tension, surface energy with varying particle sizes of the nanoparticles. The impact of surface tension driven separability are different from surface energy driven separability. Nanoparticles were observed to have more flow rate on surface energy when compared to surface tension. It was further observed that flow rate were more stable on surface energy when compared to surface tension.

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9.The effect of different approaches of measuring grain size on nanomaterials mechanical properties.
10.Conceptual model based on nanoscience and nanotechnology in design of smart home for energy efficiency.

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Topics: Fluid Mechanics, Nano-scale Mechanics, Stochastic Mechanics
Keywords: Dynamic forces, surface energy, flow rate, membrane and separation

The effect of random dynamic forces on membrane surfaces and their impact on surface energy, surface tension and flow rate during oil/water separation

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Separation technologies are affected by external and internal factors that affect flow of water through a membrane surface. The external factors on a membrane surface affect surface tension and surface energy that affect the flow of water through the membrane surface. In previous research investigation, these external factors (temperature, gravitation and electric field) has not been investigated in details. In this paper we focus on modeling the effect of membrane external factors and how they affect surface tension, surface energy and their impact on flow rate. The rationality behind this article is to predict a theoretical model that can guide the proper design of a separation membrane that will offer more enhance flow rate. Different forces on the membrane surface are influenced by their different contact angles on the pore size distribution network that affect the flow of water through the membrane.

The surface tension and surface energy are impacted by different external and internal forces due to their different contact angles of the forces that gives different flow of water through the nanostructured membrane surface. The model results also revealed that different external and internal forces offers different effect on flow of water through the membrane surface. It was also revealed that more flow rate of water on the membrane surface were observed were the external force on the nanoparticles were higher. It was also shown that the flow of water were more efficient or stable were there was more concentration of external force on the particles.

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MTech Engineering Mechanical and DTech in progress.

Research output

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4.P.B. Sob, A. Alungogo and T.B. Tengen, (2015), The Effect of Deformation Activation Volume, Strain Rate Sensitivity and Processing Temperature on Grain Size Variant, (International Science Index), International Journal of Mechanical, Aerospace, Industrial, Mechatronics and Manufacturing Engineering Vol:9, No:11, 2015, pp 1789-1792, eISSN 1307-6982

¬CONFERENCE (4 articles)
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¬TITLES OF JOURNAL ARTICLES UNDER REVIEW
9.The effect of different approaches of measuring grain size on nanomaterials mechanical properties.
10.Conceptual model based on nanoscience and nanotechnology in design of smart home for energy efficiency.

ID: 2113
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer
Keywords: Feedwater heater, Coal-fired power plant, Overall heat transfer coefficient, Dynamic modelling

Feedwater heater component development using the Flownex SE

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Large coal-fired power stations are designed to be run predominantly at full load and optimum conditions. The behaviour of plants operating at low load and varying conditions is getting more and more attention due to the introduction of variable renewable generation on the grid. Consequently, the need for a fully transient high-fidelity system based model has grown, as this will enable one to study the behaviour of plants under such non-ideal conditions.

This paper presents the development of a feedwater heater component for such a high-fidelity transient system model. The feedwater heater component is modelled in the Flownex Simulation Environment, which is a one-dimensional thermohydraulic network solver. The heater component model includes transient effects and thermodynamic relations to represent aspects such as level control and thermal inertia, all with the aim of using minimal design inputs.

In determining the heat transfer characteristics, the model makes use of plant performance data, and correlates the amount of heat transferred by using the feedwater mass flow as the load indicating parameter. This is different to most other models which require detail internal geometrical information to apply empirical heat transfer correlations. The result of the alternative approach is that very little information of the feedwater heater is required to model the heater's performance accurately, even under low load conditions or other off-design conditions.

The heater further includes level representation which is modelled by looking at several factors which influence the change of the liquid level inside the vessel. These factors include shell geometry, pipe geometry and the drain cooling zone, if applicable. The model's level change is compared to that of a 3D model and results show an overall error of less than 2%. The model further incorporates thermal inertia of all steam and liquid volumes, as well as the metal of the pipes and the tube-sheet.

As validation, a horizontal heater in an integrated network of an actual power plant was modelled and tested. The network is set up by using only design inputs from a heat and energy balance diagram and validated by using historical plant data. The integrated network shows satisfactory steady state results with temperature differences in main measurement points less than 3 °C under low load conditions. A transient scenario war ran, simulating a turbine trip. Although not much information was known of the controller's response during the trip, the results of the heater train correlate well with plant data after some calibration, such as changing the bled steam valve close speed at the time of the turbine trip.

The model was packaged into a compound component which can then be used in a full cycle using minimal design inputs whilst still producing accurate results, especially under transient scenarios. The component will form part of a new Flownex library which contains other compound components for modelling a complete plant, such as a turbine with multiple extraction points, or a boiler with complex heat exchanger configurations. This library will be distributed under license by the ATProM research group at UCT.

Bibliography
None

ID: 2114
Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis, Mechanics of Materials, Solid Mechanics
Keywords: spherical indentation, material identification, stress–strain curve, unique solution

On the uniqueness of material identification for aluminium using spherical indentation

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Indentation tests are often used in material identification where direct measurement methods can't be used, i.e. for thin films or because the equipment of interest is in use. However, uniqueness is often neglected in the analysis. A virtual indentation test was performed to measure the force versus deflection curve of the reaction load on the indenter during the indentation, where the true material parameters of a three parameter Voce material model are known beforehand. Using a radial basis function surrogate model, it was possible to show that not only is it possible for different parameters to produce the same force-deflection curve, but continuous ranges or families of parameters can also produce the same force-deflection curve for significant ranges of the parameters. This shows that there is a one-to-many correspondence between the force-deflection curve and the material parameters. Often solutions are reported without much regard to the uniqueness of the problem. However, the results of the investigation show that the uniqueness of the problem should be placed under more scrutiny for practical applications.

Bibliography
N/A

ID: 2115
Academic Track _ Resubmission of Revised Full Paper
Topics: Thermodynamics and Heat Transfer
Keywords: Superheaters, Quenching, Two phase tank, Dynamic Process Modelling

Dynamic modelling of once-through boiler heat exchangers during shutdown with level tracking as a tool to investigate quenching

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Liquid in the superheaters of large coal fired boilers has the potential to flow by gravity toward hot thick walled components, rapidly cooling them and causing quenching damage. The extent of the damage depends on the stresses induced by the temperature gradients in the material. These temperature gradients are transient by nature and depend on the level of liquid inside the component over time. The objective of this work is to develop a method that can be applied to a known quenching scenario to be able to predict the level of liquid at various positions in the superheater and piping system over time. An inverse method is applied to a simplified overall boiler model using a transient thermal fluid network approach. The model is created in the Flownex simulation software. The assumption of a two-phase homogeneous fluid in equilibrium is used together with a specific two-phase tank component that allows for separation of the phases and tracking of the liquid level. The model considers the addition of liquid to the superheater such as that which occurs if there is a separator overflow. By modelling the separator overflow, it is found that the addition of sufficient quantities of subcooled liquid to the superheater increases the pressure by evaporation of the liquid on the hot metal surfaces. The superheater pressure thus provides a basis for estimating the quantity of separator overflow that occurred for a particular event. The model is configured using the dimensions of the boiler and uses a set of plant data over a period of time when a quenching event occurred. The model estimates the quantity of water that overflowed from the separator and thus the level of liquid in the superheater system over time. The liquid level rises in the superheater until the point where overflow to the main steam system occurs. A measured temperature history on the outer surface of one of the main steam pipes is presented and analyzed with a transient heat conduction model of the pipe wall. The temperature gradients in the wall are obtained and used to calculate the stresses caused by quenching.

Bibliography
None

ID: 2117
Academic Track _ Resubmission of Revised Full Paper
Topics: Thermodynamics and Heat Transfer
Keywords: CSP, Trough, Molten Salt, Helical Coil Steam Generator, Dynamic Modelling

One dimensional dynamic modelling of the HPS2 CSP molten salt trough test facility

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Concentrated Solar Power (CSP) Plants use mirrors to focus direct sunlight to heat up a heat transfer fluid (HTF). The heated HTF is either used to heat up a thermal storage medium or generate steam for a normal Rankine cycle to generate electricity. Currently the common approach is to use synthetic oil as a HTF and molten salt as the storage medium. One of the new technologies emerging in CSP plants is to use molten salt as both the HTF and the storage medium therefore eliminating the use of the synthetic oil. For various reasons this drives down the cost of CSP plants. The HPS2 test facility, located in Evora in Portugal, is one of the first facilities of its kind where experiments will be conducted to demonstrate the use of molten salt as a HTF in a parabolic trough CSP plant. The steam generation system has a once through helical coil economizer and evaporator. This is the first helical coil heat exchanger where molten salt will be used as the heat transfer fluid. Therefore, a thermofluid process model of the test facility is needed to predict and understand the thermofluid dynamics which will occur in the test facility, particularly through transient scenarios.

A dynamic thermofluid process model of the water/steam, and thermal energy storage system in the test facility has been developed using the software Flownex. Flownex is an integrated system modelling code, where the system is discretized into spatial or conceptual volumes in one dimension for which the conservation equations for mass, momentum and energy are solved. To correctly model the helical steam generator, the developed model had to account for the added complexities of the flow characteristics where secondary flows develop. These secondary flows occur due to the centrifugal forces acting on the fluid as the fluid spirals round in a helix. Due to these secondary flows there is added mixing which can increase the heat transfer as well as the frictional pressure drop. Accounting for these secondary flows in Flownex meant that helical coil had to be simplified and different correlations for the heat transfer and frictional pressure drop had to be used.

From the steady state results, the original operating conditions that were specified, produced a large pressure drop over the steam generation system. This was due to the location of the boiling point in the helical coil steam generator. It was found that the boiling point is highly sensitive to the operating conditions of the plant. Through a sensitivity analysis new operating conditions were found, which gave the correct pressure drop over the system. Transient results of the system also show how the system responds to changing plant loads. The transient response of the molten salt temperature is important, as the salt temperature must remain above its freezing temperature.

Bibliography
N/A

ID: 2118
Academic Track _ Resubmission of Revised Full Paper
Topics: Engineering Education, Mechanics of Materials
Keywords: Hardness, Forged, Hardware, Geometry, Microstructure

Can hardness measurements be used to determine mechanical properties of hammer forged overhead line hardware?

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Hardness is a characteristic of a material and not a fundamental physical property thereof, as it is depended on elastic modulus, toughness, yield and ultimate strength. Therefore, it is use as a non-destructive method to verify if the final product achieved the required mechanical properties.

The majority of line hardware consists of both thick and thin sections resulting in a non-uniform microstructure along the profile of the hardware. Depending on the cross sectional area of these sections, variations within the microstructure can be expected, as a result of difference in cooling rate between the surface and the core of the material.

Bow shackles forged from 080M40 (EN8) material, including dumbbell tensile specimens machined from bar samples flattened by means of forging were subjected to a quench and temper heat treatment. Both Brinell (conducted on the surface) and Vickers (conducted across the cross sectional area of cut specimens) hardness measurements were conducted. The position where the hardness measurements can be conducted depends on the geometry of the hardware under testing. The measuring point may not necessarily be representative of the critical diameter, resulting in hardware with mechanical properties not suited for the application.

Due to the geometry of the bow shackle, Brinell measurements could only be conducted on the crown, the thickest section of the shackle. The experiments indicated that the material underwent decarburization at the surface, resulting in significant lower hardness being recorded compared to the hardness of the eye section for example. Removing the decarburized layer resulted in a higher hardness measurement, but it is still not representative of the overall hardness of the shackle.

Vickers measurements revealed the lowest hardness at the surface followed by a steep increase in hardness and leveling out towards the core. This hardness profile was more prominent at the crown and leg sections of the shackle. Bow shackles revealed three different hardness profiles of which the eye section had the highest hardness (higher than the specified hardness) and the crown section the lowest.

Dumbbell specimens, representative of the different cross sectional areas of the bow shackles were reduced in diameter by 1 mm intervals by means of conventional machining. Although the tensile test results revealed a change in the mechanical properties of the material with change in the hardness profile, it was based on the average hardness across the cross sectional area of the material and not a single hardness value. In addition, the hardness for the different sections of the shackles revealed significant scattering. One possible contributing factor could be the position of the shackle within the batch undergoing bulk heat treatment.

The findings of this study are that non-uniform microstructure can have a significant impact on the hardness value depending on the method used. Therefore in-depth understand of the microstructure transformation the material will undergo during heat treatment is a requirement. The use of test bar samples representative of the critical diameter/s of hardware undergoing the same treatment as the component can be used to verify the mechanical properties and hardness.

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ID: 2120
Academic Track _ Resubmission of Revised Full Paper
Topics: Thermodynamics and Heat Transfer
Keywords: Feedwater heater, Heat exchanger, Superheat, Condensation

A method to model the effect of excess superheat on the performance of a feedwater heater.

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Rankine cycle power plants make use of feedwater heaters to achieve an incrementally higher thermal efficiency. These heaters work by extracting a portion of the steam from the turbine, and condensing it on tubes which has feedwater inside. The extracted steam is often in a superheated state, and needs to be cooled down to saturated conditions before condensation can occur. In such a case, feedwater heaters have special inlet regions for the steam to be cooled down with minimum surface area, called a de-superheating (DS) zone.

It is normally assumed that the steam exiting the DS zone is saturated steam, and heat transfer to the water tubes in the condensing zone (COND) will happen through liquid condensation only. However, if the DS zone is not performing as assumed, the steam entering the COND zone can still be significantly superheated. The heat transfer coefficient of superheated steam in the COND zone is very low due to the low flow velocities, therefore one needs a substantial heat transfer surface to bring the steam down to saturated condition before condensation to occur. This has the effect of “consuming” area that could have been used for condensation, thus reducing the overall heat transferred in the heater.

This paper presents a method to determine the amount of “consumed” area, and then predicts the consequential drop in performance. The method makes use of appropriate area allocations inside the heater, and performs a sequential heat exchanger analysis using the effectiveness-Ntu method to determine the outlet conditions. An

iterative method is employed to determine the "consumed" area by means of successive approximation.

The paper demonstrates the importance of taking the effect of a poorly performing DS zone into account by analyzing a few hypothetical scenarios. By making use of this method, heater designers and process engineers can achieve a higher degree of certainty of the expected performance of the heater at various conditions.

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ID: 2121

Academic Track _ Resubmission of Revised Full Paper

Topics: Finite Element Modelling and Analysis

Keywords: Boiler tubes, Localized thinning, Non-linear finite element analysis, Defect geometric shapes, Elastic stress concentration factors

Non-Linear Finite Element Analysis of Boiler Tubes under Localized Thinning Caused by Wall Loss Mechanisms

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Reduction in wall thickness due to erosion and corrosion mechanisms is a common feature associated with boiler tubes while in-service. As the localized thinning continues for a period, the tube becomes susceptible to gross plastic deformation, which eventually leads to its rupture. In this study, a non-linear finite element analysis is done on different geometry configurations of the localized tube defect. A flawed boiler tube with different localized thinned areas were modeled and subjected to simulated operating conditions. Detailed analyses and evaluation of the tube in terms of the minimum required thickness of the localized thinned area was done. The effect of the defect geometric shapes and their dimensions on the tube geometry in relation to the failure of the tube while in-service was studied. The influence of material behavior on the failure of the tube was also examined. From the numerical results, the elastic stress concentration factors (SCF) associated with the defect aspect ratios were obtained and it was observed that these, with the stress redistribution that occur after yielding play a critical role in influencing the failure of the tubes. These findings help to predict which tube with a localized thinning geometry is safe for continued operation, and hence categorize the severity of defects.

Bibliography

N/A

ID: 2123

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics

Keywords: Vehicle dynamics, Performance based standards, Predictive models, Machine learning, H2O.ai

Model to Predict Dynamic Performance of a Tractor Semi-trailer Car-carrier

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A performance-based standards (PBS) framework evaluates actual on-road performance of a vehicle, allowing the length and mass of a vehicle to exceed prescriptive legislation, without compromising on vehicle safety and dynamic stability. This PBS approach is currently being piloted as a demonstration project in South Africa. As of June of 2018, 270 PBS vehicles are operational with a recorded 39% lower crash rate relative to conventionally-designed vehicles; testament to their improved safety. The PBS framework defines the safe performance envelope of vehicles but does not optimise their safety and productivity. The design process to achieve the optimal productivity of PBS vehicles is highly iterative. An initial design is evaluated using multi-body dynamics simulation. If the required PBS performance is not achieved, design iterations are made until the required PBS performance is achieved. The process is costly, time-consuming and computationally expensive. In this study, we simulate a range of tractor semi-trailer car-carriers representative of possible design configurations. Supervised machine learning techniques within H2O.ai driverless AI are used to develop prediction models for the low and high-speed PBS performance of a tractor semi-trailer car-carrier The vehicle design parameters that form the feature vector for each vehicle combination are chosen according to the results of previous studies which evaluated the impact of vehicle design parameters on vehicle dynamic performance. The number of design parameters is minimised to simplify the amount of input data required to train the vehicle performance models. The machine learning models for SRT, RA, HSTO, TASP, LSSP, TS, FS and STFD (PBS measures used to quantify vehicle safety) were accurately predicted for all configurations in the test dataset. The models for MoD, DoM and YDC (further PBS measures) were less accurate but produced a negligible number of false pass results where the absolute percentage errors were significant. It is envisioned that with further development and validation the simplified machine learning model will be used by the car-carrier industry to determine the preliminary PBS performance of their combinations before submitting the design for the final PBS performance assessment. Reducing or eliminating the iterative design process for optimal PBS vehicles will accelerate the design process of safer and more productive vehicles; leading to a reduction in the cost of transport in South Africa.

