Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2015, Volume 40, Issue 2, pp 603-614

Entropy Analysis of Generalized MHD Couette Flow Inside a Composite Duct with Asymmetric Convective Cooling

- Paresh Vyas , Nupur Srivastava

Abstract:

The paper presents entropy analysis of MHD generalized Couette fluid flow inside a composite duct. The composite duct is composed of two parallel walls. The upper wall is uniformly moving impermeable plate, whereas the lower wall is porous strata of finite thickness with impermeable bottom. The upper plate and the bottom are asymmetrically convectively cooled. The solutions obtained for the velocity and the temperature are exploited to enumerate entropy generation. The effects of pertinent parameters on the quantities of interest are portrayed graphically and are discussed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2015, Volume 40, Issue 2, pp 559-569

Mechanical and Tribological Behaviour of Friction-Stir-Processed Al 6061 Aluminium Sheet Metal Reinforced with Al_2O_3/0.5Gr Hybrid Surface Nanocomposite

- T. Prakash, S. Sivasankaran , P. Sasikumar

Abstract:

Friction stir processing (FSP) is a new and unique thermo-mechanical processing technique that alters the micro-structural, mechanical and tribological properties of the material in a single pass to achieve maximum performance with low production cost in less time. In this study, the influence of the FSP on the tribological and mechanical properties in terms of hardness for commercially available Al6061 Al sheet metal reinforced with aluminium oxide ($\alpha-Al_2O_3$) –graphite (Gr) hybrid surface nanocomposite was studied and investigated. FSP was carried out at various percentages (0, 2, 4, 6, 8 and 10 wt% of Al_2O_3, with 0.5 wt% Gr) and using process parameters such as traverse speed 60 mm/min, rotational speed 700 rpm and axial force as 7 KN by high-carbon high-chromium tool. The samples were characterized using X-ray diffraction and scanning electron microscope. The mechanical properties in terms of hardness and wear tests were carried out on the modified surfaces. It was observed that Al6061-6 %$\alpha-Al_2O_3-0.5$ Gr hybrid surface composite exhibited high hardness value of 165 BHN and low wear rate of 0.81 g/s. This was due to refined grain structure and uniform distribution reinforcement than others.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2015, Volume 40, Issue 2, pp 571-581

Dry Sliding Wear Characteristics of SiC and Al_2O_3 Nanoparticulate Aluminium Matrix Composite Using Taguchi Technique

- Kiran Kumar Ekka , S. R. Chauhan , Varun

Abstract:

This paper investigates the sliding wear behaviour of nanoparticle-filled aluminium matrix nano-composites (AMNCs). Two different nano-reinforcements undertaken for this study are SiC and Al_2O_3. The percentage reinforcement is also varied from 0.5 to 1.5 wt%. For investigating the wear behaviour, factors such as applied normal load, sliding speed and sliding distance are considered. Also Taguchi design of experimental technique is employed for the study and analysis of sliding wear. Findings showed that nano-SiC particulate-reinforced AMNCs show better wear resistance than nano-Al_2O_3-reinforced AMNCs. Also regression and artificial neural network are used to develop a model to predict the wear rate of these composites.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2015, Volume 40, Issue 2, pp 583-594

Pangium edule Reinw: A Promising Non-edible Oil Feedstock for Biodiesel Production

- A. E. Atabani , Irfan Anjum Badruddin , H. H. Masjuki , W. T. Chong , Keat Teong Lee

Abstract:

Biodiesel production from non-edible feedstocks is currently drawing much attention due to legitimate concerns about the effects of using edible oil for fuel. *Pangium edule* Reinw is a non-edible feedstock. *Pangium* is a tall tree native to the Micronesia, Melanesia and the mangrove swamps of South-East Asia. In this study, biodiesel production and characterization from *P. edule* oil was reported. The seeds were obtained from Bogor, Indonesia. The oil was found to have an acid value of 19.62 mg KOH/g oil. Therefore, a two-step acid–base-catalysed transesterification was used to produce biodiesel. This was followed by evaluating the physical and chemical properties of biodiesel and its blends with diesel. It has been found that the determined properties of *P. edule* methyl ester indicate that the oil can be considered as a future biodiesel source. The most remarkable feature of *P. edule* is its cloud, pour and cold filter plugging points. This biodiesel yielded cloud, pour and cold filter plugging points of –6, –4 and –8 °C, respectively. This indicates the viability of using this biodiesel in cold countries. Therefore, it is suggested that more research should be conducted on *P. edule* for future biodiesel production.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2015, Volume 40, Issue 2, pp 583-594

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Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
March 2015, Volume 40, Issue 3, pp 935-944

Numerical Simulation and Experimental Verification of CMOD in CT Specimens of TIG Welded AA2219-T87

- Mudaser Ullah , Riffat Asim Pasha , Ghulam Yasin Chohan , Faisal Qayyum

Abstract:

Compact tension (CT) specimen is used to investigate the behavior of fatigue crack growth rate (FCGR) of preheat-treated tungsten inert gas (TIG) welded aluminum alloy (AA2219-T87) on MTS-810. Filler metal used for weld is AA2319. ASTM E399 standard provides a method to convert crack mouth opening displacement (CMOD) data to crack length in CT specimens. Calibration tests are performed to obtain the plots of CMOD versus load and CMOD versus crack ratio (a/W) for different crack lengths in the base metal and the welded metal. Cracks lengths are obtained optically and calculated from CMOD as per ASTM E399. Numerical simulation is used to relate the crack length with CMOD in base metal. Validity of the ASTM standard is verified with the results obtained. Paris curves are plotted and compared for both base metal and welded metal to study the effects of welding on FCGR. It is shown that calculation of crack length through CMOD measurements is not reliable in the case of welded materials. High amount of crack closure exists in welded material, which induces large errors in calculated crack length. The microstructure evolves as a result of the TIG welding. The center of the weld nugget zone consists of dendritic structure followed by recrystallized equiaxed small-sized grains in the heat-affected zone. Grains have elongated structure in the base metal. Due to varying phase conditions and concentration of strengthening particles, a high contrast under optical microscope is clearly observed in different zones of weldment.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
March 2015, Volume 40, Issue 3, pp 945-958

A Physical Head and Neck Surrogate Model to Investigate Blast-Induced Mild Traumatic Brain Injury

- Neveen Awad , Wael W. El-Dakhakhni , Ammar A. Gilani

Abstract:

Mild traumatic brain injury (mTBI) resulting from the exposure to a blast shock wave is a challenging problem due to the broad long-term neurological deficits on the victims. The blast-related injury is not only due to the prevalence of military conflicts, but also due to increase terrorist attacks and domestic/industrial accidents. Mechanisms of blast-induced mild traumatic brain injury (BImTBI) have been controversial for a long time and nowadays are one of the most attentive topics among the neurotrauma researches. A physical head and neck model (PHNM) equipped with a surrogate gel brain was developed, and its dynamic responses to a blast wave were evaluated using a predesigned compressed air-driven shock tube. The neck model was constructed and tuned to simulate the actual human neck stiffness. The history of intracranial pressure (ICP) at different locations within the brain was monitored with four miniature pressure transducers. The acceleration of the head as well as the brain model was recorded using two accelerometers mounted internally and outside the PHNM. The shockwave effects on the PHNM were examined at different distance orientations from shock tube exit. The PHNM was exposed to free-field blast tests with controlled reliable positive peak pressure (PPP). The ICP amplitudes/profiles and the acceleration results vary according to the PHNM locations and orientations with respect to shock tube exit. The most vital parameters of ICP wave profiles including PPP, positive phase duration, and positive impulse values were greatly affected by the PHNM locations/orientations from the shock tube exit.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
March 2015, Volume 40, Issue 3, pp 901-913