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ID: 2125 / Session 1: 2
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer
Keywords: Reactor cavity cooling system, Sytem CFD, Very High Temperature Reactor, Mixed convection heat transfer

Modelling of convection heat transfer in the SNU Riser Heat transfer Experimental Facility (RHEF)

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The Reactor Cavity Cooling System (RCCS) of a High Temperature Gas-cooled Reactor (HGTR) plays an important role in ensuring the integrity of the HTGR during normal operating and accident conditions. The performance of the RCCS depends on the convection heat transfer rate in the riser ducts. Under various conditions forced, free or mixed convection may occur. In order to determine the heat transfer characteristics of the rectangular riser ducts of the PMR200 the Riser Heat transfer Experimental Facility (RHEF) had been constructed at the Seoul National University (SNU) to investigate heat transfer inside a riser duct for various heat flux and flow rate conditions. The experimental results showed that mixed convection occurred for certain conditions which leads to heat transfer deterioration. The heat transfer coefficients obtained from the experimental results were not consistent with those predicted by the mixed convective heat transfer correlations published in the literature. Therefore, a modified correlation was derived to fit the experimental data for the RCCS riser duct. In the current study a 1D systems model of the riser duct was constructed using Flownex and the proposed correlation was implemented to obtain the required heat transfer coefficients. A selected set of the SNU experiments were simulated and the predicted heat transfer coefficients and the wall temperatures extracted from the results. The experimental data was also processed using the proposed correlation to predict the heat transfer coefficients and the wall temperature. These two sets of results were compared with the measured wall temperatures and the heat transfer coefficients obtained directly from the measured data. It was found that when forced or free convection conditions dominate the agreement between the three sets of results are very good. However, when mixed conditions prevail -- neither forced and free convection dominate -- the Flownex and processed experimental results were in good agreement, but differed markedly from the results obtained directly from the measurements. This needs to be investigated in depth to develop a fundamental

understanding of the interaction between the relevant physical phenomena.

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ID: 2126

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics, Education in Applied Mechanics, Finite Element Modelling and Analysis

Keywords: composite material, user material subroutine, open source, finite element analysis

Open source implementation of a user material subroutine for composite materials

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The modeling and simulation of composite materials requires the incorporation of anisotropic material models, as well as appropriate failure criteria or damage models.

This was normally done by developing in-house codes or writing additional programs to accompany existing finite element (FE) software. However, in recent years the ability to model and simulate the complex composite behaviour in commercial FE software packages has matured. That said, even commercial FE software has a limited range of failure criteria, damage models and degradation laws to choose from.

Using open source FE packages, such as Calculix, to analyse complex behaviour of composite materials requires considerably more user interventions. One of the only options is to define multiple materials to build the composite or use a composite shell element, but the software provides no method to initiate a progressive failure and damage analysis which is required to accurately simulate composite material behaviour.

From a research perspective, new contributions in this field are made by either developing new progressive damage models (with various modes of failure and damage) for composite materials or by implementing existing models through a user subroutine in a commercial or open source environment. A user subroutine allows for the customisation of the FE software by easily adding new material models, behaviour laws, boundary conditions, etc. without having to fully understand the complex structure and flow of the underlying FE code.

The purpose of this paper is to focus on the open source implementation of a composite material model by making use of the user subroutine to add material models (UMAT) not already available.

The process for implementing a UMAT in the open source software package Calculix is first established as an example for other users. The first step is therefore to develop a UMAT for a simple material model which is already available in the FE package. The implementation process is then verified and validated by comparing the UMAT to the built-in material definition.

Next, a composite material model is chosen from literature and implemented via a UMAT. The composite material model is verified through a simple single element test and validated with experimental test data.

In short, this paper provides a method for implementing a composite material model, through the use of a UMAT, to model the behaviour of composite structures in an open source FE software package.

Bibliography

I started my academic career in 2010 on the studentship programme at the Modelling and Digital Science unit at the CSIR. During this time I published two peer reviewed conference papers. I have been employed as a research engineer since 2013 and in 2014 I received a Masters in Mechanical Engineering (cum laude) and published a journal paper that resulted from this research. I have been registered for a PhD in Mechanical Engineering at the University of Pretoria since 2017 under the supervision of Dr. Helen Inglis. The PhD research will focus on polymer nanoclay composites investigating the effects on mechanical strength.

Recent journal publications include:

Darlow, L.N., Webb, L. and Botha, N. 2016. Automated Spoof-Detection for Fingerprints using Optical Coherence Tomography, Journal of Applied Optics, 55(13): 3387-3396.

Kok, S., Botha, N. and Inglis, H.M. 2014. Calibrating Corneal Material Model Parameters using only Inflation Data: An Ill-Posed Probrem, International Journal for Numerical Methods in Biomedical Engienering, 30(12): 1460-1475.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Finite Element Modelling and Analysis, Mechanics of Vibrations, Structural Dynamics

Keywords: Finite element modelling, Modal analysis, Frequency response functions, Natural frequencies, Structural

damage detection, Damage indicator

Comparison between Free Vibration Response of Healthy and Damaged Pinned Turbine Blades

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The aim of this investigation is to explore the possibility of structural damage detection in pinned turbine blades by measuring their vibrational response. To establish the feasibility of this approach, this paper investigates whether Frequency Response Functions (FRFs) as well as their peaks (i.e. resonant/natural frequencies), is sufficient to distinguish between healthy and damaged blades in free vibration. The variation in the signature response of a population of 36 healthy blades was characterised using FEM (Finite Element Method), and verified experimentally. Damage was then induced by cutting a 1mm thick uniform notch in the root of the blade. In both the FE model and the experiment, a discernible variation in the FRF and the natural frequencies are evident for the damaged case, thus demonstrating that the vibration response is more sensitive to damage than geometrical variability. This establishes the potential of employing these variations as damage indicators. This is the first step in developing a non-destructive evaluation methodology.

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ID: 2129
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer
Keywords: Natural circulation, mixed convection, 1D system CFD, reactor cavity cooling system, experimental facility

Investigation of 1D system CFD and 3D CFD numerical methodology applied to an experimental facility

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The fourth generation gas-cooled nuclear reactor designs provide a promising prospect for energy and process heat generation. The designs` cycles have high thermal efficiencies, require relatively little fuel and are safe to operate. The process of fission does not emit carbon dioxide therefore not adding more greenhouse gases to the atmosphere.

Nuclear power stations are subject to strict regulations and safety standards since an accident could have severe consequences. The regulations stipulate, amongst other things, that the nuclear system`s behaviour must be able to be predicted under all conditions. To this end, the computational methods used to predict the behaviour must be verified and validated.

The phenomena in a nuclear reactor can be very complex and computationally expensive to model, especially when using a 3D CFD approach. The use of 1D system CFD can be employed with improvements in computational time, but with limitations in terms of detail. 1D methodology must therefore be verified and validated against 3D methodologies and experiments to ensure that all of the relevant phenomena are accounted for.

The reactor cavity cooling system experimental facility at the University of Wisconsin was simulated by using a combination of 1D methodology by using Flownex SE and 3D methodologies by using ANSYS Fluent. The facility is a scale model of the reactor cavity cooling system (RCCS) of a modular high temperature gas cooled reactor (MHTGR). The RCCS operates solely on buoyancy forces, making it independent of both operator input and power source. The buoyancy driven flow also required the proper correlations be used when numerically simulating the phenomena.

The coolant loop consists of a pipe network, which is fed from a tank, that passes through a heated cavity (the latter emulates the reactor cavity). Various levels of heat were added during experiments at the heated cavity, simulating various conditions that could occur in a full scale prototype. The experimental conditions were used as boundary conditions in the CFD/system CFD simulations and the results were compared. The heated cavity and the water tank necessitated the use of 3D CFD methodologies, while a 1D approach was used in the other parts of the system. The numerical results obtained by simulation compare well with the experimental results.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer

Keywords: Very High Temperature Reactor, conduction heat transfer, single-channel fuel module, system computational fluid dynamics

A System CFD Model of the Heat Transfer in a Prismatic Block of a VHTR.

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The conduction heat transfer through the prismatic blocks containing the fuel elements in a Very High Temperature Reactor (VHTR) is of crucial importance for the proper operation of the reactor under normal operating conditions and upset conditions. This paper discusses a system computational fluid dynamics (CFD) model that simulates the heat transfer and fluid flow in a single-channel fuel module of a prismatic block in a representative manner. The model consists of a collection of one-dimensional solid conduction heat transfer, convection heat transfer and pipe elements that are arranged in such a manner to represent the heat transfer and fluid flow in the single-channel fuel module using a network approach. The current model represents one sixth of a single-channel fuel module. The validity of the model was investigated by comparing the temperature distribution in the single-channel fuel module for various scenarios with the corresponding values obtained using a detailed CFD model of the single-channel fuel module. This model requires much less computational resources than the detail CFD and unit cell based models and can form the basis of an integrated model for the entire core.

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ID: 2131
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer
Keywords: Packed bed, Computational Fluid Dynamics (CFD), Thermal dispersion, STAR-CCM+, Large Eddy Simulation (LES)

CFD analysis of thermal dispersion in a structured packed bed

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Packed beds are generally modelled in a partial manner to avoid computational costs. This implies that only a small portion of the representative bed is modelled explicitly in CFD simulations, usually by assuming symmetry boundary conditions. Thermal dispersion requires both the small and large-scale fluid flow phenomena to be resolved. Consequently, it is required to model a large portion of the original packed bed. In this study, the original model consisted of approximately 4000 uniform spheres in a body-centered cubic (BCC) packing-structure with no contact between the spheres. A braiding effect was induced by allowing cold and hot nitrogen streams to mix within the packed region. The apparent unsteady, oscillating nature of the flow in numerous cells can result in simulation difficulties. To overcome these difficulties, an appropriate simulation methodology was developed using STAR-CCM+ by investigating the effect of several simulation parameters on the mesh quality, residuals and temperature profiles. Good agreement between the numerical results and experimentally measured temperatures has been achieved by using a locally refined mesh with the Large Eddy Simulation (LES) model.

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ID: 2134
Academic Track _ Resubmission of Revised Full Paper
Topics: Engineering Education, Mechanics of Composites, Mechanics of Materials, Solid Mechanics, Structural Dynamics, Structural Mechanics, Thermodynamics and Heat Transfer
Keywords: 4D printing, prototyping, self-actuate, stimuli

A Review of 4D Printing technology and future trends

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3D printing has gained immerse popularity since its introduction and finds application in areas such as prototyping, design largely due to its advantage of being able to quickly and inexpensively transform computer 3D files into physical objects. 3D printing has capability of printing geometrically fixed structures which are static and not suited for multifunctional use. 4D printing was developed when researchers combined smart materials and 3D printing. 4D printing use the fourth dimension of time to create shape morphing objects when exposed to stimuli after using conversional 3D printing technology such as fused deposition modelling (FDM) and selective laser sintering (SLS). 4D printing materials respond to stimuli such as pH, humidity and temperature to activate the 3D printed components without the use of electronics or motors. There has been a lot of research done on smart materials or intelligent materials capable of sensing external stimuli. In this paper 4D printing is reviewed according to activation stimuli and the uses of this technology are explored. 4D printing has the prospective to simplify the design and manufacturing of different products and has the vast potential to create parts that self-actuate to react to their environment. Applications of 4D printing are in areas such as biomedical devices, security, fabrication of patterned surfaces for optics and structures with multi directional properties.

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v.Josphat Igadwa, Nkosilathi Zinti Nkomo, Lloyd Ndlovu 2016. "Comparison of LMBP and LMBP hybrid algorithms during the prediction of ring spun yarn evenness" Appropriate Technology Conference 2016. Victoria Falls: Zimbabwe

ID: 2135
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Methods in Mechanics, Mechanics of Vibrations
Keywords: vibrating screen, Synchronisation, Multi-Body-Dynamics, Adams

RELATIONSHIP BETWEEN VIBRATING SCREEN DYNAMICS AND SELF-SYNCHRONISED EXCITATION

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A large amount of vibrating screens operates with self-synchronised unbalanced vibrating motors. A good understanding of the principles of operation of these machines is important to improving overall machine performance. This knowledge can be used to make improvements in machine power consumption, screening efficiency and the better prediction of loads can be used to improve reliability.

A representative multi-body dynamic model was constructed that includes the motor characteristics as well as dynamic properties of the screen. This model was used to simulate the phenomenon of self-synchronisation and resultant vibrating screen dynamics.

The purpose of this study was to determine the parameters that affect self-synchronisation of the unbalanced motors.

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Academic Track _ Resubmission of Revised Full Paper
Topics: Biomechanics, Finite Element Modelling and Analysis
Keywords: Finite element analysis, Digital image correlation;, Medical implant design, Additive manufacturing

VALIDATION THROUGH DIGITAL IMAGE CORRELATION OF FINITE ELEMENT ANALYSIS USED IN THE DESIGN OF A TI6AL4V MANDIBULAR IMPLANT

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This paper deals with the validation of finite element analysis (FEA) used in the design for additive manufacturing (AM) of a custom-built Ti6Al4V mandibular implant using digital image correlation (DIC). The effectiveness of the process of designing a medical implant for production by AM can still be improved, because poorly designed AM implants, as well as implant failures, still occur. An implant designed without due consideration of mechanical properties needed for typical operational conditions results in unexpected failure. This can be avoided by utilising FEA for refining medical implant designs.

In a previous study FEA was validated as a design tool to better predict mechanical behaviour and strength of medical implants through strain gauge measurements on parts of the implant. However, this approach of using single point strain gauge measurements for the validation has the limitation that the strain distribution across the whole implant surface cannot be determined. As a non-contact method and an acceptable tool for qualitative measurements, DIC can provide full-field strain distribution.

The method followed was to demonstrate the correlation between an FEA model and DIC measurements performed on a human mandibular implant. For the design of the mandibular implant the geometrical representation of an adult human mandible obtained from a computerized tomography (CT) scan was transferred to a computer aided design (CAD) model. This model was then analysed through FEA for typical static mastication load conditions. Through this simulation the distribution of strain in the implant was determined analytically. Using the same CAD model, an implant was manufactured through selective laser melting (SLM). The experimental validation of the model through DIC was done on a test bench designed to allow the application of load and boundary conditions similar to those used in the FEA model.

The results obtained from FEA were in agreement with the DIC and the principal strain distribution was found to follow the same pattern for both the simulation and the experimental model. It was concluded that the DIC results

confirmed FEA to be a powerful tool for improving the effectiveness of the design of medical implants for production through AM.

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T.C. Dzogbewu, L.F. Monaheng, J. Els, I. van Zyl, W.B. Du Preez, I. Yadroitsava, and I. Yadroitsev, “Evaluation of the compressive mechanical properties of cellular DMLS”, Proceedings of the 17th Annual International Conference of the Rapid Product Development Association of South Africa, 2016. ISBN 978-0-620-72061-8

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Academic Track _ Resubmission of Revised Full Paper

Topics: Fluid Mechanics

Keywords: Systematic Study, Integrated power plant model, Fan capacity limitations, xxx

An integrated model to study the root causes of ID fan capacity limitations in coal fired power plants.

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Coal fired power plants generate nearly 90% of the electricity in South Africa and 40% globally. These plants are made up of numerous interconnected systems and components which as a whole need to efficiently produce electricity. When some systems or components under perform, the impact is not only seen on the underperforming system or component but can affect other plant areas far removed from it. The operating point of the induced draught (ID) fan is commonly affected by underperformance in other systems. Therefore, load losses are often attributed to the ID fan performance while it is not actually the root cause. This paper describes an integrated model that was developed to study the root causes of ID fan capacity limitations. The model is used to quantify the effect of major anomalies on the operating point of the ID fan. The major anomalies of interest are: increase in condenser backpressure; changes in coal quality; feedwater heaters out of service; air ingress into the boiler; and air heater leakages.

To capture the effects of these anomalies it was apparent that a model containing the full details of all plant components would neither be necessary nor practical. Instead an approach was taken whereby the draught group is modelled in sufficient detail by solving the conservation equations of mass, energy and momentum using Flownex SE. Boundary values for this model are obtained by solving only the mass and energy conservation equations for the Rankine steam cycle using VirtualPlant, while a custom developed Mass and Energy Balance (MEB) is employed to model the combustion process in order to determine the coal, air and flue gas flow rates. The three models were first verified and validated separately using plant design data. Custom C# scripts were then built to integrate the three models by enabling dynamic exchange of data between the three software tools. The integrated model was shown to be accurate to approximately 5% for flue gas flow rates and 1.5% for temperature when compared to measurements. The anomalies listed above have been investigated with the aid of the integrated model and the impact on the operating point of the ID fan was quantified.

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EPRI, "Heat-Rate Improvement Guidelines for Existing Fossil Plants", May 1986

ID: 2138

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Fluid Dynamics, Fluid Mechanics

Keywords: gas dispersion modelling, gaussian dispersion, chemical reactions, scalar transport

A comparison of different CFD and Gaussian dispersion models

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The accidental release of flammable or toxic gases is a serious health and environmental concern, with potentially deadly consequences. The numerical modelling of gas dispersion offers a powerful means by which to predict the flow and concentration of a gas leak given atmospheric and environmental conditions. Potential risks associated with a gas leak can be better understood by modelling multiple gas leak scenarios. This understanding can also aid in the design of effective early gas leak detection systems or an integrated chemical plant design.

If a chemical plant is analysed, a study on the effect of varying gas leak location, intensity and changing environmental factors requires a large set of gas dispersion simulations. Generating the large database of simulations can be a computationally expensive exercise depending on the required model fidelity or complexity. In this paper we compare three gas dispersion modelling techniques with varying complexity.

The most commonly used gas dispersion model is the Gaussian dispersion model, where the air pollutant is assumed to have a normal probability distribution. Gaussian dispersion models are capable of modelling continuous, buoyant air pollution while taking wind direction and elevation into account. Gaussian dispersion models are however limited to flat and smooth topography, limiting the range of their applicability.

On the other end of the computational cost scale, is high-fidelity computational fluid dynamics (CFD) tools. Most

advanced CFD solvers can solve for buoyancy effects by accounting for different densities of the gas and atmosphere, the effects of temperature, complex wind patterns, include chemical reactions and provide a choice of several turbulence closure models. While high-fidelity CFD can be used to model a broad variety of complex physics, it assumes a strong interaction between the gas dispersion and the fluid flow. Examples where such a relationship is expected includes the simulation of chemical reactions and combustion, or the rapid expansion of a pressurised gas.

In the large majority of gas dispersion problems, the gas or pollutant will not influence the outside atmosphere. For this reason we compare the Gaussian dispersion model and high fidelity CFD with a third option, where gas dispersion is treated as a scalar transport problem. The gas dispersion can here be modelled by seeding a source into a pre-computed fluid flow field, and solving a set of scalar transport equations. The simplified model still accounts for complex geometries, turbulent flow and complex boundary conditions. The air flow and gas transport are solved separately, reducing the overall computational cost.

In this study, we first illustrate the capability of OpenFOAM to solve buoyant gas dispersion, with turbulence and chemical reactions (in the form of methane combustion). We then introduce the simplified gas dispersion scalar transport problem, and compare both CFD methods to the Gaussian dispersion model.

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https://scholar.google.co.za/citations?user=97rgEwgAAAAJ&hl=en&oi=ao

ID: 2139
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Computational Methods in Mechanics, Fluid Mechanics
Keywords: sea ice modelling, OpenFOAM, visco-plastic rheology, dynamic relaxation

Implementation of a visco-plastic sea-ice model into OpenFOAM

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Sea-ice plays an important role in global climate. It influences the global ocean circulation, and affects global climate due to its inherent reflective nature. In most models used to study long term climate change, sea-ice is often treated simplistically. With the advances in numerical schemes however, modern sea-ice models have become far more comprehensive.

Sea-ice is a heterogeneous, anisotropic material, and generally forms a highly fractured surface cover with various shapes and sizes of ice floes. The local distribution of ice-thickness, floe sizes and lead fractions varies across the various polar regions. At length scales, in the order of 10 to 100kms, sea-ice can be appropriately described as a continuum medium. Pack ice behaviour on these large scales have been observed to have a maximum compressive strength related to ice thickness and fractional coverage. It has a low tensile strength and rate-dependent inelastic response to shear deformation.

Many models have been developed to describe the ice dynamics at large length scales. Early studies focused on free drift descriptions with no ice interaction. Once ice reached a certain height or mass, or encountered land, it would be forced to stop. Other ice rheologies included treating ice as a Newtonian viscous fluid , cavitating flow model or a plastic material. A nonlinear visco-plastic model first proposed in 1979 is still considered the de facto description of sea ice dynamics, forming the basis of most modern sea-ice studies.

In this paper we outline the development of a visco-plastic sea-ice model into OpenFOAM. The visco-plastic model consists of four equations, describing the sea-ice height, concentration (or compactness), strength as a function of height, and a force balance equation between the internal ice stress state and the external wind and ocean stresses (described in our study using a quadratic boundary layer).

The visco-plastic model equations are solved using a co-located finite volume approach, which is stabilised by adding an extra term to the momentum equation. The four sets of governing equations are solved in a staggered fashion, and iterated until convergence using dynamic relaxation to improve the convergence rates. We conclude by illustrating the performance and accuracy of the visco-plastic sea-ice model on a number of benchmark problems.

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https://scholar.google.co.za/citations?user=97rgEwgAAAAJ&hl=en&oi=ao

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Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Composites
Keywords: 3D Printing, adhesion, printing parameters, FDM process, cotton, PLA

A study of the factors affecting the adhesion of 3 D printed PLA on cotton fabrics

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3D printing technology is an additive manufacturing that creates objects from CAD models by layering. 3D printing has in recent years found applications in the textile industry with possible opportunities for mass customization, where fabrics structures have combined with polymers to produce 3D printed composite structures. The adherence of the 3D printed polymers on fabrics has necessitated the need to study the fabric/polymer adhesion properties. The aim of this study was to study the factors affecting the adhesion of cotton fabric and 3D printed polylactic acid (PLA) polymer. 3D printing process was done using a Fused Deposition Modelling (FDM) printer. 3D printing parameters, that is, extrusion temperature, extrusion speed, fill density and the thickness of the model, were varied

to determine the optimal printing parameters. Printing was done on 31 samples based on the central composite design of experiments. The samples were then washed and tested for adhesion properties according to ISO 6330, DIN 53530 and ISO 6133 standards.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Fluid Dynamics

Keywords: Greenhouses, CFD, Natural convection, heat transfer

The effect of side ventilator positions a on single span, naturally ventilated greenhouse – a CFD Study

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Many practical applications encountered in engineering involve natural air ventilation. A typical example is heating/cooling of indoor environments such as greenhouses. Naturally ventilated greenhouses can be utilized to control the indoor microclimate in areas where the ambient conditions are not too extreme. The indoor environment of greenhouses is of vital importance, as the quality and quantity of the crop production are directly affected. In this study, natural ventilation in a two-dimensional single-span greenhouse containing both a roof and side ventilator is numerically investigated using Computational Fluid Dynamics (CFD). The floor and roof are kept at different constant temperatures, promoting buoyancy driven flow within the cavity. The side walls are kept adiabatic. The main objective of this study is to investigate the influence of side wall ventilators on the natural convection inside the greenhouse. Results were compared for a cavity containing various sizes roof ventilators. Preliminary results of the study reveal that the performance of a single-span naturally ventilated greenhouse is considerably influenced by the addition of a side ventilator. The importance of using CFD as a tool in the design phase to investigate the influence of side ventilators on the indoor climate in greenhouses is also illustrated.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Vibrations, Structural Dynamics

Keywords: Electromagnetic acoustic transducer, guided wave ultrasound, rail monitoring

Experimental Development of Electromagnetic Acoustic Transducers for Measuring Ultrasonic Guided Waves

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Guided wave ultrasound offers the potential to monitor long sections of structures such as pipes and rails from a single transducer location and is used in a system for monitoring continuously welded rail track which was developed in South Africa. This system makes use of permanently attached piezoelectric transducers spaced approximately 1 km apart for transmitting and receiving ultrasound. The design of such systems is complicated by the fact that numerous modes of propagation exist and that these modes are generally dispersive. Future developments of the system require the use of an array of transducers to be able to distinguish the different modes which propagate and reflect from defects in the rail. Piezoelectric transducers bonded to the rail have been found to interfere with the propagation of ultrasound and this scattering makes the array processing ineffective. Electromagnetic acoustic transducers (EMATs) have been developed by other researchers for transmitting and receiving Lamb waves in plates and surface waves in the head of a rail. These transducers are generally optimised to transmit guided waves as EMATs produce very small excitation forces (Lorentz forces). In this paper we describe the initial development of EMATs for the purpose of receiving guided wave ultrasound in the low frequency range up to 50 kHz.

The EMAT is comprised of a coil placed on a soft layer on the rail surface with a magnet placed on top of the coil. The magnet produces a magnetic field in the rail and when an ultrasonic wave causes a surface velocity an eddy current is established in the skin. The eddy current induces an opposite current in the coil and this current is amplified electronically and detected as a measure of the velocity of the rail surface. EMATs were constructed and measured in the lab and the performance of these devices will be compared to a laser vibrometer and a piezoelectric transducer. Measurements with an array of transducers on an operational heavy haul rail line will be presented. Phased array processing of these signals is performed, using dispersion characteristics computed from a semi-analytical finite element model, to extract various guided wave modes of propagation. The EMAT transducers are easy to construct and performing the field measurements was relatively simple. The signals generated by the EMATs are small and pre-amplifiers with large gain were developed. The transducers do not interfere with the waves in the structure and show excellent agreement with laser vibrometer measurements. The signal to noise ratio is significantly worse than that of piezoelectric transducers. This can be improved to some extent in applications where time is available to perform a large number of averages.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics, Finite Element Modelling and Analysis, Mechanics of Vibrations, Structural Dynamics

Keywords: Guided waves, SAFE forced response, Abaqus/Explicit, cut-off frequency, mode extraction

Comparison between SAFE forced response and Abaqus/Explicit solutions of a rail excited at cut-off frequency

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The ability to model guided wave excitation and propagation is essential when designing non-destructive evaluation and monitoring systems. Elastic waveguides can support many different modes of propagation, each of which propagate at different speeds and are generally dispersive. This complex behaviour can be modelled using numerical methods. The frequency at which a particular mode can start to propagate is known as the cut-off frequency. At frequencies below the cut-off, the wavenumber is located in the complex plane and results in what are known as evanescent waves, which do not propagate but many have relatively large amplitude, concentrated at the source of excitation. At the cut-off frequency, the wavenumber ``cuts-off'' on the real axis at zero, and the mode starts to propagate. If a mode is excited at or close to its cut-off frequency, resonant-like behaviour is observed (similar to exciting a finite structure at its natural frequency). This phenomenon is of interest if relatively short toneburst signals are employed to excite the elastic waveguide. These short time signals would excite a broad frequency band which could contain one or more cut-off frequencies.

In this paper, we present a comparison between two different methods for modelling the response of an elastic waveguide to a point force excitation. Both excitations containing, and not including a cut-off frequency, are considered. Firstly, an Abaqus/Explicit model is presented. In order to simulate an infinitely long waveguide, reflections from free ends are eliminated using absorbing boundary conditions. The Abaqus/Explicit time domain results are compared to time domain results computed using a semi-analytical finite element (SAFE) method forced response solution. The SAFE method is formulated and solved in the frequency domain, and encounters numerical difficulties when transforming results to the time domain if cut-off frequencies are excited. These difficulties are due to the fact that the steady state solution at the cut-off frequency is unbounded. Several methods to alleviate these numerical difficulties are presented and compared.

A frequency domain comparison between the two models is also performed. The SAFE method computes the amplitude of each mode, as a function of frequency and therefore modal contributions are naturally separated. In order to perform the comparison, a procedure to extract modal amplitudes from the time domain Abaqus/Explicit results is required. A method previously used to extract modal amplitudes from experimental results is used for this purpose. Good agreement between the SAFE and Abaqus/Explicit results is demonstrated in both the time and the frequency domains.

Bibliography

Available upon request

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Academic Track _ Resubmission of Revised Full Paper

Topics: Finite Element Modelling and Analysis

Keywords: Damage Detection, Probability of Detection, Environmental and Operational Conditions, Receiver Operator Characteristic Curves

Estimation of Probability of Defect Detection by Combining Simulated Defect Signatures with Operational Measured Data

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Continuously welded heavy haul railway lines experience very large stresses due to high axle loads and varying environmental conditions. These extreme loading conditions can lead to the development of cracks and eventually rail breaks, which are the most common cause of train derailment. The need to detect rail breaks was therefore identified by Transnet Freight Rail, leading to development of the Ultrasonic Broken Rail Detection (UBRD) System by the CSIR and the Institute for Maritime Technology (IMT). With the current system, is it possible to detect only complete rail breaks. Current research efforts are aimed at detecting damage, such as cracks, before a complete break occurs. A method to quantify the probability of detecting various damage types would be very useful to evaluate system performance during the design phase.

Defects such as cracks in rails can be detected by comparing numerous ultrasonic signals, recorded using a permanently installed monitoring system, over a period of time. These signals will contain reflections from benign structural features (such as welds) which do not represent damage, as well as potentially small reflections from damage. Variations in environmental (e.g. temperature) and operational (e.g. rail maintenance) conditions may produce large changes in the ultrasonic signals thereby masking the damage. The challenge is therefore to distinguish between these benign signals and the true damage signals. This task is further complicated by the fact that obtaining monitoring data for different damage scenarios under varying environmental and operational conditions is virtually impossible since detected defects in sections of an operational rail track are immediately removed and replaced with new rail. Laboratory damage experiments are also not possible due to end reflections from short sections of rail dominating the response. Therefore, damage signals can only practically be obtained from numerical simulations. The aim of this paper is to demomnstrate a procedure to combine simulate damage

signals and measured data obtained under operational conditions, concentrating specifically on temperature variations.

First, measurements from a damage free rail, subjected to real operational conditions are obtained. Thereafter artificial damage signals, computed using numerical simulations and modified to represent the appropriate temperature conditions, are added to the measured signals. Unsupervised machine leaning algorithms for extracting and classifying signal features associated with different sources from measurements can then be applied to detect and classify the synthetic damage. In this way, numerous damage scenarios can be investigated without having to interfere with rail operations by performing destructive tests. Receiver Operator Characteristic (ROC) curves, which plot the probability of detection against the probability of false alarm, will be estimated for selected damage scenarios. The above procedure is developed and tested using a purely simulated dataset, with both damage and operational measurements, with temperature variations and reflections from welds synthesized, before being evaluated with experimental field measurements.

Bibliography

Available upon request.

ID: 2146

Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Vibrations

Keywords: Base-line subtraction, iterative scaled transform, scale-invariant correlation, temperature compensation

Temperature Compensation for Ultrasonic Guided Wave Measurements

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Guided wave ultrasound is an increasingly popular non-destructive method for inspecting and monitoring elongated elastic waveguides, such as pipes and rail. Monitoring systems using a pulse-echo mode of operation typically excite guided waves using permanently installed piezoelectric transducers, and reflections from defects are often detected using the same transducer. Many propagating modes are usually excited by the transducer, and the propagation speed and dispersion characteristics of each mode are different. The propagation speed is also temperature dependent, and therefore reflections from discontinuities in the waveguide have different arrival times depending on the environmental temperature. In order to differentiate between reflections from benign structural features such as welds and growing defects such as cracks, measured signals are compared to a baseline signal with no damage. However, since measured signals are temperature dependent, potentially masking damage signatures, a method to compensate for temperature is required for effective baseline comparison.

In this paper various temperature compensation methods will be applied to measured guided wave signals, collected from an operational train rail. The measured results were sampled at various times of the day under different environmental conditions. The primary purpose of this paper is to analyse various signals which have similar signal characteristics, however due to environmental conditions (such as temperature differences) are not identical.

This paper compares three temperature compensation methods, namely scale-invariant correlation (SIC), a combined scale-invariant correlation with iterative scaled transform (SIC/IST) and a method developed by the authors, called envelope stretching (ES). Simple baseline subtraction is used as a basis to evaluate and compare the various methods.

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ID: 2148 / Session 4: 1

Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Vibrations

Keywords: SAFE, rail, mesh adaptation, material and geometry parameterisation, Guyan reduction

Adaptive SAFE model of a rail for parameter estimation

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Guided wave ultrasound (GWU) is very attractive for non-destructive evaluation and monitoring of elongated structures such as pipes and rails. Propagating waves can be excited using permanently installed piezoelectric transducers, and can propagate long distance (kilometres in some cases). When operating in pulse-echo mode, reflections from defects can be sensed using the same transducer used to excite the wave. A guided wave ultrasound based monitoring system has been developed and is currently being used to monitor the Oreline UIC-60 rail track between Sishen and Saldanha. The current system works in pitch-catch mode, with alternating transmit and receive stations and detects only complete rail breaks.