Characterization of NiTi and NiTiCu Porous Shape Memory Alloys Prepared by Powder Metallurgy (Part I)

- Alaa Abdulhasan Atiyah , Abdul-Raheem Kadhum Abid Ali ,
  Nawal Mohammed Dawood

Abstract:

In this paper, the effect of compacting pressure (150–450 MPa) and copper (Cu) additions (2.5, 5, 7.5 and 10 wt%) on the microstructure and physical properties of NiTi-based shape memory alloys prepared by powder metallurgy is studied. Many characterization techniques were employed in this study such as X-ray diffraction method and scanning electron microscope. The chemical composition of the prepared alloys and microstructure was achieved by using scanning electron microscope equipped with EDS. Differential scanning calorimetric is utilized to measure the transformation temperature of the prepared alloys. Several physical tests such as particle size distribution measurements, density and porosity of green compacted samples and density and porosity after sintering are achieved. XRD test shows that the master sintered samples consist of three phases at room temperature: NiTi monoclinic phase, NiTi cubic phase and Ni_3Ti hexagonal phase. Furthermore, ($CuNi_2Ti$) intermetallic compound is appeared in the samples with 2.5, 5, 7.5 and 10 wt% of Cu. According to the results, it was found that compacting pressure has an essential effect on the decreases in porosity percentage and the results show that (Cu) additions increase porosity percentage in all weight percentages of additives.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
March 2015, Volume 40, Issue 3, pp 923-933

Optimisation of Electrophoretic Deposition Parameters in Coating of Metallic Substrate by Hydroxyapatite Using Response Surface Methodology

- Mahtab Assadian , Mostafa Rezazadeh Shirdar , Mohd. Hasbullah Idris , S. Izman , Davoud Almasi , Mohammad Mahdi Taheri , Mohammed Rafiq Abdul Kadir

Abstract:

Hydroxyapatite bioactive coating was deposited on treated medical grade stainless steel 316L by electrophoretic deposition. Two independent variables including deposition voltage and time span were evaluated in order to investigate their effect on substrates' corrosion potential and coating mass. After deposition, coated substrates were post-treated in a vacuum furnace at 800 ∘ C. The experimental plan was based on a central composite design to create a precision of the mathematical models. The precision of mathematical model and relative parameters were evaluated by variance analysis. Optimum parameters value, considered as simultaneous minimum ion release and maximum coating mass, were predicted at the deposition voltage of 25.93 V and deposition time span of 159 s. The validity of the model generated by response surface methodology was evaluated by comparing the predicted and experimental results. In addition, close agreement between experimental and predicted results was observed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
March 2015, Volume 40, Issue 3, pp 915-922

Morphology, Structural and Electrical Properties of Ag–Cu Alloy Nanoparticles Embedded in PVA Matrix and Its Performance as *E. coli* Monitoring Sensor

- Huda Abdullah , Norshafadzila Mohammad Naim , Aisyah Bolhan , Noor Azwen Noor Azmy , Aidil Abdul Hamid

Abstract:

A new low-cost, simple and clean method for microbial monitoring sensor based on bimetallic thin film is fabricated in this research. The nanocomposite of Ag–Cu doped with PVA has been synthesized via sol–gel method and deposited on glass substrate. Ag–Cu alloy thin films with various concentrations were characterized using XRD, FTIR, UV–Vis, AFM, TEM and *I* –*V* measurement. The peaks in XRD pattern confirm the presence of Ag, Cu and Ag–Cu alloy nanoparticles in FCC structure. FTIR spectra found the O–H stretching of hydroxyl group and C–H stretching of PVA. The resonance UV–Vis absorption peaks are all sharp and lie between the wavelengths of 296–299 nm. The surface of the films has been found to be smoother as the Cu concentrations increased. The sensor performance was tested by measuring the changes of current of the film using *I* –*V* measurement. The $Ag_{0.2}$–$Cu_{0.8}$ alloy film shows obvious changes in current when it was incubated with *E. coli*. The sensitivity measurement, *S*, shows that the high sensitivity can be observed at higher concentrations of Cu.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1197-1203

Effect of Post-Treatment Techniques on Corrosion and Wettability of Hydroxyapatite-Coated Co–Cr–Mo Alloy

- Mostafa Rezazadeh Shirdar , Sudin Izman , Mohammad Mahdi Taheri , Mahtab Assadian , Mohammed Rafiq Abdul Kadir

Abstract:

This study is a comparison between the effect of sintering and alkaline post-treatment techniques on calcium phosphate-coated Co–Cr–Mo alloy in terms of electrochemical corrosion behavior and wettability. The Co–Cr–Mo substrates were electrophoretically coated by calcium phosphate in a solution of $Ca(NO_3) \cdot 4H_2O$ and $NH_4H_2PO_4$. The sintering and alkaline post-treatment techniques were then conducted to convert an as-deposited dicalcium phosphate dihydrate phase to crystalline hydroxyapatite (HA). The coated layers were characterized in terms of phase, crystallinity and composition using X-ray diffraction, Fourier transform infrared spectroscopy and energy-dispersive spectroscopy. In addition, morphology and thickness of coated layers were evaluated using a scanning electron microscope. The results indicate HA-coated samples with a sintering post-treatment technique exhibit more improvement in corrosion parameters, such as corrosion potential (E_{corr}) and corrosion current density (I_{corr}), but lower enhancement in hydrophilicity. However, the HA-coated samples with an alkaline post-treatment technique reveal higher hydrophilicity with lower improvement in corrosion resistance.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1187-1196

Evaluation of Performance of Natural Rubber Composites with Different Sizes of Waste Tyre Rubber (WTR) and Precipitated Silica on C–M–M

- V. Chandran, T. Manvel Raj , T. Lakshmanan , M. Senthil Kumar

Abstract:

Effect of different sizes of waste tyre rubber on natural rubber–silica compounds was studied with a view to assess the mechanical performance of rubber articles. The WTR was intended as a filler material to blend with natural rubber and form a novel rubber composite material. In this work, WTR particles were prepared in three different sizes (150–250, 450–600, and 1200–1500μm) using pulverization method. Then, the particles were blended with natural rubber and silica compounds, and the blend was synthesized by two-roll mill and hydraulic press. The composite material samples ranged from 0 to 40 phr of WTR loading in each size, and silica loading was fixed at 20 phr. The various proportions of samples in all sizes were characterized in respect of their curing characteristics, mechanical properties, and morphology test (C–M–M). Curing results showed that scorch time and optimum cure time significantly decreased in all particle sizes. Minimum torque increased with the addition of WTR, and maximum torque was vice versa. The results of the mechanical properties showed that the particle size 150–250μm affected better enhancement in the mechanical properties than the other particle sizes. However, tensile strength and elongation at break decreased while WTR loading increased. Hardness increased up to 30 phr and tear strength increased up to 20 phr of WTR in rubber compounds for small particle sizes which were comparatively higher than other sizes. The morphology of the samples examined by scanning electron microscopy revealed that particles of small size got uniform dispersion and lesser torn surfaces. The results indicated increased life duration of rubber articles for potential applications.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1173-1186