GWU-based monitoring systems are complicated by the fact that many different modes are simultaneously excited, and these modes propagate at different speeds and are dispersive. These propagation characteristics are required when performing signal processing in order to identify different modes of propagation and to compensate for dispersion, which is required to detect and locate defects. The semi-analytical finite element (SAFE) method has become a popular method for efficiently computing dispersion curves of elastic waveguides. The dispersion curves of a rail are dependent on material properties as well as the rail geometry, neither of which are known to a sufficient degree of accuracy. The rail geometry in particular changes over time due to wear and regular maintenance operations which include rail grinding of the crown (to restore the profile and prevent shelling). It is therefore useful if the dispersion curves of the rail or rail properties can be estimated from measured signals obtained by the

monitoring system.

The material and geometric parameters are implicit in the computation of the dispersion curves, and therefore in order to infer the properties from dispersion curves, in inverse problem needs to be solved using an iterative approach. In this study we show how dispersion curves can be computed using the SAFE method. A mesh convergence study is performed to determine a suitable discretisation such that results are not mesh dependant. Modes which propagate long distance in rail are identified and procedure to track these modes in the frequency domain is presented. Finally, in order to efficiently compute the dispersion curves, a model reduction method (Guyan reduction) is presented. In this study the SAFE forward problem is analysed for efficient and accurate computation of dispersion curves. Geometrical parameters which describe the head wear are established. The geometry of the rail is then described using these parameters for use in an optimisation procedure to estimate the rail properties (which is not presented here). An automated re-meshing strategy using radial basis functions is presented. Elastic properties of the SAFE formulation are written in terms of the ratio of elastic modulus and density. It is shown that a simple scaling of the dispersion curves is possible when considering materials with a different elastic modulus-density ratio, but the same Poisson's ratio. Finally, a sensitivity study of the selected parameters is presented in order to select the most sensitive parameters for future use in the inverse problem.

Bibliography

NA

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Academic Track _ Resubmission of Revised Full Paper

Topics: Discrete element modelling

Keywords: DEM-CFD modeling, porous media, packing structures, coal discard dumps

DEM-CFD air flow simulation through varying coal dump porous media packing structures

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In this project a DEM-CFD numerical model to predict air flow through various coal dump porous media packing structures is presented. Varying coal dump packing formations were generated by discharging particles of different sizes at specific heights, rates and trajectories to mimic the actual coalpile formation processes and as such improve the modeling accuracy's packing dynamics and as well as assisting in better understanding the flow of air through the porous bed. Initially, the porous dump, consisting of both spherical and non-spherical heterogeneous particles is modeled using the DEM method from which resultant geometrical properties such as porosity and permeability were quantified via analytical techniques and later on used as input data to model air flow within the porous domain using the CFD model. Using the developed model, it was found

that coal particles sizes and shapes, dropping height and trajectories tend to

form different coalpile packing structures and of which the resultant coal packing structures give rise to different flow patterns within the dump depending on their geometrical parametric orientations. Overall, the model's accuracy is validated through comparing its predicted results with other available numerical data.

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ID: 2151

Academic Track _ Resubmission of Revised Full Paper

Topics: Aerodynamics, Computational Methods in Mechanics, Fluid Mechanics

Keywords: Surrogate modelling, Radial Basis Functions, RBF, CFD, Flight Envelope

Improved accuracy considerations in Radial Basis Function surrogate models for variable resolution, scale, dimension and discontinuity.

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Surrogate- or metamodels approximate and so reduce the computational cost associated with evaluating computer experiments of interest over a set of design variables. Radial Basis Functions (RBFs) are a popular metamodel choice due to its ease of implementation and availability in popular scientific programming languages. An RBF surrogate can be used to interpolate or regress field information located at select points within a sampled Design of Experiments (DoE) domain. This is done using one of a vast range of basis function choices available for both global or local support.

In metamodel based design optimisation, RBFs are used to approximate the objective functions outputs from Finite Element Analysis (FEA) and Computational Fluid Dynamic (CFD) simulations. The metamodel is then searched for the local or global minimum, reducing the computational cost. Once the metamodel objective function is searched for a potential design, the associated computer experiment is again performed and the process repeated until convergence is satisfied. These metamodels can also be used to approximate fields or operational characteristics subject to variation in a multidimensional control parameter space.

The correct use of RBF metamodels first requires a model appropriate choice of basis function. The inclusion of a higher level model definition, using a polynomial for example, is another important consideration. By using cross-validation, dimensional scaling and error indicators calculated and inherited from Bayesian statistics or Machine Learning algorithms, the accuracy of the surrogate approximation can further be improved. Multiple surrogates may also be needed if discontinuities exist within the design space of the underlying computer experiment. In this

conference contribution, many of these non-standard considerations are addressed and illustrated using Python code.

The work focuses on the knowledge transfer and correct use of RBF surrogate models. The model implementation and considerations are first illustrated on benchmark test functions. This is followed by a CFD test-problem on the particular use of RBF to construct a flight envelope of an object, illustrated using the interaction of two diamond airfoils. The test-problem shows the practical design of an RBF surrogate considering discontinuities in the drag, lift and moment coefficients as a result of interaction between various shock waves in the transonic and supersonic regime.

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ID: 2152 / Session 1: 1
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Thermodynamics and Heat Transfer
Keywords: pyrometallurgy, combustion, fluid flow, computational modelling

Toward computational combustion models of metallurgical converting processes

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In many flowsheets used in the high-temperature metallurgy industry, alloy converting is required as a secondary treatment stage in order to refine products from primary smelting furnaces to acceptable quality. This process entails contacting molten metal alloy with oxygen in a vessel called a converter. The oxygen reacts chemically with undesirable and less noble components of the alloy to produce metal oxides, forming a separate slag phase which is generally discarded from the converter unit as a waste product. Alloy converting is applied extensively in the production of raw material products such as low carbon ferromanganese and ferrochromium, as well as in treatment of the complex alloys arising from pyrometallurgical processing of e-wastes and related processes.

In the present paper an initial computational modelling study of a particular converter unit design, the Top Blown Rotary Converter (TBRC), is presented. The TBRC consists of a cylindrical vessel which is lined with insulating refractory materials, inclined at an angle, and rotated about its axis. Material to be converted is batch-fed to the unit, and an oxy-propane lance is inserted into the mouth of the vessel. The lance is generally controlled to produce an excess of oxygen, thereby providing both thermal energy via combustion of propane and available oxygen for the alloy converting process.

To advance the state of the art and improve design and operability of TBRC units, the capabilities of computational models of the fluid flow, heat transfer, and chemical reactions occurring in the gas phase of the converter were explored. Models were implemented and executed using transient combustion flow solvers present in the OpenFOAM® open-source computational mechanics platform, and the impact of chemical reaction mechanism complexity on solver performance and accuracy is discussed. The distribution of energy and reaction products through the interior of the TBRC was examined as a function of the flowrates of oxygen and propane to the lance at different stoichiometric ratios, and converting rates for the various conditions were estimated from the flux of oxygen to the boundaries representing the molten alloy.

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ID: 2153
Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Vibrations
Keywords: Robot, orthogonality, flexible, restrained, multilink

Parametric Study of Natural Frequencies and Mode Shapes of Planar Flexible-link Robots with Elastic Rotational Restraints at the Joint-Link Couplings

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Most studies on the dynamics of multilink flexible robots tend to consider either the classic clamped mass or pinned mass boundary conditions. In those situations where the elastic deformation at the link-hub connection allows for restrained rotation, the classic clamped or pinned boundary conditions will fail to accurately represent the actual physical properties of the coupling.

In this paper, parametric study of natural frequencies and mode shapes of planar multilink lightweight manipulators accounting for flexible coupling between flexible links and joints is presented. Joint- link couplings are modelled as pivots with rotational constraints. The links are modelled as Euler Bernoulli beam and the assumed mode method is used to derive the natural frequencies along with the mode shapes for various joint-link coupling stiffness coefficients. It is established that the model proposed in this work mimics the traditional clamped –mass boundary conditions when high hinge torsional stiffness coefficient to the link flexural stiffness coefficient ratio is reached, while the traditional hinged-mass case with a fundamental mode of rigid rotation is achieved when the ratio drops to almost zero.

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Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Vibrations
Keywords: Multilink, coupling, stiffness, hinge, rotational.

Dynamic Modelling and Simulation of Planar Flexible-link Robots with Elastic Rotational Restraints at the Joint-Link Couplings

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This paper presents the dynamic model of multilink flexible robot with elastic rotational restraints at the joint-link couplings. The proposed model is flexible as it can mimic the classic clamped case model considering an infinite hinge torsional stiffness coefficient to the link flexural stiffness coefficient ratio. The particular case of flapping motion is also a degenerate case of the proposed model where the stiffness coefficient to the link flexural stiffness coefficient ratio is almost zero. Considering that most joint- link couplings are subject to some degree of elastic deformation, the proposed model can be considered more suitable for modelling multilink flexible robots. Simulations are conducted to validate the theoretical model.

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ID: 2155
Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis, Micro-scale Mechanics, Nano-scale Mechanics
Keywords: finite element modeling, thin films, coatings, nanoindentation, scratch tests

A Review of Finite Element Modeling of Nanoindentation and Micro-Scratch Techniques in Characterizing Thin Films

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Nanoindentation experiments are generally used in characterizing the elastic-plastic properties of thin films whereas scratch tests are used to study the critical loads which lead to facture of the films. However, present researches have demonstrated that these experiments can provide more information on deformation, fatigue and fracture behavior of the thin films. Finite element modeling is extensively being used to extract as much information as possible from these experiments about the thin films. It has been demonstrated that through FEM software, load-displacement curves for nanoindentation tests can be extracted with minimal errors. FEM has successfully been used to analyze and compute stress distributions and fracture toughness of thin films during scratch experiments. In this review article, detailed procedures of nanoindentation and scratch tests for characterization of thin films are presented. Then, using peer-reviewed research articles for the past ten years (2008-2018) on finite element modeling of these experiments, a critical review of the latest development in the subject area is analyzed. The review article aims at documenting the achievements of the previous research activities on FEM of these experiments while advancing new research ideas for future studies and focus.

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Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Methods in Mechanics, Thermodynamics and Heat Transfer
Keywords: Thermo-acoustic, cooling, optimization, GAMS;

Numerical optimization of small-scale thermo-acoustic refrigerators considering maximum cooling

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The use of sound wave to remove heat could potentially contribute significantly to the development of a more affordable, sustainable search of an effective solution for electronics coolers. This work provides details of a mathematical programming model formulation that address the issue of dimensional optimization of a small-scale standing-wave thermo-acoustic refrigerator system. The cooling load has been considered as main criteria in the formulation and the measurement of the performance of the system. The dimensional parameters describing the heart of the device, namely the porous media (or the stack), where the heat pumping takes place are the variables to optimize. The problem has been formulated as a non-linear programming problem with discontinuous derivatives and implemented in the General Algebraic Modelling Systems (GAMS). The main contributions of the work are the detailed GAMS model and the clarity about the most preferred position and length of the stack considering prior knowledge of its porosity. This work will undoubtedly clarify the selection of the best geometrical configurations at the initial design stage.

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Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis, Mechanics of Composites
Keywords: Fibre waviness, Cure simulation, ply drop-off, ANSYS, ACCS

Prediction of fibre waviness in a thermosetting composite panel with ply drop-offs

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Composite materials have become more popular over the past years due to their high strength-to-weight and stiffness-to-weight ratios. However, the production of high quality composite structures presents many challenges due to numerous defects possible during the manufacturing processes. The most critical defects are thermal deformations (which include spring-in and fibre waviness), and residual stresses which can lead to a total scrap of the component if they are not fully accounted for in the design. Therefore, residual stresses and thermal deformations need to be predicted and controlled accurately during the design process, and this is challenging due to the complex behaviour of composite materials. Current designers rely on a trail-and-error approach, and experience to predict these process-induced residual stresses and thermal deformations. This approach gives reasonable results for relatively simple structures. Complex structures require a sophisticated numerical model to capture the interactions between different geometric features. However, without effective analytical tools that can perform an in-depth simulation of the curing process, sophisticated numerical models are difficult to develop. LMAT, a consulting company based in the UK recently developed the ANSYS Composite Cure Simulation (ACCS) toolbox that allows the prediction of residual stresses and thermal deformations during the curing process.

This study focuses on employing the ACCS toolbox capabilities to predict the formation of fibre waviness defects on tapered composite panels formed by terminating plies (ply drop-off) at various locations. Tapered composite

panels offer weight and material savings off structures subjected to uneven payloads. However, ply drop-off introduces discontinuities in the structure which results in difficulties such as stress concentrations at the drop-off regions. During the curing process, high residual thermal stresses are induced at the stress concentrated regions and the loading from those residual thermal stresses is believed to results in buckling of the fibres (fibre waviness) during consolidation. There are two types of fibre waviness in practice, the in-plane and out-of-plane fibre-waviness. The in-plane fibre waviness usually occurs on thin laminates because the out-of-plane motion of the fibres is restricted whereas the out-of-plane fibre waviness occurs on thick laminates due to large through the thickness temperature gradients. The fibre waviness defects significantly compromise the compressive strength of the structure and it can be undetectable if it occurs on inner plies.

The research will involve developing finite element model of the ply drop-off on a unidirectional prepreg-based composite panel. The curing simulations will be performed on the model using the ACCS toolbox to predict process induced-residual stresses and deformations. To predict fibre waviness from the curing simulation result, the mechanism behind fibre waviness must first be understood. Therefore, the effect of various parameters will be investigated by comparing the simulation results with the experiments. Fibre waviness driving parameters will then be used to derive failure criteria for predicting fibre waviness at ply drop-off.

Bibliography

None

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Academic Track _ Resubmission of Revised Full Paper

Topics: Fluid Structure Interactions, Structural Dynamics, Structural Mechanics
Keywords: BTD, Blast, Torso, Surrogates

Experimental and Numerical Validation of a Simplified Rigid Torso Surrogate used for Investigating the Fluid-Structure Interaction of Air Blast Waves

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Blast waves from landmines and Improvised Explosive Devices (IEDs) produce an almost instantaneous rise in pressure which causes Primary Blast Injuries (PBI). The primary blast injuries are caused directly by the blast wave and encompasses injury to air containing organs such as the lung, ear, and bowel. The most notable primary injury is the blast lung, which is a contusion of lungs in which blood contaminates the alveoli leading to death. The PBI criteria are specified in test standards to relate pressure measurements in a testing environment to a risk of PBI. This study examines the adequacy of using a torso surrogate to measuring pressure profiles both experimentally and numerically.

A simplified rigid human torso surrogate, referred to as the Blast Test Device (BTD), was manufactured and tested. The BTD comprises a high-density polyethylene (HDPE) cylinder with an outer diameter of 300 mm, height of 802 mm and wall thickness of 20 mm. The BTD was exposed to complex blast waves in free-field conditions, which were created by detonating 300 g Plastic Explosive (PE4) at three different heights above ground over a smooth, concrete surface.

The experimental results were compared to the numerical results as well as results available in literature. The experimental results were compared with respect to incident pressures, reflected pressures and positive phase duration of the blast wave. Morphological correlation was observed between the experimental and literature results, however time delays for initial peaks were observed in three of the comparisons. The numerical predictions also compared well morphologically, but with time delays observed for side-on pressures, as well as differences in initial peak pressures.

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(http://www.sciencedirect.com/science/article/pii/S0734743X15000408)
Keywords: MiL-Lx; Blast Impact; IED; Military combat boots; Anti-Vehicular Landmine

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Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics, Stochastic Mechanics
Keywords: Quarter-car model, Stochastic mechanics, Autonomous vehicle, Dynamic load coefficient

A probabilistic quarter-car model for predicting worst-case vehicle performance

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Vehicle preview models have gained increasing popularity in recent years as a means of predicting potentially hazardous vehicle control inputs and attempting to mitigate their effects. These models are even more important in the field of autonomous vehicles as the vehicle itself is providing the potentially hazardous control input. In these cases, it is important to verify that these inputs will actually achieve the desired control objectives, and not result in a loss of traction or destabilisation of the vehicle.

Unfortunately, the validity of these models is limited by the fidelity of the mathematical model and the accuracy of the estimated vehicle parameters. In the real-world, vehicle parameters are subject to change over time as a result of wear-and-tear, installation of after-market parts and vehicle loading.

In this paper a method to propagate any uncertainty in the vehicle parameters through these models to determine

variability in the output is presented. In doing so, worst-case estimates of the performance of the vehicle in certain situations may be provided.

The authors introduce this method using the basic quarter-car model as a demonstrator. After developing the statistical model, the estimated outputs are verified using a Monte Carlo simulation, and conclusions are drawn on the performance of the vehicle under parameter uncertainty.

The results show that under ideal road conditions, any parameter uncertainty has very little effect on the road-holding performance of a vehicle, but on increasingly rougher roads, this parameter uncertainty plays a substantially larger role. As such, the methods presented in this paper are therefore suitable for use in self-driving cars that are designed to operate in off-road conditions.

Bibliography
In submission

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Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Composites
Keywords: Natural fibres, kenaf, flax, composites, tensile strength, design, materials

The Effect of Fibre Length on the Tensile Strength of Natural Fibre Composites

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Critical fibre length affects the integrity of the mechanical properties of a composite, in particular, the tensile strength. Predicting the critical fibre length using theoretical relations becomes more difficult when dealing with discontinuous, randomly oriented natural fibres which are also subject to microscopic flaws and structural variations. Kenaf and flax fibre reinforced polypropylene composites were investigated where fibres were cut to 5, 10, 20 and 30 mm mean fibre length (MFL). Chemical modification was conducted in three phases of alkanisation, neutralisation and silanisation in order to increase the interfacial adhesion between the hydrophilic fibres and hydrophobic matrix. Natural fibres were mixed with polypropylene fibres in fibre weight fractions of 15, 20, 25 and 30 percent and were processed into nonwovens using two cycles of carding and needlepunching. Composites were manufactured by compression moulding 10 layers of nonwovens. The ASTM-D638 standard was used to perform tensile testing where it was shown that the ultimate tensile strength (UTS) increased up until 10 mm MFL and between 10 and 20 mm MFL for flax and kenaf samples respectively, reducing thereafter. The maximum UTS achieved was 81.8 for flax and 77.3 MPa for kenaf composites. 'Effective fibre length' was used to describe the actual fibre length subject to tensile testing as the initial prepared MFL was limited by the gauge dimensions of 13 mm x 50 mm. A MATLAB code was written to analytically determine the effective fibre length. Using this model, it was deduced that the critical fibre length for flax and kenaf samples manufactured using the prescribed methodology was 8.65 and 8.76 mm respectively. Design points were discussed, exploring the effective optimum fibre length and fibre loading in discontinuous, randomly oriented natural fibre composites.

Bibliography
None

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Academic Track _ Resubmission of Revised Full Paper
Topics: Fluid Structure Interactions, Mechanics of Vibrations
Keywords: Fluid forces, axial force, Fluid Structure Interaction, rotor-stator rub, vibration analysis.

Rub-Impact of Coupled Vibration of Vertical Rotor-Stator System Submerged in Incompressible Fluid

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Abstract—The interactions between rotor-stator submerged in incompressible fluid flows are strong nonlinear phenomena that have a wide applications in scientific and engineering disciplines. This paper presents vibration analysis of vertical oscillating rotor-rub system interacted in incompressible flow regimes. The governing equation of the coupled lateral and torsional vibrations of a rotor-rub system and the inviscid fluid forces action are firstly established base on Energy Principle and Lagrange Euler method for the incompressible fluid. The unsteady rotor-stator-fluid motion is simulated by means of explicit time-accurate solver and a coupling Wavelet Transform (WT) algorithm. Simulation results are presented for large rotation, axial force effect, rotor-stator impact and aero-elastic motion of rotor-fluid system is validated by comparing the numerical with solution for rotor-stator in air ambient environment. The results obtained in the present work agree well with those from the literature.

Bibliography
None

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Topics: Discrete element modelling
Keywords: Discrete Element Modelling, Particle Shape, Angularity, Convex Polyhedra, Non-Convex Polyhedra

A numerical study in the modelling of particle non-convexity for hopper discharge applications

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Computing efficiently with non-spherical particles in discrete element simulations remains a challenging endeavour. To complicate matters further, it is often required to resolve particle angularity and non-convexity as has been demonstrated experimentally to be important for a number of applications. Angularity is achieved by modelling particles as polyhedra as opposed to the conventional multi-sphere particles or more recently superquadrics. The latter two approaches introduce rounded edges that may result in an insufficient description of angularity for some applications. Fortunately, the last decade has seen the computation of polyhedral convex particles in discrete element simulations, which of late are often being accelerated by computing on general purpose graphical processing units (GPGPUs). However, the computation of non-convex polyhedral particles has remained elusive with a limited number of studies that have been conducted towards this aim, albeit the importance of the mechanical interlocking that results from particle non-convexity has been well known for years.

This study demonstrates the importance of modelling particle non-convexity for hopper discharge applications, in particular, we highlight the validation against a hopper flow experiment, using identical convex and identical non-convex 3D printed particles. Thereafter we conduct a numerical investigation into the discharge and force chain development for three discharge openings using convex and non-convex particle systems. Significant differences in discharge is evident for the smaller openings between convex and non-convex particle systems. In addition, differences in the development of inter-particle force chains is also evident between convex and non-convex particle systems.

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ID: 2168
Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis, Mechanics of Vibrations, Structural Dynamics, Structural Mechanics
Keywords: Structural damage, Modelling, FEM, Strain Modes, Vibration data

MODELING OF STRUCTURAL DAMAGE BY DISPLACEMENT AND STRAIN MODES

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A numerical analysis was performed to test the feasibility of detecting the existence of structural damage on a Euler-Bernoulli beam using Finite Element Method (FEM) based on strain mode technique. The Strain modes were obtained as a derivative of vibration displacement data with respect to a spatial variable. A periodic excited force excited the vibration response of a cantilever steel beam hinged at one end. Modal analysis was performed and unique frequency features and mode shapes extracted to detect damage. The extracted data from the frequencies and mode shapes reveal that the strain mode method is efficient for detection of occurrence and location of damage in a Structural Health Monitoring.

Bibliography
MODELING OF STRUCTURAL DAMAGE BY DISPLACEMENT AND STRAIN MODES

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Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Methods in Mechanics, Finite Element Modelling and Analysis, Mechanics of Composites, Mechanics of Materials
Keywords: Bilinear material, Silicone composite, Soft robots, Material design

Bilinear Response in Paper-Silicone Composite Material

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Soft robots made from elastomeric materials have the benefit of being cheaper and of lighter construction when compared to hard-linked robots. These benefits, along with their suitability to complex use cases, has garnered increased research interest in soft robots. Where the control of conventional robots rely on the predictability of the rigid connections, soft robots rely on changes in the geometry of various regions of the articulating body, thereby embedding the control directly into the state of the device. By embedding the controls into the morphology in this

way, complex manipulation can be achieved through simple proportional pneumatic pressure changes. Soft robots capable of bending typically make use of a strain limiting layer in their construction to generate an asymmetric stiffness in the body to achieve the preferential behaviour. This paper presents a new idea to manufacture a bilinear crimped strain limiting layer making use of paper and silicone. The morphology is empirically determined through silicone prepolymer castings manufactured from 3D printed moulds, an analytical derivation, and numerical models. It was found that a higher degree of crimp in the paper layer allowed for a delay in the strain required for activation. The analytical derivation that predicts the engineering strain at which the transition occurs correlates well to that predicted using the numerical model. Physical testing was restricted to measuring averaged surface strains and it is shown to be in close agreement with the numerical models for two-thirds of the cases tested.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Fluid Dynamics, Fluid Mechanics, Thermodynamics and Heat Transfer

Keywords: suction recirculation, double suction centrifugal pumps, computational fluid dynamics, recirculation

Simulation of suction recirculation in double suction centrifugal pumps

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Part-load operation conditions of a centrifugal pump will impose potentially strenuous effects on the operation and reliability of the turbomachine in question due to the risk of suction recirculation. Suction recirculation in centrifugal pumps can be described as the flow reversal of the outer streamline in the impeller suction eye during operation at a reduced flow rate (with regards to the Best Efficiency Point) and can also cause damaging suction recirculation cavitation.

Results presented in this paper concern interesting flow details of the suction recirculation phenomena and the visualization of the phenomena, as well as the simulation of overall pump differential head generation prediction for the considered pump geometry. The simulation data was found to be within acceptable ranges when compared with experimental results.

Bibliography

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Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Composites, Mechanics of Materials, Nano-scale Mechanics

Keywords: Composite Material, Inter-separation Distances, 3D-printing, Thermal Stability, Strength

The Effect of Particle Inter-Separation Distances and Volume Fraction on Thermal Stability and Strength of 3D Printing Composite Material

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Inter-separation distances, volume fractions, shapes and sizes of composite material particles are often characterized to investigate the use of the material for various applications. Notwithstanding the increasing composite material characterization research outputs, the characterization of 3D printing composite materials has been more limited. Much economic advantage of 3D printed products in many key sectors of economies such as construction, mining and other manufacturing industries has therefore not been realized. 3D printed tools can be used to increase profitability in mass production of plastic material for construction such as pipes, cables, floorings and insulation materials which constitute significant costs in construction. In this study, the effect of particle inter-separation distances and volume fractions is investigated with the aim of enhancing the thermal and mechanical stability of cheaper 3D printing plastic material. Four samples with various volume fractions (which are 1:1, 2:3, 1:2, and 2:1) determined by a model that relates inter-separation distances to strength (i.e. forces of attraction between particles) were prepared. XRD (X-ray Diffraction) was done to measure inter-separation distances, TGA (Thermogravimetric Analysis) to test thermal stability and the model was used to estimate strength enhancement for each sample. After following the above procedures, the ratios 1:2 and 2:3 yielded more enhanced results than the ratios 1:1 and 2:1. The model showed approximately 25% greater strength for the optimal ratio 1:2 than 2:1 (the suboptimal). The XRD pattern confirmed the formation of the composite (POSS/Clay) for all the samples meaning that the chosen materials had successfully combined as required. All the ratios had few XRD diffraction peaks corresponding to thorough mixture with consistent particle inter-separation distances. The optimal ratios had lesser d-spacing distances that resulted in higher strength values (i.e. force of attraction between particles) from the model. TGA results showed that the samples with ratios 1:2 and 2:3 had about 16 ºC higher thermal stability than 1:1 and 2:1. The sample with the optimal inter-separation distances and volume fraction had strength and thermal stability which indicate material durability and can result in withstanding operating temperatures for the Plastic Injection moulding application identified. This study further presents an opportunity to print functional 3D printed plastic injection moulds, which can lead to creation of new 3D tools industries and more job retention in the country`s construction industry as well as other sectors such as in footwear production.

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M-Tech Student

Recent Publication

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Data driven teaching and learning interaction, a case study

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The exponential expansion of data storage capacity and modern computation power certainly add to the fuel driving the fourth industrial revolution. Data exploration and mining lead the extraction of features essential for guiding behaviours, informing decisions and directing the most appropriate sequence of actions for the achievement of targeted results. Customer's experience, perception and feedback are as essential to business as assets/machines lifecycle, availability and operational condition monitoring data are to Industry. Everyone is on a sensor fusion mission, harnessing every available piece of information to augment insights and improve efficiencies. Similar to customer experience and feedback, the teaching and learning transactions can be an insightful data mine. This paper is an exploration of the potential to harness the intelligence in data collected from the teaching and learning interaction as a diagnosis and prognosis toolset in an attempt to inform and support the teaching learning transactions. The student and the facilitator/lecturer are both agents (active stakeholders) in the production of data used and analysed in the process.

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Eudes K Tshitshonu is a lecturer in the department of Mechanical Engineering at the Vaal University of Technology. He has a particular interest in the fusion of modern computational tools to enhancethe teaching and learning interaction.

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SURVEY STUDY FOR THE CAUSES OF FAILURE OF PLASTIC CHAIRS USING FINITE ELEMENT ANALYSIS (case for Plastic Industries, Pretoria, South Africa.

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Plastic chairs find their wide application in social gatherings like church, parties, community meetings and even funerals. This is owing to their light weight thus easy for transportation. The plastic chairs are also available at affordable prices. Plastic chairs tend to fail without a warning while in service, injuring the chair occupant, sometimes severely depending on the place of accident and nature of fall. By considering loading of the chair by a person of average weight, forces acting on the chair were computed. The person is considered to be resting both arms on the arms of the chair and his back reclined on the back rest of the chair. Material type of the chair is Acrylonitrile Butadiene Styrene (ABS) which is an opaque thermoplastic and amorphous polymer. Taking the sitting chamber into consideration, the stress effects are spread across the plastic chair. The maximum stress experienced by the chair material is between 48.9MPa and 28MPa. With arms and sitting chamber taken into consideration, the stress effects are spread across the plastic chair including the legs, sitting chamber and back rest. The maximum stress experienced by the chair material is between 259MPa and very much below 12MPa. Deformation is the amount of stretching that an object undergoes due to the loading. The displacement will be distributed on the plastic chair &within the sitting chamber. The material experiences different displacement &with the least displacement as mm and the maximum displacement as mm which occurs at the very center of the plastic chair. The FEA analysis was carried out and results were obtained and conclusions made. The recommendation given by the researchers should assist in reducing the risk of failure of the plastic chairs in service.

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USE OF FINITE ELEMENT ANAYSIS TO ANALYSE POTENTIAL CAUSES OF PRODUCT FAILURE ALONG WITH LABORATORY TESTING DURING PRODUCT TESTING: (CASE OF THE STANDARDS ASSOCIATION OF ZIMBABWE).

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Traditionally, engineers have used laboratory testing to investigate the structural behaviour of steel building products and systems subject to the expected wind and earthquake loads and to develop appropriate design rule.

Laboratory testing was also used to develop new building products and systems. Conventional design methods are being used to predict the strength and behavior of members used for structural construction. However these methods cannot fully predict the behavior of these members under different loading conditions during their practical applications. In structural analysis, the FEA simulation method can be used to choose the best structural members to use for a design, the best material to use, analyze the strengths of existing designs or to establish new standards be it to the manufacturers of the structural members or the designers of the structures. In this paper the researchers analyzed the following situations: Effect of material on the strength of a structural member using beams of the same cross section but different materials, Effect of the design of the structural member (cross section of the member) on the strength of the member, Effect of loading condition on the strength of the member (how different members of different cross sections respond to different loading conditions) and Effects of temperature. Material with the lower yield strength would experience greater stresses (201 Annealed Stainless Steel experienced a maximum stress of 12.22MPa as compared to 12.1MPa experienced in the Alloy steel beam.) However there is no significant difference between the results obtained since the materials used were both used. Information obtained from such a simulation can be used to make decisions on which materials to be used or to set or inspect the standards of the materials used by aiding laboratory testing.

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Topics: Computational Fluid Dynamics, Fluid Mechanics
Keywords: head loss coefficient, spacing ratio, computational fluid dynamics, pipe bends.

Determination of the head loss coefficient of closely spaced pipe bends

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The head loss coefficient (HLC) of closely spaced pipe bends is presented in this study. The objective of this study was to develop an accurate but simple empirical correlation for computing a HLC of two 90 degree smooth pipe bends that are separated by a short pipe. ANSYS® CFX® 11.0, a commercial Computational Fluid Dynamic (CFD) package, was used to provide flow visualisation and the magnitude of the HLC.

The computational model was validated by comparing the HLC of a single bend and was found to be sound. The computational results for closely spaced pipe bends were compared to experiments that were conducted on smooth pipes and bends. The experiments showed HLC trends similar to those of the CFD simulations and of published data. The HLC is expressed as single value for the two bends. The study found that this value increases as the spacer length between the two bends increases. The HLC depends on two geometric parameters, viz., spacing ratio and curvature ratio. When the spacer length exceeds 10D the HLC converges to the value for the sum of two conventional single bend HLCs.

Bibliography
None

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Topics: Biomechanics
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A Micromorphic Approach Modelling the Anisotropic Material Behaviour of the Human Heart

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Computational cardiac mechanics models need to take into account the complex underlying micro-structure of the cardiac tissue in a sufficiently accurate manner, address biological effects such as residual stresses, remodelling or rearrangement of micro-structural components and are numerically robust and efficient.

It has been discovered that the initially crimped and coiled collagen fibres straighten during diastolic filling, the interconnected fibre sheets are able to slide over one another and fiber rearrangement and spatial reorientation is taking place.

This work adoptes a generalized continuum approach [1] which features extra degrees of freedom and corresponding strain and stress measures. The approach can therefore account for the hierarchical fibrous characteristics of the myocardium which are associated with micro-structural deformation of muscle-fibre bundles as well as their motion relative to the bulk material representing the constraining cytoskeleton.

The micromorphic generalised cardiac mechanics model is applied to finite element modelling of patient-specific hearts making use of cardiac magnetic resonance (CMR) scans provided for this investigation by the Cape Universities Body Imaging Centre (CUBIC). With the anatomical heart models calibrated, the fibre strain, fibre stress and active tension distributions are computed. The comparison with simulated results using a classical myocardial tissue model indicates clear differences due to elastic non-affine fibre reorientation which renders the

tissue more compliant.

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Topics: Mechanics of Composites, Mechanics of Materials
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3D PRINTING OF CARBON NANOFIBER-PLA COMPOSITE

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In this paper a study to develop composite material for 3D printing was done. Composites are low cost and can help improve the 3D economy as a result they can be used as an alternative for manufacturing application. Composite materials are not commonly used in manufacturing processes although they have good mechanical properties and can be used in various types of processes. The reinforcements used for this research were calcium carbonate, polymer derived ceramics and natural fibers. A twin-screw plastic extrusion machine was used to mix these materials and extrude a composite material filament of 3mm which is required by a Wanhao duplicator 5S mini desktop 3D printer. Printed composite samples were tested for Vickers hardness and Ultimate tensile strength. The results of the findings from this study will guide a discussion on the feasibility of the 3D printing of polymer composites for engineering applications.