Energy and Exergy Analysis of Solar Air Heaters with Varied Geometries

- P. Velmurugan, R. Kalaivanan

Abstract:

An indoor standard test procedure is developed to experimentally investigate the steady state energy and exergy performance of single-pass flat plate solar air heater (SPFPSAH), roughened plate dual-pass solar air heater (RPDPSAH), finned plate dual-pass solar air heater (FPDPSAH) and wire mesh dual-pass solar air heater (WMDPSAH) at varied mass flow rates and solar intensities. The analytical solution of the energy balance equations for various elements of the SPFPSAH, RPDPSAH, FPDPSAH and WMDPSAH is determined using a MATLAB 8.1 program and correlated with experimental findings. The analytical and experimental results show that the energy and exergy performance of WMDPSAH is superior to FPDPSAH, RPDPSAH and SPFPSAH. The pressure drop of WMDPSAH is higher than that of FPDPSAH, RPDPSAH and SPFPSAH. From the economic analysis, WMDPSAH is found economically viable within the opted conditions compared with FPDPSAH and RPDPSAH. The analytical and experimental results are in fairly good agreement.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1123-1139

Experimental Investigation on Heat Transfer Enhancement from a Channel Mounted with Staggered Blocks

- M. Sivasubramanian , P. Rajesh Kanna , M. Uthayakumar , P. Ganesan

Abstract:

The present work experimentally investigates heat transfer enhancement from a channel mounted with staggered blocks. The effect of the geometrical parameters, such as the square and circular shapes of the blocks and the ratio of the centre to centre spacing between the blocks (L_x/L_y ratio) along the stream-wise direction and transverse direction of flow, has been investigated. Experiments were conducted using the newly developed experimental setup for Reynolds number ranging from 100 to 500 based on the hydraulic diameter and the average velocity of flow through the channel. The heat input values varied from 100 to 300 W with a step of 50 W, and water was used as working fluid. The results suggest that the variation of the Reynolds number significantly influenced the heat transfer enhancement compared with other geometrical parameters. The square- shaped block imposed greater impact on the heat transfer than the circular blocks. An increase in the heat transfer was observed while increasing the L_x/L_y ratios from 1.5 to 2.5 for the square blocks, whereas it was reduced for the circular blocks.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1141-1150

Thermal Performance Studies on Multi-pass Flat-plate Solar Air Heater with Longitudinal Fins: An Analytical Approach

- P. Velmurugan, R. Kalaivanan

Abstract:

In this study, thermal performance of double- and triple-pass solar air heater with longitudinal fins is mathematically evaluated. The effects of parameters, viz. mass flow rate, solar intensity and inlet temperature upon outlet temperature, thermal efficiency and increments in efficiency, power consumption are presented. The analytical solution for the mathematical model involving energy balance equations of different components of solar air heater is obtained using a MATLAB 8.1. Triple-pass solar air heater with fins exhibits better thermal performance, whereas double-pass solar air heater with fins is economically viable within the opted conditions. The results of the analytical models are in good agreement with experimental findings of earlier researchers.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1165-1171

FEM Techniques Comparison for SIF Computing of Cracked Plate

- Elkahina Sari, Mourad Zergoug

Abstract:

The main purpose of this paper is to perform a computation comparison of stress intensity factor 'SIF' evaluation in case of cracked thin plate with aluminum alloy 7075-T6 and 2024-T3 used in aeronautics structure under uniaxial loading. This evaluation is based on finite element method with a virtual power principle through two techniques: the extrapolation and $G-\theta$. The first one consists to extrapolate the nodal displacements near the cracked tip using a refined triangular mesh with T3 and T6 special elements, while the second, consists to determine the energy release rate G through $G-\theta$ method by potential energy derivation which corresponds numricaly to elastic solution post-processing of a cracked solid by a contour integration computation via Gauss points. The SIF obtained results from extrapolation and $G-\theta$ methods will be compared to analytical solution in particular case. To illustrate the influence of the meshing kind and the size of integration contour position, simulations are presented and analyzed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1111-1122

Influence of Stainless Steel Wire Reinforcement on the Impact Resistance of GFRP Composite Laminates

- K. Pazhanivel , G. B. Bhaskar , A. Elayaperumal , P. Anandan , S. Arunachalam

Abstract:

Plain GFRP laminates and stainless steel (SS) wire reinforced GFRP laminates were prepared by hand layup method. The composite specimen reinforced with SS wires placed at various pitch distances was fabricated, and drop-weight impact tests were conducted with velocities of 2.80, 3.13 and 3.43 m/s. The impact damage area was evaluated by using lighting technique, and fracture behaviors were analyzed using scanning electron microscopic images. Impact energy absorption and damage area due to low-velocity impact on the GFRP composites without wires and SS wire reinforced GFRP composites were calculated, and efficiency of absorption was compared with respect to impact velocity and pitch distance.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
April 2015, Volume 40, Issue 4, pp 1151-1164

Effect of Tool Material Properties and Cutting Conditions on Machinability of AISI D6 Steel During Hard Turning

- Manoj Nayak , Rakesh Sehgal

Abstract:

Hard turning offers numerous advantages to grinding operation; however, there is a critical need for research to clarify issues related to high cutting forces, high temperatures, and surface roughness to meet the challenges it can offer as an alternate to grinding process. Mathematical models are generated for each response variable (main cutting force, thrust force, cutting temperature, and surface roughness) in terms of actual values of the factors (cutting speed, feed, and tool material) to establish relationships using design expert software for statistical investigation. A 3^3 full-factorial design with a total of 27 experiments was obtained for parametric analysis and investigation of machinability of AISI D6 tool steel using three different grades of low-content cubic boron nitride (CBN-L) inserts. The parametric analysis study shows that the main cutting force, thrust force, and surface roughness increase with feed. The thrust force and cutting temperature get influenced by tool material properties. It was established that grain size, CBN content, edge geometry, and hardness of the tools affected all the output characteristics. Scanned electron microscopy and energy-dispersive X-ray of the worn tools showed crater wear, chipping, and fracture of cutting edges, while abrasion and diffusion/dissolutions in CBN tools were the wear mechanisms affirmed in this study.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2015, Volume 40, Issue 5, pp 1517-1527

General Semiempirical Engine Model for Control and Simulation of Active Safety Systems

- Amir Hasan KaKaee, Behrooz Mashadi , Mostafa Ghajar

Abstract:

Mathematical models of vehicle subsystems have main contribution in control and simulation of active safety systems. Among the others, internal combustion engine is a subsystem having high degrees of complexity and nonlinearity, and there is no any accurate and simple model yet being able to predict the engine behavior over the entire range of its variables. In this paper, a semiempirical model is proposed for spark ignition engines that predicts steady torque in terms of throttle position and engine speed. In model development phase, both the physics of the problem and analysis of the measured data are used. Required data for model development are obtained from a validated comprehensive one-dimensional engine model, and the prediction capability of the proposed model is investigated using experimental data. The performance of the model is also compared with a conventional neural networks model. Results show the superiority of the proposed model in comparison with black box models in terms of accuracy, computational cost, and interpretability. This model can be used for determining the required throttle position based on the acceleration demand in longitudinal vehicle dynamics control tasks.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2015, Volume 40, Issue 5, pp 1529-1538