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Keywords: Heat-affected zone (HAZ), Weld metal (WM), Weld bead, Microstructure, Toughness;Temper bead welding ;High Temperature Heat Affected zone

The Effect of Weld Bead Heat Input on 3CR12 Stainless Steel

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Welding is used in building ships, bridges, pressure vessels, industrial machinery,

automobiles, rolling stock and many other applications. Problems associated with welding are common issues in these fields. Besides the problem of low ductility and poor toughness of 3CR12 stainless steel welds, microstructures characteristics of the weld bead section as a result of weld heat input and heat transfer rate, susceptibility to cracking caused by poor welding techniques and heat treatment of weld beads is a major concern affecting the mechanical performance of 3CR12 stainless steel. The utilization of welding in the fabrication of engineering components depends on the weldability of the material. Welding ability of 3CR12 stainless steel refers to the maximum hardness of the high temperature heat affected zone (HT HAZ) and the cold cracking vulnerability of the welds. When stainless steel is welded, non-uniform heating and cooling in the weld metal and in base metal generate harder Heat Affected Zone (HAZ), cold crack vulnerability and residual stresses in weld beads.Welding procedures for 3CR12 recommend the use of minimum heat input to avoid weld defects and unfavourable material properties. However, there are many methods for reducing the effects of HAZ problems. Among them is temper bead weld heat input. Varying the heat input into the weld bead may optimise heat input into the materials that result in improved mechanical performance. This paper reports on the effect of varying weld bead heat input on the mechanical properties of 3CR12 welds. The focus is on tensile strength, microhardness, and microstructural changes. Heat input was varied by altering the welding parameters such as the welding voltage, welding current, and feed rate. The results showed that it is possible to alter the weld bead mechanical properties by fine-tuning the welding parameters and hence the weld bead heat input.

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Development of a Transient Numerical Model for a Hybrid Rotary Kiln

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ABSTRACT

The Hybrid Rotary Kiln (HRK) is an industrial device used for the thermal treatment of powdery, granular, lumpy, dry or wet materials. Kilns are widely used in cement production, drying of bricks, strengthening of petroleum coke for aluminum production, ceramics processing, glass processing and reclaiming of nickel from used batteries. The HRK is classified into Direct Heated Rotary Kiln (DHRK), Indirect Heated Rotary Kiln (IHRK) and Combination of Direct and Indirect Heated Rotary Kiln. The study of kilns has shown that there are significant problems related to poor heat transfer. This leads to unfinished processing such as incomplete drying or chemical processes. Product reworks lead to increased costs. In addition, incomplete combustion of fuel that leads to harmful emissions of flue gasses thus exacerbating environmental pollution. To address these challenges, a transient numerical model is required to better analyze and design more efficient kilns. A CFD model was developed using Star CCM+. To validate the model, experimental tests were conducted on an industrial prototype using a ceramic material and LPG fuel. The temperatures achieved during the test were 694 degrees Celsius for the burner, 135 degrees Celsius for the ceramic material with exhaust gases exiting at 154 degrees Celsius. Such high exhaust temperatures represent significant energy losses which can be mitigated by optimizing the kiln process parameters.

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ID: 2193
Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis
Keywords: Conductor Vibration, Linear beam, Curved Beam, FEM, MATLAB, Experimental studies

Numerical Simulation of the Dynamic Characteristics of Power line Conductors:

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Abstract

This paper describes the essential concepts of mechanical vibration that occurs on power line conductors usually caused by wind loading. This phenomenon is an impending factor to the design and construction of power lines. Over the years extensive studies have been done in this area of mechanical oscillation of transmission line conductors by several researchers in order to understand the dynamic motion and then try to predict the conductor response. Achieving this, can form the bases that can be used to formulate a mitigating process to alleviate the adverse effect of this phenomenon. Base on the fact that the mechanisms of conductor vibrations exhibit a complex dynamics, the exact modelling of this problem is impossible.

In this study, a numerically based investigation of the response of conductors was carried out i.e. finite element analysis (FEA or FEM). The conductor is considered to be a distributed parameter system such as a taut string or beam. When modelled as a beam, the Euler-Bernoulli beam is commonly used. In this work a comparison was carried out where the conductor was modelled using the Euler-Bernoulli beam theory, using both linear and curved

beam models. Thus, both models was used to model the conductor using the finite element method.

Based on the finite element method, computer programs were developed to evaluate the conductor's dynamic behaviour and implemented in MATLAB environment. The dynamic responses of the conductor were simulated to represent the aeolian vibration. The results from both models were compared. Experimental studies were conducted to compare and validate both the FEM models.

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ID: 2194

Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Composites

Keywords: Strain magnification/reduction, interfibre spacing, xxx, zzz

Variation of the Transverse Strain Matrix/Fibre Magnification/Reduction and Stress Ratio with the inter-fibre spacing/fibre radius (s/r) ratio

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Expressions relating the transverse matrix/fibre strain magnification/reduction and transverse stress ratios in fibre reinforced composites to the inter-fibre spacing/fibre radius (s/r) ratio are developed here, based on; the models of direct deformation and assuming transverse iso-stress, the equivalence of strain energy applied to a Representative Volume Element (RVE) model and assuming transverse iso-stress, and the equivalence of strain energy together with the Halpin-Tsai semi-empirical equations applied to an RVE without any assumption of transverse iso-stress. The variation of the matrix/fibre strain magnification/reduction, respectively, and stress ratios with the (s/r) ratio are investigated. It is found that for all three models, the matrix/fibre strain magnification/reduction decrease at decreasing rates with increasing (s/r) ratios. The matrix/fibre strain magnification/reduction are seen to be higher for the square array than for the hexagonal array in the first model. The assumption of a transverse iso-stress state is shown to lead to an underestimation of fibre/matrix strain reduction/magnification with reference to the third model for both reinforcing fibre packing geometries and with reference to the 1st root of the third model, respectively. The transverse iso-stress state is shown not to exist and a dependency of the stress ratios on the reinforcing fibre packing geometry is established.

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Maina Maringa and Masu L. M. "Matrix and fibre stress and strain magnification using strain energy equivalence and the Halpin–Tsai equations", Volume: 34 issue: 13, page(s): 1059-1074, July 1, 2015 https://doi.org/10.1177/0731684415587730

ID: 2196

Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Composites

Keywords: Newtonian Fluids, Hookean solids, 2-phase, fluid mechanics

Improving the Predictive Capacity of Newtonian Fluid Theories on the Elastics Moduli Ratio (Ec/Em) of Particulate Composites

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The limitations of existing 2-phase Newtonian fluid theories in predicting the elastic properties of 2-phase particulate composites, are addressed by introducing changes to them based on known properties of the particulate composites at 0 and 100% reinforcing filler volume fraction. In developing the new expressions, the assumption is made that the constituent components of the composite are perfectly plastic with a Poisson's ratio of 0.5 in consistence with the known fact that Newtonian fluids are incompressible. The developed equations are tested over the full particulate filler reinforcing volume fraction range and compared with the lower and upper bounds defined by the Reuss and Voigt rules. The equations are also tested for application to composite constituents that are not perfectly plastic. In both cases, the developed equations are seen to be a great improvement on existing theory.

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Maina Maringa and Masu L. M., "Developing analytical solutions for transverse, matrix strain magnification and fibre strain reduction in uniaxially aligned continuous fibre reinforced composites, based on the principle of conservation of strain energy and the Reuss rule", pp 2017 Global Conference on Polymer and Composite Materials (PCM 2017), IOP Conf. Series: Materials Science and Engineering 213 (2017) 012004 doi:10.1088/1757-899X/213/1/012004.

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L. B. Malefane, W. B. du Preez, M. Maringa, "Testing for homogeneity and orthotropy of Ti6Al4V (ELI) parts built by Direct Metal Laser Sintering", Rapid Product Development Association of South African (RAPDASA) 17th Annual International Conference, Pre-conference Seminar on Additive Manufacturing of Titanium Parts, VUT Southern Gauteng Technology and Science Park, 2-4 November 2016, South Africa, http://conferences.sun.ac.za/index.php/rapdasa17/rapdasa17.

Maina Maringa, "A Semi-Empirical Method for Determining the Averaged Orientation of Reinforcing Fibre in Fibre Reinforced Composites", Journal of Sustainable Research in Engineering, Vol 3 No 1 (2016), pp 16-21

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Maina Maringa and Masu L. M. "The effects of different fibre packing geometries on the transverse matrix strain magnification and fibre strain reduction in uniaxially aligned continuous fibre-reinforced composites", Journal of Composite Materials, Volume: 50 issue: 29, page(s): 4159-4170, December 1, 2016, https://doi.org/10.1177/0021998316631701

Maina Maringa and Masu L. M. "Matrix and fibre stress and strain magnification using strain energy equivalence and the Halpin–Tsai equations", Volume: 34 issue: 13, page(s): 1059-1074, July 1, 2015 https://doi.org/10.1177/0731684415587730

ID: 2197
Academic Track _ Resubmission of Revised Full Paper
Topics: Thermodynamics and Heat Transfer
Keywords: Cooling Tower Analysis, Merkel Theory, Thermal Performance, Tower Characteristic Range, Approach

Experimental study of Part load performance of a counter flow cooling tower

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Abstract— The thermal efficiency of a wet cooling tower is subject to climatic conditions, principally "ambient wet-bulb temperature". Cooling towers find the widest application in steam power plants as heat rejection devices. In this paper, an in-depth analysis of a counter flow wet cooling tower is undertaken with a view of understanding its part load performance characteristics. The performance of a counter flow cooling tower is evidently described using variation of water and air temperatures, as well as the analogous driving force for evaporation and convection heat transfer, along the depth of the tower. The impact of individual influences from either method of heat transfer to the overall heat transfer in the cooling tower is considered. It is established that the principal method of heat rejection in a cooling tower is evaporation. The difference in water and air temperatures along the depth of the tower (process line) is described by means of psychometric charts. The aim of this study was to predict, through an accurate and simple calculation/simulation, the performance of a cooling tower during changing environmental and operating conditions. The analysis revealed that when the process temperature is increasing as is the case in summer months, less water rather than "more water" is often necessary to bring down the process temperature. The outcomes of this study will create a possibility for cooling tower designers to incorporate simulation in the evaluation and optimization of thermal performance of heat rejection plants.

Bibliography

Mr. EMMANUEL BAKAYA-KYAHURWA is a lecturer in Mechanical Engineering at the University of Johannesburg.

He is a graduate of Mechanical Engineering from Makerere University (1986). He also studied at Kings College, University of London for his Msc in Mechanical Engineering (1990). Prior to joining academia Mr Bakaya-Kyahurwa held the position of Maintenance engineer at Ugma Engineering Corporation, a large metallurgical workshop in Uganda where he worked for several years.
Mr Bakaya-Kyahurwa has participated in a number of projects as consultant such as the project on Developing Energy Efficiency and Energy Conservation in the Building Sector (Botswana). He has also been involved in the development of curricula for short course on Energy Efficiency and Energy Management.
Mr Bakaya-Kyahurwa's research interest is in applied heat engineering and renewable energy.

ID: 2200
Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Materials
Keywords: rotary friction welding, Ti-6Al-4V, process parameters, mechanical properties

The influence of rotational speed and pressure on the properties of rotary friction welded titanium alloy (Ti6Al4V)

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This paper presents the investigation of rotary friction welding of Ti-6Al-4V 12.5 mm diameter rods. The process parameters used for this research were rotational speed, pressure and upset distance. The varied process parameters were rotational speed and pressure while the upset distance was kept constant. The mechanical properties of the weld joint were examined. The results revealed that the rotational speed and pressure have significant influence on the ultimate tensile strength, microstructure and joint integrity. An increase in rotational speed increased heating time as an effect greater volume of material was being heated resulting in a reduced tensile strength of the weld joint. The presence of voids was also reported at a lower pressure and high speed. Further analysis was conducted on the microstructure of the welded joints.

Bibliography
I am an M-Tech student currently. I graduated for B-Tech and National Diploma with Cum Laud at University of Johannesburg and Mangosuthu University of Technology in 2017 and 2015 respectively. I Have worked in the manufacturing Industry as a Technician in-training.

ID: 2201
Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Materials
Keywords: Rotary friction welding, Ti-6Al-4V, Process parameters, Microstructure, Microhardness

Analysis of the Microstructure and Microhardness of Rotary friction welded Titanium (Ti-6AL-V4) Rods

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This paper presents the evolution of mechanical properties in Ti6Al4V rods welded by rotary friction welding. This is evaluated by monitoring the microstructure and microhardness changes resulting from the welding. 16 mm diameter rods were joined by rotary friction welding utilizing different process parameters settings, namely; axial force, rotational speed and upset distance. The microstructure and micro hardness analysis were observed on each of the weld zones/regions. The micro hardness results revealed higher hardness on the weld zone and low hardness on the heat affected zone when compared to the parent material. The higher axial force resulted in higher hardness in the weld zone as a result of more friction and hence higher heat input which led to refined microstructure. Microstructure characterization for the different weld zones due to varying process parameters is also discussed.

Bibliography
National Diploma in Mechanical Eng in 2003, B-Tech in Mechanical Engineering in 2004, M-Tech in Mechanical Engineering in 2006 at Cape Peninsula University of Technology (CPUT)

ID: 2202
Academic Track _ Resubmission of Revised Full Paper
Topics: Thermodynamics and Heat Transfer
Keywords: Power Plant, Boiler Analysis, Super heater tubes, Uncertainty analysis, Mass and Energy Balance

Mass and energy balance and associated uncertainty analysis of super heater process parameters at 100% boiler maximum continuous rating

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Cyclic operation of power plants may result in accelerated life consumption of components. Super-heater and re-heater heat exchanges can experience temperature excursions significantly above design due to cyclic operations. Increased temperature and decreased hardness values of the tube metal are typical problems in power plants. Monitoring of super heater tubes (SHT) may include, but is not limited to, tube metal surface temperature measurements. In this study the final super heater of a power plant was analyzed by monitoring tube metal temperatures and other derived parameters during maximum load operating conditions. Thermocouples where installed to monitor the metal temperatures on the SHT. Process parameters such as the steam and flue gas temperature, pressure and mass flow rate we measured and measured data was used as input data to derive other

parameters using the Mass and Energy Balance (MEB) methodology. Data analysis was done during steady state operation at maximum load (100%, Boiler Maximum Continuous Rating (BMCR)). Measurement uncertainties were determined by considering instrument and statistical uncertainties which were then propagated through to the derived data. SHT metal temperatures and process parameters were analyzed to determine the extent of temperature maldistribution at 100% MCR. The results show significant temperature maldistribution on the SHT. The data produced here will support validation of detailed heat exchanger process models as well as the development of on-line process condition monitoring algorithms.

Bibliography

Identification and analysis of steam temperature maldistribution in super heater tubes via measured and derived parameters

ID: 2204

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Fluid Dynamics

Keywords: CFD, ANSYS CFX, bubble column, turbulence model

Numerical simulation of the hydrodynamics in a bubble column reactor: influence of turbulence models

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Bubble column reactors have been used extensively for multiphase reactions. In order to design, scale up and optimize these reactors, numerical techniques such as computational fluid dynamics (CFD) have been used due to their good accuracy at low cost. The turbulence in a bubble column reactor is significant; therefore, in order to model the hydrodynamics accurately, appropriate turbulence models have to be selected. In this work, the hydrodynamics in a bubble column reactor was simulated using ANSYS CFX 18. After preliminary evaluation of the optimum grid size, the effect of different turbulence models was investigated. The simulated hydrodynamic profiles were compared to experimental axial liquid velocity, gas holdup, turbulent kinetic energy and turbulent dissipation rate profiles. The grid independence studies showed that 98,000 nodes was the optimum grid size. Among the different turbulence models, the Reynolds stress model (RSM) was found to be the most accurate. However, due to its high computational cost, the slightly less accurate RNG k-ε model was found to be more appropriate with a good balance of accuracy and cost. The commonly used standard k-ε turbulence model was found to be the least accurate. This study demonstrated the accuracy of CFD simulation for hydrodynamics simulation in a bubble column reactor as well as the importance of turbulence models for achieving accurate simulation.