Effect of Multiwall Carbon Nanotubes on the Ablative Properties of Carbon Fiber-Reinforced Epoxy Matrix Composites

- Muhammad Shakeel Ahmad , Umar Farooq , Tayyab Subhani

Abstract:

The effect of multiwall carbon nanotubes (MWCNTs) on the thermal and ablative properties of carbon fiber epoxy matrix composites was investigated. Thermochemical and oxidation reactions were found to dominate the ablation mechanism. Shear forces and high temperatures were produced using oxy-acetylene torch. Three types of composites were investigated: (a) carbon fiber epoxy matrix composites, (b) carbon fiber epoxy matrix composite containing 0.2wt% MWCNTs and (c) carbon fiber epoxy matrix composite containing 0.4wt% MWCNTs. Composites containing 0.2wt% MWCNTs showed 5.4% increase in erosion resistance, while composites containing 0.4wt% MWCNTs showed 9.6% increase in erosion resistance compared with carbon fiber epoxy matrix composites. Thermal conductivity increased with the addition of MWCNTs, i.e., 15 and 52% in composites containing 0.2 and 0.4wt% MWCNTs, respectively. Due to the addition of MWCNTs, the increased thermal conductivity of MWCNT-loaded epoxy matrix affected the ablation behavior of carbon fibers and resulted in gradual thinning of carbon fibers.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2015, Volume 40, Issue 5, pp 1497-1515

Mathematical Determination of a Flute, Construction of a CAD Model, and Determination of the Optimal Geometric Features of a Microdrill

- Teshome Mulatie Bogale , Fang-Jung Shiou , Geo-Ry Tang

Abstract:

The objective of this paper was to determine mathematically a flute, to construct a CAD model and to determine the optimal geometric features of a 0.1mm diameter of a microdrill based on the stress analysis. The flute of a microdrill was determined mathematically by defining the undercutting relative positions of both the microdrill and grinding wheel and their profiles with respect to setting angle. The mathematically determined flute was used to construct a CAD model of a microdrill using Pro/Engineer software. The cross-sectional comparison between the model and fabricated microdrill was carried out by cutting at different lengths, and the results of the web thickness of the model and the fabricated microdrill were approximately the same. Similarly, the images of primary flank areas and secondary flank areas of fabricated microdrills were taken using optical microscope, and they were compared with the shapes of cutting edge, chisel edge, primary flank areas and secondary flank areas of the model. Based on this comparison, they were almost the same. Hence, the consideration of the mathematically determined flute for the construction of the CAD model of a microdrill was feasible. The optimal geometric features of a microdrill have been determined by setting design control parameters for geometric features and carrying out optimization of the stress/displacement analysis using Pro/Mechanica software so that the maximum Von Mises stress of the microdrill was minimized below the compressive strength of the material property.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2015, Volume 40, Issue 5, pp 1471-1485

Machinability Study on Finish Turning of AISI H13 Hot Working Die Tool Steel With Cubic Boron Nitride (CBN) Cutting Tool Inserts Using Response Surface Methodology (RSM)

- Pardeep Kumar, S. R. Chauhan

Abstract:

Finish turning of hardened die tool steel offers an economical alternative to grinding process. This study investigated the effects of machining parameters including workpiece hardness in a range of 45–55 HRC on cutting forces (F_c & F_t), surface roughness (R_a) and cutting edge temperature (T) in finish turning of AISIH13 die tool steel with CBN inserts. Workpiece material AISIH13 has been selected on the basis of its wide applications in die making industries in the range of hardness 45–60 HRC. A central composite design has been used for the design of experimentation, and by using response surface methodology, a mathematical model has been developed. This study reported that the cutting forces are primarily influenced by the hardness of workpiece material. The work material hardness, feed rate and depth of cut are also statistically significant on cutting forces. Also, cutting forces increases, with the increase in workpiece hardness, feed and depth of cut, whereas the cutting speed has least impact on cutting forces. In fact, increase in hardness of work material resulted in better surface roughness as well as increase in tool tip temperature. Furthermore, optimum parameters are obtained through multi-response optimization technique using desirability function approach. The novelty aspect of the present study is that it contributes to practical industrial application of finish turning for the die and mold makers to select the optimum cutting conditions in a range of hardness of 45–55 HRC.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2015, Volume 40, Issue 5, pp 1487-1495

Vibration Control of Rotating Blades Using Root-Embedded Piezoelectric Materials

- L. Malgaca, H. Al-Qahtani , M. Sunar

Abstract:

The problem of rotating blade vibrations has been recognized as one of the major causes of the system failure in many applications of engineering systems such as turbine blades of turbomachinery in petroleum and airline industries. Having motivated by the successful use of a piezoelectric sensor to capture vibrations of a rotating blade from its root (fixed end), this study aims at controlling the rotating blade vibrations through piezoelectric materials at the root. Vibrations of the rotating blade are sent back to the piezoelectric actuator placed at the bottom of its root via velocity feedback and proportional control schemes in order to act on the rotating blade for vibration attenuation. The case study on a smart rotor system shows the potential of root-embedded piezoelectric materials in controlling rotating blade vibrations at different shaft speeds.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1681-1693

Experimental Investigations on the Improvement of an Air Conditioning System with a Nanofluid-Based Intercooler

- N. Balaji, P. Suresh Mohan Kumar , R. Velraj , N. Kulasekharan

Abstract:

The present work is aimed to reduce the compressor load in a domestic air conditioning system, by introducing a shell-and-coil type heat exchanger as an intercooler. The intercooler uses initially a binary mixture of ethylene glycol:water at 30:70 ratio as a shell-side base fluid and later uses nanofluids with Al_2O_3 nanoparticles of different volume concentrations. The coefficient of performance (COP) of the system was estimated at different shell-side fluid flow rates of 1, 1.5 and 2 LPM. COP was found to increase with the decrease in the refrigerant temperature at the compressor inlet, due to the reduction in the compressor work input. A highest increment in the COP of around 31 % was observed for the base fluid and 49.32 % was observed for the 0.75 % nanofluid with a flow rate of 2 LPM compared with the case without intercooler. An appreciable reduction in power consumption of 12.24 % was also observed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1695-1705

Residual Strength and Damage Characterization of Unidirectional Glass–Basalt Hybrid/Epoxy CAI Laminates

- Jefferson Andrew , C. Ramesh

Abstract:

Residual strength and damage characterization of glass fiber, basalt fiber and its hybrid reinforced in epoxy laminates were studied under compression after impact loading. It involves the exploitation of certain characteristics of basalt fiber, in order to ascertain basalt as a suitable alternative to glass fiber. Basalt fiber, extracted from basalt stone, is economically feasible over conventional fibers such as glass or carbon and has relative advantages, both physically and chemically. Low-velocity impact tests under impact energy of 2.17 J and compression test were conducted on each set of laminates, and along with that, the non-impacted specimens were also compared. The results obtained from compression after impact test revealed that glass laminate possessed the highest resistance to impact damage, and this particular hybrid configuration did not prove superior over plain glass or basalt in both impact and compression tests. Therefore, for compression after impact scenarios, basalt does not serve as a viable alternative for glass fiber, especially in this hybrid configuration.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1727-1732

Elastic Limit Analysis for Elliptical and Circular Tubes Under Lateral Tension

- M. Zheng, Y. Zhao , H. Teng , J. Hu , L. Yu

Abstract:

The elastic limit analysis for elliptical and circular tubes under lateral force is conducted in the present paper, and elastic–perfect plastic material model is employed. An analytical expression for describing the elastic limit load of elliptical and circular tubes under lateral force is obtained. It shows that the critical load for elliptical and circular tubes under lateral force increases with the plastic yielding strength of the tube material, the ratio of the wall thickness to radius, the wall thickness and the length of the tube, as well as the degree of deviation from circular tube monotonously. The experimental results from available literature for both steel and aluminum tubes are cited to verify the proposed expression, and it shows that the expression reflects the loading capacity of elliptical and circular tubes quite well, which indicates the proposed expression is a reasonable formula.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1669-1679

Reflow Optimization Process: Thermal Stress Using Numerical Analysis and Intermetallic Spallation in Backwards Compatibility Solder Joints

- F. Che Ani , A. Jalar , R. Ismail , N. K. Othman , M. Z. Abdullah , M. S. Abdul Aziz , C. Y. Khor , M. Abu Bakar

Abstract:

This study applies the reflow optimization process to investigate the phenomenon of spalling in aerospace backward compatibility solder joints when utilized with a Ni substrate [electroless nickel immersion gold, printed circuit board surface finish, and ball grid array (BGA) pads]. The backward compatibility assembly comprised a lead-free tin–silver–copper (96.5Sn3.0Ag0.5Cu/SAC 305 alloy) solder ball assembled with tin–lead paste. The soldering of the lead-free BGA was conducted using two reflow temperature profiles and two conveyor speeds under a nitrogen atmosphere in a full convection reflow oven. The optimized reflow profile has peak temperatures ranging from 237.06 to 237.09°*C* for 68.94–69.36 s. Scanning electron microscope reveals intermetallic compound formation with maximum thicknesses which are lower than 12 µm as per aerospace requirement. Intermetallic compound spalling of solder ball interface components was not observed. However, spalling between printed circuit board and solder bulk was noted. Nevertheless, at both reflow temperature profiles, the composition and phase distribution of the lead-free BGA ball and tin–lead solder paste were fairly uniform across all joints. This work also presents a finite element-based simulation of backward compatibility assembly in reflow process. A growing number of manufacturers are changing their components to lead-free types without notifying customers. If an aerospace production line is still running a tin–lead-based process, understanding how these lead-free components are processed with tin–lead solder becomes essential. This paper will serve as a reference for manufacturing engineers, particularly those involved in surface mount technology application.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1707-1726

Dynamic Response of Viscoelastic CNT Conveying Pulsating Fluid Considering Surface Stress and Magnetic Field

- A. Ghorbanpour Arani, M. Yousefi , S. Amir , P. Dashti , A. B. Chehreh

Abstract:

A viscoelastic carbon nanotube (CNT) conveying pulsating fluid is presented which is based on Euler–Bernoulli beam theory. Runge–Kutta scheme is chosen in order to illustrate the transverse and longitudinal behavior of structure. The effects of surface stress, magnetic field and nonlocal small-scale theory on motion of structure are expressed in this study. Equilibrium equations of CNT conveying pulsating fluid are obtained using energy method. Galerkin, differential quadrature and Runge–Kutta methods are applied to solve equations of motion. In this paper, the effect of pulsating fluid on longitudinal behavior of CNT and transverse displacement of CNT are presented. The static and dynamic transverse distributed loads and their effects on CNT are expressed. In this study, regions of CNT with chaotic, quasi-periodic and periodic behaviors are presented. Also the effects of various parameters such as distributed loads, surface stress and magnetic field on those regions are demonstrated. The results of this work could be helpful in design and manufacturing of nano-/micromechanical system in advanced medical applications such as drug delivery systems with magnetic field as a parametric controller.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1743-1756

Experimental and Theoretical Comparative Study of Performance and Emissions for a Fuel Injection SI Engine with Two Octane Blends

- A. E. Khalifa, M. A. Antar , M. S. Farag

Abstract:

Experimental and theoretical investigations are carried out to study and compare the effect of using two gasoline blends, namely octane 91 and octane 95, on the performance and exhaust emissions of a modern fuel injection SI engine at different engine speeds and loads. Theoretical combustion model is able to predict the engine performance when compared to the experimental findings. Results show that the engine performances of both fuels are comparable, with marginal differences, under the tested operating conditions, practically for engine speeds less than 3500 rpm. Higher power and less specific fuel consumption are observed when octane 91 fuel is used compared with octane 95 blend. Both blends do not show a tendency of knock occurrence. In general, both fuels show similar trends for CO, CO_2 and NO_x concentrations in the exhaust, whereas the unburned hydrocarbons are slightly higher when octane 91 fuel is used. In the higher speed range between 3500 and 5000 rpm, a noticeable decrease in CO_2 concentration, an increase in specific fuel consumption and CO concentration are observed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1733-1741

An Experimental Investigation for Multi-Response Optimization of Friction Stir Process Parameters During Fabrication of AA6061/B_4C_p Composites

- M. Puviyarasan, V. S. Senthil Kumar

Abstract:

In this work, friction stir processing (FSP) has been employed to fabricate metal matrix composites by incorporating B_4C reinforcement particles into the aluminum AA6061 matrix. Taguchi experimental design, consisting of three factors and three levels, is used for minimizing the number of experiments. The factors considered are tool rotational speed, traverse feed and tool tilt angle. Desirability function analysis was employed to optimize the FSP parameters for simultaneous improvement of tensile strength and microhardness of the composites. The optimal parameters were found, and it was confirmed by experimental results. The composites fabricated using optimal process parameters exhibit a higher tensile strength (174 MPa) and microhardness (183 Hv). The tensile strength and microhardness values observed have been correlated with microstructural studies. Scanning electron micrograph revealed defect-free fabricated composites and uniform distribution of reinforcement particles in the stir zone.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1647-1655

Investigation on the Effects of Process Parameters on the Mechanical and Corrosion Behaviour of Friction Stir-Claded AZ31B Magnesium Alloy

- K. Ganesa Balamurugan , K. Mahadevan

Abstract:

Al5086 aluminium alloy was claded to AZ31B magnesium alloy using friction stir processing. The effect of process parameters like tool rotational speed and travel speed on the corrosion resistance, microhardness and tensile properties of the claded AZ31B magnesium alloy was investigated. The study revealed that the samples processed at a higher process parameter range exhibited higher corrosion rate due to the presence of the higher percentage of magnesium trace elements on their surfaces. The precipitation of intermetallics in the stir zone influenced the microhardness values, and the intensity of intermetallics along the line determined the tensile properties of the claded AZ31B magnesium alloy.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
June 2015, Volume 40, Issue 6, pp 1657-1667

Performance Characteristic Analysis of Automated Robot Spray Painting Using Taguchi Method and Gray Relational Analysis

- R. Bhalamurugan, S. Prabhu

Abstract:

This study investigates the performance characteristics of an industrial robot ABB-IRB1410 for an automated painting process using Taguchi orthogonal array (OA) and gray relational analysis (GRA) and compared with the manual painting method using HVLP gun. The multi-response process is converted into single objective and optimized using GRA. The method established in this study combines both OA and GRA. The experiment is designed using Taguchi's L9 OA. The foremost objective of this experiment is to identify the control parameters for the improved quality of paint coating measured in terms of thickness variation, surface roughness and film adhesion. In addition to that analysis of variance and regression analysis are carried out to find the influencing parameters on each response variables individually and to build the mathematical model, respectively. Also the GRA result is compared with the optimized value determined by the exhaustive search method.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2747-2761

Study of the Delamination in the Case of Piezoelectric Bimorph Beams "Static Behavior"

- Adel Zemirline , Mohammed Ouali , Ali Mahieddine

Abstract:

The first-order shear deformation theory is used to study the static behavior of a piezoelectric bimorph beam with delamination between its layers. This delamination is taken with several lengths and locations along the beam with different boundary conditions. The results show that the shape of the axial displacement field is not affected by either the length of the debonded zone or the variation in the ambient. However, this shape is deformed when an electrical field is applied.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2729-2738

Fabrication of Hybrid Mg/(Al_2O_{3p} + SiC_p + Gr_p) Metal Matrix Composite on Developed Gas Injection Liquid Stir Casting Setup

- Jaspreet Hira , S. K. Mangal , Alakesh Manna

Abstract:

This paper presents the fabrication process of hybrid Mg/(Al_2O_{3p} + SiC_p + Gr_p) metal matrix composite on developed gas injection liquid stir casting setup. In this study, the microstructure, grain morphology and the presence of elements in fabricated composite are investigated through high-resolution scanning electron microscope and X-ray diffractometer. A gas injection liquid stir magnesium metal matrix composite casting setup has been designed, fabricated and utilized for the purpose. Different sets of experiments have been performed in a controlled environment of argon gas. Different tests have been conducted on the prepared Mg-MMC to investigate its physical and mechanical properties of the prepared MMC. The test results reveal that the micro-hardness of hybrid Mg/(4wt% SiC_p + 2wt% Al_2O_{3p} + 1wt% Gr_p) MMC is about 1.5 times of the pure Mg-matrix. Tensile strength of fabricated hybrid Mg/(8wt% SiC_p + 2wt% Al_2O_{3p} + 1wt% Gr_p)-MMC has also increased to 1.4 times of pure Mg-matrix. From the results, it is concluded that the developed gas injection stir Mg-MMC casting setup can be effectively utilized for the fabrication of hybrid Mg/(Al_2O_{3p} + SiC_p + Gr_p)-MMC and can be used for many industrial and engineering applications.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2763-2784

Development of Forming Temperature Curves for Warm Deep Drawing Process Under Non-isothermal Conditions

- M. Huseyin Cetin , Abdullah Ugur , Osman Yigit , Hasan Gokkaya , Erol Arcaklioglu

Abstract:

Temperature is the main effective process parameter in the warm deep drawing (WDD) process to improve the formability of light-weight engineering materials, and this feature requires the accurate measurement and assessment of temperature for process stability. In this study, an evaluation of the WDD process was conducted according to the forming temperature curves (FTCs) characterized from work piece temperatures instead of tool temperatures, as usual. To achieve this goal, a special index material was developed to accurately obtain FTCs from the work piece material under closed and heated tool conditions. The differences of temperature on work piece material are required to define temperatures by curves. The characteristic behavior of these curves was investigated under non-isothermal WDD of AA 5754-O. In the experimentation stage, the process parameters, namely FTC, blank holder force and punch velocity, which assure successful deep drawability, were determined according to the failure-free cups by analyzing wrinkling and tearing conditions and minimum cup height parameters as output parameters. As the next step, optimum conditions were investigated by evaluating the cup volume and spring-back parameters. As a general conclusion, approximately 330°C in the flange–die radius region and 100°C in the cup wall-punch bottom region are the ideal optimum temperatures for the warm deep drawing process.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2785-2794

Equal-Channel Angular Pressing of Thin-Walled Copper Tube

- F. Al-Mufadi , F. Djavanroodi

Abstract:

During the last decade, materials with high strength-to-weight ratio have been in demand for industrial usage. Various severe plastic deformation methods such as SE process and HPTT process for tube-shaped specimens have been proposed and experimented. The common difficulty among these SPD techniques for producing tube-shaped specimens is theirs expensive and complicated setups. It is ideal to introduce a new method based on the simplicity of setup and low cost to produce thin-walled ($R/t > 10$, where R is the radius and t is the tube wall thickness) UFGed tube-shape component. Based on this conception, a new technique has been proposed and experimented. In this work, thin-walled copper tube specimens with 1 mm wall thickness and 23 mm diameter have been successfully ECAPed up to four passes through two different fundamental routes (B_C and C) with the die channel angle of 90° using flexible polyurethane rubber pad. Hardness measurements on both annealed and ECAPed tubes show that 90 % increase in hardness value and also 200 % reduction in the grain size were achieved after four passes. Furthermore, the thickness measurement taken from several locations of the tube indicated that the process did not change the dimension of the deformed specimens.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2701-2709

Microstructure and Mechanical Properties of ZTA Ceramic-Lined Composite Pipe Prepared by Centrifugal-SHS

- J. An, J. Zhao , Z. G. Su , Z. Wen , D. S. Xu

Abstract:

A type of zirconia-toughened alumina (ZTA) ceramic-lined composite steel pipe was fabricated by using self-propagation high-temperature synthesis and centrifugal casting technique. The microstructure and phase constituents of ZTA ceramic layer were analyzed by means of optical microscope, scanning electron microscope and X-ray diffractometer (XRD). The fracture toughness of ceramic layers and mechanical shock of Al_2O_3 and ZTA ceramic-lined composite pipes were measured using Vickers indentation microfracture method and the repetitive impacting method. The results show that the phase constituents of ZTA ceramic layer were Al_2O_3, $FeAl_2O_4$ and t-ZrO_2 phases, and no m-ZrO_2 phase was detected by XRD. Addition of ZrO_2 reduced the width of Al_2O_3 dendrites and led to formation of a microstructure with fine ZrO_2 particles distributed at boundaries of Al_2O_3 dendrites. The fracture toughness was increased from 0.56 MPa $m^{1/2}$ of Al_2O_3 ceramic layer to 5.74 MPa $m^{1/2}$ of ZTA ceramic layer. The mechanical shock resistance at the center of the ceramic-lined composite pipe was increased from twice to 19 times after addition of ZrO_2 into the Al_2O_3 matrix.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2685-2699

Robust Controlled Manipulation of Nanoparticles Using the AFM Nanorobot Probe

- A. H. Korayem, M. H. Korayem , M. Taheri

Abstract:

The manipulation of nanoparticles is a current topic of research in the nano world. This is an important subject, since by displacing the nanoparticles, a structure different from the one which is currently available can be obtained. To achieve such a purpose, the atomic force microscope (AFM) is employed as a manipulator to push or pull the target nanoparticles on a substrate and get them to the desired locations. The important point in this process is the amount of force which is necessary to move a particle to the intended spot. Also, to estimate the time for the onset of nanoparticle movement in the sliding mode, it becomes important to obtain the critical time as well. In this paper, through the dynamic simulation of a nanoparticle, its governing manipulation equations have been derived and simulated, so that they can be applied to determine the critical force and time for gold, yeast and platelet nanoparticles in gas, liquid, alcohol, and plasma mediums. Another important issue in the manipulation of nanoparticles is the control of the AFM probe. So, we propose to use an appropriate input such as the torque applied to the probe tip in order to control the probe deviation from its center and to observe the amount of probe displacement along its vertical direction so that, during the moving operation, the AFM probe always remains in contact with the nanoparticle being displaced. This control issue has been investigated for various liquid environments and with different biological and non-biological nanoparticles. Furthermore, the probe of the AFM has been controlled in water, alcohol, and plasma mediums by employing the sliding mode control approach.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2711-2720