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ID: 2206

Academic Track _ Resubmission of Revised Full Paper

Topics: Finite Element Modelling and Analysis

Keywords: anion, backpropagation neural network, general regression neural network, wastewater

ARTIFICIAL INTELLIGENCE NEURAL NETWORK TECHNIQUES TO PREDICT THE REMOVAL OF ANIONS FROM WASTEWATER

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This paper attempts to predict anions (NO-3, SO-24, Cl-) from wastewater using artificial intelligence neural network methods such as backpropagation neural network (BPNN) and general regression neural network (GRNN). The configuration of BPNN giving the smallest mean square error (MSE) was three-layer neural network with tangent sigmoid transfer function (tansig) at hidden layer with 14 neurons, linear transfer function (purelin) output layer and Levenberg-Marquardt Algorithm (LMA). GRNN algorithm with radical basis function (RBF) network, the optimum smooth factor (SF) was selected 0.10 according to evaluated criteria in training and test data. The comparison was done between the predicted concentration and the measured data for the two methods (BPNN and GRNN) taking into account the correlation coefficient (R2) for anions. The results indicated that the artificial neural network can be used as a viable method to rapidly, cost-effectively predict the removal of anion from wastewater and reduce the computational efforts.

Bibliography

Kalufandu Aziza is a Master student in the Department of Chemical Engineering, Vaal University of Technology, South Africa.

ID: 2208

Academic Track _ Resubmission of Revised Full Paper

Topics: Aerodynamics

Keywords: VAWT, optimization, pitch control, genetic algorithim

Reduction of the torque ripple of a vertical axis wind turbine with genetic algorithm optimization

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Vertical axis wind turbines have a place in the renewable energy market. They are not currently implemented on a commercial scale but have found a niche space in urban areas. Here the turbulent wind conditions and limited space are more easily tapped into with a vertical axis wind turbine. However the challenges facing these types of turbines have hampered deployment. One of these issues is the fluctuating torque experienced during operation, which can lead to over designed power trains. This work serves to provide a

procedure for blade pitch control to reduce the fluctuation while attempting

to maintain a high power coefficient

Bibliography

Numerical optimization of a small-scale wind turbine though the use of surrogate modelling, Journal of Energy in Southern Africa, 28 (2017), 79-91

ID: 2209

Academic Track _ Resubmission of Revised Full Paper

Topics: Aerodynamics

Keywords: Renewable Energy, xxx, yyy, zzz

Effect of cold climate on wind turbine in terms of aerodynamic lift and drag

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Being one of the most environment-friendly and renewable, wind energy attracts enormous interest globally. Some of the best sites for wind farms installation are cold regions, where the air density is favourable as a result of low-temperature conditions. Super-cooled droplets and precipitation affect the wind turbine operations and change the aerodynamic profile of the blade through ice accretion. Ice accretion during wind turbine operation leads to uneven load balance as ice on the leading edge deteriorates the aerodynamic characteristics of the blade and often cause a shutdown of the wind turbine. Ice accretes as a result of super-cooled water causing air bubbles to be trapped within the ice, resulting in a solid phase characterised ice, however with the increase in temperature this ice further melts and the droplets then impacts on the surface and flow over it before freezing to form glaze ice. This paper considers the concept of heat and mass transfer to mitigate the effect and impact of low-temperature on the wind turbine aerodynamic lift and drag coefficient. An experimental approach was employed, using a wind turbine in an artificial climate chamber, where ice accretion was simulated by spraying water droplets to determine the effect of cold climate on the aerodynamic lift and drag coefficient. The results from this paper show that icing can decrease the power output in cold regions. The wind turbine rotation speed is dependent on the temperature around the turbine blade. As icing can cause a significant reduction in the aerodynamic lift coefficient. This paper reviews the operation of wind turbines in humid and cold regions.

Bibliography

NA

ID: 2210

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics

Keywords: MATLAB Simulink, Hydraulic Pump/Motor, Hydraulic hybrid, xxxx

Analysis of the performance of a hybrid hydraulic Pump/Motor using MATLAB Simulink

D. L. Wressell[1], L. Tartibu[1], K. Tekweme[1], N. Pathmanathan[2], D. Madyira[2]

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The law of conservation of energy states that energy is neither created nor destroyed; in application, it is converted from one form to another. The MISER hydraulic hybrid technology is an innovative approach to kinetic energy recovery, storage and re-application for any form of vehicle. This technology makes use of a hydraulic system to reduce the fuel consumption of vehicle. MISER achieves this by means of a combination of regenerative braking, hydraulics and using gas compression to provide an almost loss-free medium for fast storing and fast release of energy that contributes to optimised engine performance. The system uses a hydraulic Pump/Motor (P/M) and nitrogen filled accumulators to store the excess and unwanted kinetic energy at time t and at time t+, to reuse the stored energy. The hydraulic Pump/Motor (P/M) is a critical component in the system and very little is known of its performance characteristics. This study provides clarity on the development of the system model and the performance of the hydraulic system. The system model consists of two air-filled hydraulic accumulators, a MISER P/M, a reservoir and a flywheel which is used to represent the inertia of the vehicle. The model has been developed and implemented in MATLAB Simulink. An integration Solver is used to simultaneously solve the governing equations and predict the system performance. Power losses and roundtrip efficiency is then determined once the system performance variables have been measured and integrated into the model. The study is positioned to make a part contribution to environmental impact savings in the field of sustainable development.

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ID: 2211
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Methods in Mechanics, Finite Element Modelling and Analysis, Mechanics of Materials, Solid Mechanics
Keywords: Rail corrugation, Modal analysis, Frequency Response Function

Application of Modal Analysis to Establish the Wavelength Fixing Mechanism for Rail Corrugation

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Modal Analysis are conducted to establish the correlation between the natural frequencies of a locomotive wheelset and those of corrugation on the rails. Rail corrugation exists on the railway tracks owned by Transnet. The corrugated track runs from Belfast to Steelpoort at the Limpopo province in South Africa. Modal analysis is conducted at the Transnet Engineering Koedoespoort Facility in the wheels department. One locomotive wheelset consisting of two wheels and a traction gear pressed onto an axle is used for modal analysis. The aim of this experiment is to investigate how the D39 200 locomotive class wheels behave under vibrational excitation, and to obtain the contact point Frequency Response Functions (FRF). Corrugation frequency is calculated using train speeds and corrugation wavelengths. The modal analysis performed shows a discernible correlation between the lateral (transverse) natural frequencies of the locomotive wheelset and those of corrugation on rails at the Belfast to Steelpoort line. The D39 200 locomotive class is the only class of locomotives that hauls trains on the Belfast to Steelpoort line. Corrugation wavelengths are also correlated to train and track geometry parameters such as train speeds, track curve radius and tractive effort. There is a strong discernible relationship between corrugation wavelengths and train speeds; this is true especially for loaded trains. The train speeds are directly proportional to the wavelengths, whereas the tractive efforts are inversely proportional. This makes sense given the fact that in It is found that in general, tractive efforts are inversely proportional to train speeds. The greater the curve radius, the longer the wavelengths. In It is recommended that in order to avoid long-pitch corrugation, the track curve radius should be reduced to less than 400 m, this means smaller radius curves have mostly short-pitch corrugation (wavelength < 80 mm) and large radius curves have mostly long-pitch (wavelength > 80 mm).

Bibliography
An Atmospheric Water Generation Solution for Coastal Rural South Africa

ID: 2212
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Methods in Mechanics, Mechanics of Materials, Mechanics of Vibrations
Keywords: Design, Acoustics, Boilersm, xxxx

Development Design of an Acoustic Cleaning Apparatus for Boilers at SASOL Synfuels Power Station Plant in Secunda

D. Kallon, P. M. Shandu, L. Tartibu, R. Mutyavavire
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This paper assesses the maintenance techniques employed to clean coal fired boilers used for power generation at SASOL Synfuels Power Station based in Secunda, in the Mpumalanga Province of South Africa. Adequate maintenance of boilers used in power stations can result in improved efficiency of the boilers and this ultimately translates to reduced operating cost of the power generation plant over the long term. This research investigates the parameters required for the design and installation of an acoustic apparatus for the inline cleaning of these boilers. The sound energy from a sonic horn is converted to vibrations along the boiler tubes thereby dislodging soot. In this work a model of an acoustic cleaning apparatus is developed. The model is tested through numerical simulations using Ansys. The results shows enhanced cleaning at low risk of corrosion and erosion to the surrounding structures especially boiler tubes. The resulting improvement on the boiler performance is noted. The acoustic cleaning technique is, therefore, proposed as an improvement in maintenance of boilers which in turn improves the boiler's capacity and efficiency while reducing outages.

Bibliography
A sustainable power generation solution based on thermo-acoustic technology

ID: 2213
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Methods in Mechanics, Fluid Mechanics, Soil and Rock Mechanics
Keywords: Computational dynamical model, Tumbling mills, Power draw, xxx

Towards a Computational Dynamical Model for Tumbling Mill Power Draw

D. Kallon[1], A. Halodou[1], A. Nel[1], I. Govender[2], A. Mainza[3]
[1]University of Johannesburg, South Africa; [2]University of KwaZulu-Natal, South Africa; [3]University of Cape Town, South Africa; dkallon@uj.ac.za

A computational dynamical model of tumbling mill power draw distribution is developed based on data obtained from Positron Emission Particle Tracking (PEPT) experiments conducted at a Specialized (PEPT) facility run by the University of Cape Town. This is the only facility of its kind in South Africa fully dedicated to research involving Positron Emission Tomography (PET) as applied to industrial applications – that is, the only application outside medical use. The UCT PEPT Cape Town facility is housed within South Africa's main accelerator research lab called the iThemba LABS that runs a specialized cyclotron which produces positrons for use in medical PET and industrial-related PEPT research. The signal express software is used to record power draw data from a lab scale

tumbling mill running at varying speeds and with varying load fractions of glass beads. The MATLAB is then used to reconstruct the trajectory of the tracer particle for further analysis. For the analysis presented herein, parameters are obtained directly from the flow dynamics of the PEPT tracer particle.

Bibliography

Circulation rate modelling of tumbling mill charge using positron emission particle tracking

ID: 2214

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Fluid Dynamics

Keywords: Hydrocyclone, CFD, Air-Core, Eulerian-Eulerian

A Numerically Stable Eulerian-Eulerian Model of Air-Core Formation in a Hydrocyclone

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Due to its importance in industry, the hydrocyclone is constantly undergoing research and development. Experimental based research and development is expensive and tedious, thus, industries frequently rely on computational fluid dynamics to provide greater insight into hydrocyclone behaviour and optimisation. Various numerical models of hydrocyclone behaviour have been developed to improve the accuracy of the model predictions of the multiphase interactions in hydrocyclones. Numerous challenges are faced when modelling the air-core. To ensure that the simulation predictions are accurate focus has been placed on ensuring that a fully formed and stable air-core has developed. This research is based on analysing the air-core stability for a hydrocyclone using computational fluid dynamics. Experiments are conducted using a 3D-Printed, fifty millimetre diameter hydrocyclone. The simulation was performed using ANSYS Fluent whereby the multiphase interactions were modelled using the Eulerian-Eulerian multiphase model. Three mesh densities were analysed for mesh independence purposes. Comparisons were made between the air-core surface, velocity profiles and experimental data. It was found that a reduction in mesh size and the inclusion of air flow at the inlet resulted in an improvement of air-core stability and accuracy when compared to previous research. This has been validated through comparing predicted results from simulation to experimental results and theoretical results.

Bibliography

The first author is a Masters student. Thus, he does not have recent publications.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Engineering Education, Finite Element Modelling and Analysis, Structural Mechanics, Thermodynamics and Heat Transfer

Keywords: Direct Fired Rotary Kiln, Transient Numerical Model, Structural Analysis, Finite Element Method, Heat Transfer, Thermal Stress, Thermal Strain

Experimental and Numerical Investigation of the Structural Performance of a Direct Fired Rotary Kiln

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Rotary kilns are advanced thermal processing systems which are used to cause a chemical reaction or a physical change in solid material through elevated temperatures. There are two main types of rotary kilns, directly fired and indirectly fired rotary kilns. Directly fired rotary kilns process material in direct contact with the processing gas and flame. The indirect fired kiln processes material in an inert environment, which avoids direct contact with the processing gas and flame. Due to elevated operating temperatures, complex loading scenarios arise. These may lead to axial distortion, transverse distortion, blistering, necking, banana distortion, misalignment and kinks. These behaviours complicate structural performance assessments of rotary kilns. Furthermore, their sheer size and harsh operational environment make it difficult to take measurements. Therefore numerical modelling tools can be applied to optimize the design of rotary kilns. The aim of this investigation was to develop a validated numerical tool that can be used in the structural analysis of rotary kilns. Validation data was obtained by testing the direct fired rotary kiln pilot plant at Drytech International for three different scenarios, i.e. (1) rotation, (2) rotation and loading and (3) rotation, loading and heating. Through real time strain measurements, transient response validation data was obtained. A validated transient finite element numerical model was then develop using Abaqus. It was determined that the stress behaviour of the kiln is a function of the percentage fill in the kiln and temperature i.e. the strain and stress variation is directly dependent on the percentage fill and temperature fluctuations. Further work is required on a full scale direct fired rotary kiln.

Bibliography

I am a Post Graduate student at the University of Johannesburg

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Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Materials

Keywords: Bamboo, Bambusabalcooa, Tensile, Bending, Buckling

Mechanical Characterisation of Bambusabalcooa for Bicycle Construction

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Bamboo is a naturally occurring eco-friendly composite material with significant potential for application in structural engineering applications. It is sustainable and can be used as an alternative material for such materials as steel, aluminium and composites. This work presents the mechanical characterisation of one type of locally grown bamboo, Bambusabalcooa, harvested from a small bamboo forest in Stellenbosch. The bamboo was allowed to dry for six months before testing. Tensile, bending and buckling tests were conducted on this bamboo to determine its mechanical properties and its suitability for application in bicycle construction. Tensile test specimens were extracted from the nodes and internodes of the bamboo. The mean tensile strength of the samples was found to be 208.39 MPa at the nodes and 239.07 MPa at the internodes. Bending tests were carried out on bamboo samples extracted from the internodes. The mean maximum shear force and bending moment were found to be 2816.63 N and 332.36 Nm respectively. Buckling tests were carried out on the nodes and internodes of the bamboo. The mean critical load was found to be 51.21 kN at the nodes and 126.38 kN at the internodes. The results proved that this type of bamboo is well suited for bicycle construction. A prototype bamboo bicycle was then constructed and is currently under road tests.

Bibliography

Final year project,

ID: 2225

Academic Track _ Resubmission of Revised Full Paper

Topics: Engineering Education

Keywords: Mathematics gap, engineering education, xxx, yyy

Impact of gaps in mathematics abilities before learners start their engineering studies

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Mathematics is a key course in the syllabus of engineering and is critical to the education of engineering students irrespective of their field of study and work. Many aspects of engineering activity require formulating a problem correctly and finding an adequate method to solve the problem. It can be argued that mathematics is the backbone of engineering.

It is important for educators to understand how various backgrounds of students affect their learning so that practices in the classroom are inclusive and not exclusive. This is especially true in South Africa where we have a range of schools with a range of different standards even though the final examination is the same.

There seems to be a gap that exists between high school and first year engineering programs. Students entering first year engineering programs tend to struggle with first year mathematics.

Calculus can be divided into two subfields: differential calculus and integral calculus. Matric topics and the way they are taught creates a gap between high school and university engineering mathematics. The situation in South Africa in respect to mathematics is more pronounced than elsewhere. It is concluded that South Africa is still failing to meet expectations in mathematics instruction. Institutions of higher education may have to find strategies or interventions that would impact the student's success especially in engineering courses.

Mathematics education begins in language and often problems occur because of language. In South Africa there is an additional challenge to provide mathematics to a diverse society in a number of official languages. Stereotypes also have an impact on mathematics achievement. Many pupils believe that mathematics is only for clever pupils or those that inherited mathematical ability.

This study will compare the curriculum of high school and university engineering mathematics. Data will be interrogated to study pass rates of engineering mathematics. A survey will be completed to determine engineering students experience with mathematics and the mathematics gap between high school and university engineering.

Is there a mathematics knowledge gap in South Africa? What is the impact on engineering students? Is it the responsibility of tertiary institutions to address this gap? If it is the responsibility of tertiary institutions what are possible strategies to bridge this gap?

Key words: Mathematics gap, engineering education.

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H. Steenkamp, A.L. Nel.; Could Industrial Engineering techniques improve retention of engineering students in higher education?; SAIIE conference, Oct 2017

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Academic Track _ Resubmission of Revised Full Paper

Topics: Finite Element Modelling and Analysis, Mechanics of Materials

Keywords: Aluminium 8015 Alloy, Cold rolling, MSC Marc Mentat, 2D/3DFE Model.

Modeling and Simulation of first pass in the Cold Rolling Process of Aluminium 8015 Alloy

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The Cold rolling process is a strain-hardening mechanism and is widely known for its strength improvement, excellent surface finish and dimensional tolerance. The aim of this work is to model and simulate the first pass of the industrial cold rolling process of Aluminium 8015 alloy. Process parameters obtained from the practical industrial cold rolling of the aluminium alloy was used in the development of 2-D and 3-D finite element models for the first pass. These were achieved in the MSC Marc-Mentat Software. The research result comprising of the roll force, roll torque, contact frictional force, equivalent Von Mises stress and shear stress were investigated. Findings

reveal the deformation rate pattern and neutral points in the roll bite. Conclusively, the 3-D finite element model developed is effective in analyzing deformation of metals in the roll bite as compared to the 2-D model.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Engineering Education

Keywords: employability improvement skills, workplace organization, Work integrated learning, xxx

Evaluation of the applicability of Employability Improvement Skills during students' Work Integrated Learning training program.