Effect of the CNT Content on Microstructure, Physical and Mechanical Properties of Cu-Based Electrical Contact Materials Produced by Flake Powder Metallurgy

- T. Varo , A. Canakci

Abstract:

In this study, Cu matrix nanocomposites with reinforced CNT particles (0.5–5 wt %) were successfully fabricated by employing flake powder metallurgy with warm-pressing and sintering technology at 950 °C for 2 h. The properties of the composite powders were analyzed using a hall flowmeter for the apparent density, a laser particle size analyzer for the particle size and a scanning electron microscopy for the powder morphology. The green and sintered density, hardness and electrical conductivity of Cu–CNT contact materials were determined utilizing Archimedes method, a hardness analyzer and an electrical conductivity measurement device, respectively. The results showed that both consolidation ability and electrical conductivity of the Cu–CNT nanocomposites decreased by increasing the CNT content. The lowest density was 6.3 and 6.73 g/cm^3 for green and sintered Cu–5wt% CNT nanocomposites, respectively, while the highest density value was 8 and 8.57 g/cm^3 for green and sintered Cu–0.5wt% CNT nanocomposites, respectively. The measured conductivity values were 74.56 IACs for 0.5 wt% CNT- reinforced sintered samples and decreased up to 46.3 for 2 wt% CNT-reinforced sintered samples and then decreased to 5.3 IACs for 5 wt% CNT-reinforced sintered samples.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2721-2727

Prediction of Accurate Values for Outliers in Coal Drying Experiments

- Mustafa Tahir Akkoyunlu, Mehmet Cabir Akkoyunlu , Saban Pusat , Coşkun Özkan

Abstract:

Coal drying is a quite important process from both burning efficiency and granulation perspective. Therefore, coal drying experimentation processes always attract researchers from various fields. Those experiments are quite costly since they require expensive laboratory equipment and considerable labor hour. Even if the costs of experiments are tolerable, often long experiment periods and large number of experimentation will cause serious problems for prompt academic results. During the analysis of experiments, researchers convert the results into graphical form. However, when creating charts, it is observed that some of the results diverge from the others abnormally marking some measurement as outliers. In such cases, experiments should be repeated to eliminate the effects of these abnormalities. Due to high costs and time constraints, repetition of an experiment is not preferable in general. To predict the accurate values for outliers and overcome issues generated by these abnormalities, artificial neural network (ANN) is employed in this study and tolerable deviations and acceptable experimental costs are reached by using ANN.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
September 2015, Volume 40, Issue 9, pp 2739-2746

Evaluation of High-Temperature Oxidation Behavior of Inconel 600 and Hastelloy C-22

- Ammar Abdulkareem Hashim, Ali Sabea Hammood , Nawal Jasem Hammadi

Abstract:

The aim of this study was to investigate the oxidation behavior of nickel-base superalloys (Inconel 600 and Hastelloy C-22) by the determination of the oxidation rates of alloys at elevated temperatures and at ambient air. The cyclic oxidation method was adapted by heating of alloys periodically in still air at 900, 1000 and 1100∘C followed by cooling at ambient temperature. The weight change measurement was recorded during the cyclic oxidation tests. The X-ray diffraction and microstructure study were also used as characterization methods to illustrate the properties of studied alloys and oxide film that formed on the surface of oxidized alloys. Inconel 600 and Hastelloy C-22 showed their ability to develop a uniform protective oxide film. The oxide film that formed on both alloys was chromia oxide Cr_2O_3 with smaller amount of spinel oxide $NiCr_2O_4$. The results of the weight gain measurements suggest that the oxidation kinetics of both alloys follows the parabolic behavior during the experimental tests. Also both alloys at 1100∘C exhibited severe spallation of oxide film with linear decreasing in the weight change measurements. The p-kp model was implemented to describe the subsequent cyclic process of oxide growth and spalling.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3299-3311

Experimental Modelling and Analysis in Abrasive Waterjet Cutting of Ceramic Tiles Using Grey-Based Response Surface Methodology

- M. Santhanakumar , R. Adalarasan , M. Rajmohan

Abstract:

The better machining capabilities of abrasive waterjet cutting (AWJC) characterized by the absence of thermal distortion make it highly competitive with other cutting processes employing plasma and lasers. The present report was oriented towards examining the effect of AWJC parameters like abrasive grain size, abrasive flow rate, nozzle–workpiece standoff, water pressure and jet traverse rate on the surface roughness and taper angle of cut produced with ceramic tiles. Taguchi's L_{27} orthogonal array was used for conducting the cutting trials, and a combined technique of grey-based response surface methodology (g-RSM) was disclosed for obtaining the optimal level of AWJC parameters. The g-RSM method was supplemented with analysis of variance to identify the vital parameters affecting the quality characteristics. The optimal parameter setting was validated by conducting a confirmation test. The cut surfaces were also examined using field emission scanning electron microscope images, P-profile plots and atomic force microscope images.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3285-3297

Natural Convection in a Partially Heated Triangular Cavity with Different Configurations of Cold Walls

- Manoj Kr. Triveni , Rajsekhar Panua , Dipak Sen

Abstract:

This study predicts the natural cooling of partial base hot wall of right-angled triangular cavity filled with water. The base wall of the cavity is divided into three parts ($s = b/3$) and made it to be partially active. The side and hypotenuse walls are detached from the middle and arranged in four different configurations namely AB, AD, BC and CD for cooling purpose. The thermally active parts such as hot and cold walls of the enclosure are maintained at constant temperature, while the remaining parts of the wall are kept insulated. The governing equations such as mass, momentum and energy equation are solved by finite volume method. The problem has been solved for different parameters such as partial hot wall, configurations of cold walls and Rayleigh number ($10^5 \leq Ra \leq 10^7$). Results are obtained from the numerical simulation using a commercial software package, FLUENT, and presented in the form of streamlines, isotherms and average Nusselt numbers. The investigation reveals that both the temperature profile and flow field are significantly affected by partial heating, changing the positions of the cold walls and Rayleigh number. It is also observed that the heat transfer rate increases with the increase in Rayleigh number.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3313-3319

Stagnation Point Flow of Walters' B Fluid Using Hybrid Homotopy Analysis Method

- M. Sajid, Ambreen Arshad , T. Javed , Z. Abbas

Abstract:

A hybrid homotopy analysis method is presented in this paper. This method combines the features of homotopy analysis and shooting methods. In this method, the accuracy and speed of convergence is established by dividing the entire domain in subintervals. In each subinterval, the solution is approximated by employing homotopy analysis method using polynomial base functions. The proposed hybrid homotopy analysis method is computationally more efficient and offered not only numerical values, but also closed-form analytic solutions in each subinterval. The proposed method is applied to discuss the stagnation point flow of viscoelastic Walters' B fluid. The overshoot in the velocity profile predicted in the existing approximate numerical solutions is controlled, and physically realistic solutions are presented for both weakly and strongly viscoelastic Walters' B fluids. The convergence and accuracy of the obtained solutions is validated through the residual errors. It is evident from the obtained results that proposed hybrid homotopy analysis method is a powerful technique for solving nonlinear problems.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3337-3344