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The purpose of this paper is to evaluate the extent to which University of Johannesburg Industrial Engineering students made use of the employability improvement skills during their Work Integrated Learning (WIL) period. The National Diploma class of 2016 went through An Employability Improvement Training Program (EIP) that was offered by both the University of Johannesburg and the Japanese International Cooperation Agency (JICA). The JICA-EIP training was aimed at preparing students for work readiness. The training had two components, theory and practical. The theory focused on concepts that included planning, cost, delivery, quality, waste, Kaizen, JIT, productivity and the workplace organisation. The practical component involved the assembly of a toy truck in a simulated production line. A survey was carried out to ascertain employability skills that students had gained through the JICA-EIP training. Students considered employability skills that included planning, teamwork, communication, critical thinking and problem solving to be of more value in their future WIL training. To achieve the objective of this a self-administered questionnaire and interviews were carried out with the same students who had completed the WIL training in 2017. Only students who went through the employability improvement project completed the questionnaire but the interviews also included students who had not attended the JICA-EIP training program. The results of this paper reflect that students applied the employability skills during their WIL training. Students highlighted the importance of teamwork, communication, critical thinking, planning and problem solving. During interviews we witnessed that students who attended the JICA-EIP training were happy and engaged with the interviewers much more than those who had not attended. The value of this paper is to improve the JICA-EIP employability skills training project in order to make sure that students are employable before they are hired by industry.

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ID: 2238

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics, Mechanics of Materials

Keywords: mathematical modelling, constitutive modelling, polypropylene fibers, mechanical properties, viscoelastic behaviour

The Development of a Mathematical Criterion for a Single Layer Dunnage Bag

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The transportation of cargo plays a vital role in the global distribution industry. The success of each trip is determined by the condition of the cargo at the final destination. Dunnage bags have changed the way cargos are transported throughout the world. These woven polypropylene (PP) dunnage bags (DBs) are inflatable bags that are used to secure and stabilise a cargo. The DBs that are presently produced have a woven PP cover (that provides for the strength of the bag) and are stitched together with an interior airtight polyethylene (PE) bladder to provide for the inflatable property.

The aim of the project is to develop a mathematical criterion that can find a single layer candidate material. This material should provide the same properties as the combination of the original double-layered DBs. In addition, this candidate material should lower the labour intensity of combining the two materials and in-turn decrease the production costs.

Various interdisciplinary fields are integrated in this project. Accordingly, a standard approach is sought after that incorporates mechanical engineering, materials engineering, polymer science, material science and mathematical modelling that interrelates the project. The traditional material science tetrahedron (MST) is a phenomenal interdisciplinary research tool that connects material science and engineering with the four areas of focus being the

material structure, processing, properties and performance (Yang and Tarascon, 2012). This tool was utilized during the development of the mathematical criterion.

The DBs display distinct viscoelastic behaviour, which means that as time and temperature changes, the properties of the bags also change. Pedrazzoli used different analyses to study the viscoelastic properties of polymers. Dynamic mechanical analysis and quasi-static analysis, which include tensile-, creep- and tear- tests, were performed to detect changes in the mechanical performance of the material (Pedrazzoli, 2014). Accordingly, this project investigates both the dynamic mechanical and the quasi-static properties of the DBs (this includes properties such as stiffness, toughness, creep resistance and non-air permeability).

In the interest of finding a single layer DB material, it is essential to characterize the current double layer DB accurately. The first step towards depicting the exact properties and behaviour of a double-layered DB is to determine under which conditions the bag operates. This refers to the different loading conditions, temperature fluctuations and pressure variations throughout a typical trip in a container. The loading conditions include rapid loading, cyclic loading and creep. These conditions are simulated using large-scale burst tests. The mathematical criterion is a mathematical model that incorporates the physical operating conditions of the DBs with the mechanical properties using constitutive modelling and scientific equations from the various fields. Essentially, the mathematical criterion is a "black box" that is fed with a diverse set of data from experiments such as tensile tests, permeation tests, large-scale burst tests, DMTA tests and creep-relaxation tests. Then, using constitutive modelling, validation methods and equations from the various fields, the data is transformed into a "fail" or "pass" criterion for the candidate materials.

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ID: 2240

Academic Track _ Resubmission of Revised Full Paper

Topics: Computational Methods in Mechanics, Discrete element modelling, Mechanics of Materials, Solid Mechanics

Keywords: Screw press, Oilseeds, Oil yield, Mechanical energy, Expeller.

Design and Performance Analysis of Vegetable Seed Oil Expellers: A review

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For cooking and edible purposes, oil expelled from vegetable seeds such as cashew nuts, sunflower, soybean, olives has been in use for centuries. The increase in demand of the oils has prompted for development of more efficient methods to extract the oil from these vegetable oilseeds. At large scale production, the modern most preferred method has been solvent extraction which is expensive and requires sophisticated technical expertise both to set up and operate. However, for small production operations, the mechanical extraction method is preferred more. The mechanical screw expellers are easy to use and the investment capital is low hence favourable for small producers and farmers in the rural areas and marginalized communities. Nonetheless, because of the low energy efficiency of the mechanical expellers and high electricity tariffs, there has been a need to develop more energy efficient expellers which can incorporate the use of renewable energy (Solar) for oil production in these underdeveloped areas. Various research studies have been done in the past either by altering the processing parameters (temperature, pressure, screw speed or the seed moisture content) and or trying different screw and the pressing barrel design properties namely the pitch size, tapered screw or the grilled barrel. Different authors have also developed a number of mathematical models to describe and predict the performance of the expellers for various designs and processing conditions in relation to the produced oil yield and energy efficiency. An analysis of these mathematical models and an evaluation of recommendations from the previous expeller designs and research studies was done.

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Academic Track _ Resubmission of Revised Full Paper

Topics: Mechanics of Materials

Keywords: Characterization, Coating, surface pre-treatment, Wear

Characterization and Wear Behaviour of Hydrophobic Silane Coating

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The efficiency and functionality of [Tris(trimethylsiloxy)silyethyl]dimethylchlorosilane (Alkyl) hydrophobic silane coating were characterized. The effect of two types of surface pretreatment (i.e. plasma oxide and silicon oxide) on AISI 304 with a deposit of the hydrophobic silane was investigated. The chemical stability and functionality of the coating were determined by X-ray diffraction (XRD) and Attenuated Fourier Transform Infrared (FTIR-ATR) respectively. The dry sliding wear behaviour was investigated using multifunctional vacuum tribometer. The result shows that plasma oxide surface pretreatment is better in chemical stability than the surface prepared using silicon

oxide, however, silicon oxide has better wear property as compared to plasma oxide pretreated surface coating.

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A. D. Baruwa, O. P. Oladijo, N. Maledi and E. T. Akinlabi "Characterization of hydrophobic silane film deposited on AISI 304 stainless steel for corrosion protection

ID: 2244
Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis, Mechanics of Materials, Structural Dynamics, Structural Mechanics
Keywords: Elastic-plastic materials, spent fuel, interim dry storage cask, mesh density ratios, finite element analysis.

STRUCTURAL ANALYSIS OF NUCLEAR SPENT FUEL DRY STORAGE CASKS

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Abstract

The structural analysis of nuclear spent fuel dry storage has been successfully carried out. This, together with the use of representative material properties for the interim dry storage cask (IDSC) material, has laid the basis for studying the performance of IDSC design under handling drop. A series of refine meshing sizes and drop orientations have been carried out. The three refine mesh density ratios were 1:1, 2:3 and 1:2 to the default and three drop orientations were vertical drop, oblique drop at 45 and 60 degrees. The objective was to establish a parameter that could predict whether the IDSC could withstand the force of impact initiated from 9 metres height.

This height is accounted as worst loading case based on previous research conducted in handling drops in nuclear firms. Finite element (FE) simulations were performed using ABAQUS/Explicit. The results of certain significant stages while running simulations cycles have been presented, screening the effect of the refine mesh modifications on various drop orientations. Thus the highest rate of damage can be expected at an oblique drop at angle of 60 degrees. As the process of structural analysis continues it was prefer that the concrete pad to be made deformable.

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ID: 2249
Academic Track _ Resubmission of Revised Full Paper
Topics: Computational Fluid Dynamics, Mechanics of Materials
Keywords: Wear, Material, Velocity, Angle, CFD

INVESTIGATION OF MATERIAL WEAR FORMATION ON CENTRIFUGAL IMPELLER

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Material wear formation on centrifugal fan impeller has been a major problem to many process plants in the whole world and this has been regarded as a grey area to many of original equipment manufacturers (OEM) of extraction fans. This paper reports on an investigation on Induced draught (ID) centrifugal fan used in Sugar Mill Plant situated in Swaziland. The aim is to establish the uncertainty of what type of wear is taking place, how wear is formed and what caused this wear. The research has revealed that material wear formation on sugar mill plant is caused by particles impaction such as bagasse ash on the impeller. Computational Fluid Dynamics has been used as a tool to simulate impaction of flow around the impeller to work out the impingement angles and velocity of particles. After performing simulation using SolidWorks, angle of impingement was found to be high at the impeller inlet and gradually reducing angle close to zero when referring to the backplate. The highest angle found after simulation was 67°, this angle correlate with the theory mentioned for brittle material, thus state that brittle material is susceptible to wear formation when impact angle is higher and close to 90°. Computational Fluid Dynamics using SolidWorks has been verified by using a third party company that worked on Creo 3.0 simulation. Research has revealed that material selection to be based on particles impingement angle is key as applied to centrifugal fans and related applications.

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Academic Track _ Resubmission of Revised Full Paper
Topics: Mechanics of Composites
Keywords: mercerisation, silane, sisal, compression, shear, sisal-epoxy composites

The Compression and Shear Mechanical Properties of Treated and Untreated Sisal Fibre-Epoxy Resin Composites

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The influence of chemical treatment of sisal fibres through the subsequent processes namely mercerisation (alkali treatment), silane treatment and eventually acid hydrolysis on the fibres were investigated. The effect of the treated fibres on compression strength and shear strength of their composite with epoxy resin matrix were also studied. Scanning electron microscopy of the surfaces of the treated and untreated fibres showed that the chemical treatment processes enhanced the removal of surface impurities and therefore increased the roughness of the surfaces of the fibres. This avails an increased surface area for interlocking with matrix and is, therefore, expected to enhance adhesion of the two. The treated fibre reinforced composites were observed to have higher values of compression and shear strength than the untreated fibre reinforced composites. These higher values were attributed to better interfacial bonding due to better mechanical interlocking between the treated fibres and epoxy resin arising from the increased roughness of the treated fibres.

Bibliography
Wilson Webo, Leonard Masu and Maina Maringa

ID: 2252
Academic Track _ Resubmission of Revised Full Paper
Topics: Finite Element Modelling and Analysis, Mechanics of Materials, Solid Mechanics
Keywords: concrete, chloride-induced corrosion, Theory of Porous Media, fluid transport, solute transport

Towards modelling the penetration of Iron III chloride in reinforced concrete affected by chloride-induced corrosion using the Theory of Porous Media

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The initial efforts in the development of a numerical model using the Theory of Porous Media (TPM) for the penetration of intermediary rust product into reinforced concrete (RFC) subjected to chloride-induced corrosion in the marine splash and zone is presented. Research has shown that although majority of time-to-cracking service life models neglect the permeation of rust into the cement paste adjacent to the reinforcement, it is this mechanism that is responsible for discrepancies between experimental data and model results.

The model presented describes the transport of water and gas through the capillary pores in concrete and the diffusion of "FeC" "l" _"\3"^"\-" within the pore solution. "FeC" "l" _"\3"^"\-" is a soluble chloride complex formed as an intermediary product during the oxidation reaction at the anode of the corrosion cell. This solute is transported in the pore solution from low oxygen conditions and is oxidized in oxygen-rich conditions resulting in the precipitation of rust in the concrete pores. The Theory of Porous Media has proven proficient for modelling the material behaviour of porous solid bodies saturated with one or more fluids but has yet to be applied to chloride-induced reinforcement corrosion of RC. This work outlines the initial efforts of using TPM to model the rust transport process coupled with the poro-elastic material response of reinforced concrete. The latter accounts for the stress build-up due to precipitation and volume expansion. The chloride complex is described by a concentration within the liquid phase and hence is not assigned a unique volume fraction. Precipitation of the rust is not included here as it will be added at a later stage in the development of a more accurate reinforced concrete chloride-induced corrosion model. It is intended that the model thus developed may be adapted for other deterioration mechanisms in concrete.

Bibliography
N/A

ID: 3184
Revised REVISION
Topics: Thermodynamics and Heat Transfer
Keywords: Heat transfer, combustion, spherical domain, radiative heat loss, RKF45.

Steady-state Heat Transit Analysis in a Spherical Domain

R. S. Lebelo, K. C. Moloi, C. Chitumwa, M. Sadiki, P. Baloyi
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The analysis of heat transfer in a stockpile of combustible material is studied in this article. A combustible material is the one whose carbon or hydrocarbon component reacts spontaneously with the oxygen trapped within the

stockpile, due to the exothermic chemical reaction. In this type of reaction, heat is released as part of the products. The combustion process is very complicated, but to investigate the transfer of heat in the reaction, a one-dimensional, irreversible complete combustion process is assumed. The study is modeled in a spherical domain that is assumed to lose heat to the environment by radiation. The differential equation for energy transfer is modified to allow a thorough investigation of the behaviors of some embedded parameters such as the activation energy and the rate of reaction. The resulting equation that governs the problem is tackled numerically by using the Runge-Kutta Fehlberg (RKF45) method coupled with the Shooting Technique. The results are depicted graphically and discussed appropriately. The general observation is that the reaction rate parameter enhances the spontaneous combustion, while the reaction order parameter tends to reduce the process.

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MAJOR CORRECTION-Academic Revised Manuscript
Topics: Mechanics of Composites
Keywords: Composite wheels, fatigue failure, composite failure mechanisms, finite element analysis

Development of a numerical model for failure prediction in carbon fibre composite wheels

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Fatigue failure prediction in composite wheels in simulated dynamic cornering fatigue

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Keywords: Composite wheels, fatigue failure, composite failure mechanisms, finite element analysis

Abstract

The wheel of a road going passenger vehicle is arguably one of the most important components of the vehicle. It is responsible for transmitting power from the drivetrain to the road while also contributing to vehicle dynamics. As a wheel failure under load is potentially catastrophic, even fatal, it is vital to ensure that the wheel of a road going vehicle can withstand all required loads. In addition to the design consideration of strength of the wheel is its mass. Both the wheel mass and rotational inertia affect the vehicle's performance and efficiency, which has led to substantial efforts to reduce wheel weight. As the use of steel and aluminium alloys for wheels is a highly studied subject, which has arguably reached the peak of possible weight reduction, composite materials are seen by some as the next step in vehicle – and wheel weight reduction. Despite the tremendous potential of carbon fibre as an automotive material due to high strength and low weight, the prevalence of carbon fibre reinforced plastics (CFRP) on road vehicles is limited. While development of carbon fibre wheels is ongoing, the expense of manufacturing and testing prototypes can be quite high, and thus it is becoming more important to develop models for composite failure prediction. The purpose of this study is to develop a finite element simulation of a composite layup of a car wheel with the intention of developing a model for both the prediction of failure location and failure mechanism of a wheel undergoing a bending load. Simulations were run on a wheel geometry as an isotropic material to determine possible stress concentrations, before a composite material simulation is to be run. A first prototype has been manufactured for the purpose of validating the computer model. Once the model has been validated, the wheel will be tested to failure under the dynamic cornering fatigue test. Using the model and analysing the failed specimen, the intended model will be developed. Following this, an optimisation process will be conducted to further reduce the weight of the wheel and ensure compliance with the dynamic cornering fatigue test.

Bibliography

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Limitations of the Predictive Capacity of Newtonian Fluid Theories on the Shear Moduli Ratio (Gc/Gm) of Particulate Composites

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Expressions are presented here from existing literature that relate the viscosity of 2-phase Newtonian fluids to the shear modulus ratio of 2-phase Hookean particulate composites. This approach is based on the rationale that for similar geometries the two types of materials, fluids and hookean solids, obey similar rules. Since Newtonians fluids are practically incompressible, the Hookean solids are also taken to be incompressible, with a Poisson's ratio therefore of 0.5. Application of these expressions to filler reinforced composites with their known properties at the

limiting values of 0 and 100% reinforcing filler volume fraction, highlights their limitation in predicting the properties of the composites. A case is made therefore, for modifying the equations presented in order to improve their predictive capacity by tying them to these known values.

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