Failure of Polyester Laminated Automotive Ignition Coils Influenced by Environmental Factors

- A. Nawaz , B. Islam , R. Akhtar , K. Alamgir , S. Noor

Abstract:

This paper focuses on the ignition coil failure caused primarily by environmental factors. Two environmental parameters (i.e., environmental temperature and relative humidity) were considered to highlight their potential consequences using potting method. Environmental temperature affects the bubble sizes in lamination. Inside these bubbles at high voltage, there is a possibility of spark occurrence, which ultimately leads to failure of ignition coils. Second factor is relative humidity, which plays more severe role in the failure of the coil by enhancing the possibility of occurrence of corona even in small-size bubbles. In addition, we analyze both environmental parameters in combination. Results of the study reveal that both environmental parameters in combination play a devastating role in the failure of the coils. Additionally, this study also concludes that potting method can only be done in open environment in the month in which relative humidity is less than 25%.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3321-3328

Online Prediction of Tool Wear in the Milling of the AISI P20 Steel Through Electric Power of the Main Motor

- Etory Madrilles Arruda , Sérgio Luiz Moni Ribeiro Filho , José Tarcisio Assunção , Lincoln Cardoso Brandão

Abstract:

Molds and dies have specific geometries that are linked to the profile of injected products. The great challenge for modern industry is to manufacture these products with high quality and low time. Ball nose end cutters provide flexible manufacturing due to their geometry that allows a single point of contact on free-form surfaces. However, the exact definition of the tool's wear during the milling of molds and dies is complex. This work shows the monitoring of tool wear based on information obtained from the electric power consumed by the main motor. Experiments were carried out on work pieces of AISI P20 steel with dimensions of 20 × 20 × 10 mm. The tools used in the test were solid carbide ball nose mills with a diameter of 6 mm. Analysis of variance was applied to define the most influential input parameter in the milling process, considering electric power and torque as a response. The results showed that the online monitoring of the tool based on electric power information can be a good technique to define the tool's wear during the milling process. Moreover, the electric system of monitoring was easier to assemble than traditional devices, such as piezoelectric dynamometers or load cells, because it provided an assembly without great interference in the machine tool or milling process. The energy analyzer was capable of detecting a variation in the electric power. The electric power and the torque decreased when the tool's wear increased from new to worn tool.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3329-3335

Effects of Borided Cylinder Liner on Engine Performance in a Firing Diesel Engine

- Mehmet Cakir , İsmail Hakkı Akcay

Abstract:

The correlations between engine performance and the borided cylinder liner have been investigated experimentally on firing diesel engine. The inner surface of cast iron cylinder liners of the engine was boronized using powder box-boronizing technique at 780 °C for 4 h. The boronizing thickness was approximately 25μm at the cross section of cast iron cylinder liner after boronizing process. Diesel engine was operated with original cylinder liner and borided cylinder liner. Engine performance data were measured with the help of a hydraulic dynamometer. Indicated mean effective pressure was measured through the in-cylinder pressure detector. Indicated and brake parameters were compared for both motors. Borided engine liner temperature was measured as higher than that of original engine. Similar measurements were seen in the exhaust temperatures. Mechanical efficiency is improved about 6% with cylinder liner boronizing.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3273-3283

Pipelines Reliability Analysis Under Corrosion Effect and Residual Stress

- Mourad Nahal, Rabia Khelif , Rabah Bourenane , Saad Salah

Abstract:

This work focuses on a development of a finite element model that simulates corrosion phenomenon and its influence on structure rupture (pipelines). Subsequently, the pitting effect on reliability and pipelines lifetime is studied. In this paper, the investigated structure material is characterized experimentally, in order to determine the maximum strength and stress resistance. Therefore, a numerical model was developed under ANSYS code to simulate different loads to obtain the stress concentration factor as the stresses could surpass the yielding limit in the corrosion impact, and to determine the Von Mises stress. A corrosion model and residual stresses used in the literature are coupled with the probabilistic model to find the limit state function. Thus, failure probability and structure reliability index under the effect of pitting corrosion phenomena are calculated and the obtained results are discussed and analyzed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2015, Volume 40, Issue 11, pp 3263-3272

A Modified Particle Swarm Optimization Technique for Crack Detection in Cantilever Beams

- Prabir K. Jena , Dayal R. Parhi

Abstract:

An inverse analysis of the crack identification problem is investigated by the modified particle swarm optimization (MPSO) technique. The objective of the present analysis is to predict the unknown crack location and its depth from the knowledge of frequency data obtained from theoretical and experimental investigation. In this paper, the proposed modified PSO (MPSO) mechanism employs the strategy of squeezing the physical domain of the search space in each iteration to accelerate the search process while maintaining the inherent structure of PSO algorithm. Analytical and experimental results of the cracked beam structure are compared with those obtained by modified PSO (MPSO) to ensure the integrity of the algorithm. To show its effectiveness, the results of the MPSO are compared with the results obtained by differential evolution. Simulation results reveal the better performance of the proposed algorithm in terms of predicting the location and depth of the crack.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3723-3729

Effects of the Difference Between the Static and the Kinetic Friction Coefficients on a Drill String Vibration Linear Approach

- Liping Tang, Xiaohua Zhu

Abstract:

Stick–slip phenomenon in drill string is a self-excited vibration that is detrimental to the drilling equipment as well as to the drilling efficiency. Although there are a number of publications on this subject, there is yet not a generally accepted interpretation of its causes. In this paper, an analytical model that differs from the classical block-on-belt one is presented. The equation of motion of the drill bit in the slip phase is obtained and its solution determined for a set of parameters usually found in actual practice, which includes a drill string length of 3000 m. By choosing different sets of friction coefficients, the influence of the difference between the static and the kinetic ones on the occurrence of stick–slip vibration and the performance of the drilling equipment is investigated.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3731-3743

A Finite Element for Spatial Static Analyses of Curved Thin-Walled Rectangular Beams Considering Eight Cross-Sectional Deformation Modes

- Lei Zhang , Zhencai Zhu , Gang Shen , Guohua Cao

Abstract:

A new two-node finite element is proposed for the spatial static analyses of thin-walled curved beams with rectangular box sections considering eight cross-sectional deformation modes. These modes are determined with cross-sectional deformation shape functions and are used to construct the mid-plane contour displacement field and the three-dimensional displacement field. The coupling between the eight deformations and the curvature effect is carefully treated in the deduction of the beam potential energy. Then, the governing equations of the thin-walled curved beam are formulated involved with the principle of minimum potential energy. For the finite element implementation, the governing equations are approximated with C^0 continuous interpolation function. The validity of this study is verified through numerical examples.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3709-3722

Multi-response Optimization of Cutting Parameters for Hole Quality in Drilling of AISI 1050 Steel

- Güven Meral, Murat Sarıkaya , Hakan Dilipak , Ulvi Şeker

Abstract:

In this study, the surface roughness, dimensional accuracy, and circular and cylindrical deviations characterizing the hole quality were investigated experimentally. AISI 1050 steel in experiments was chosen as reference material due to its extensive applications in many areas. Uncoated and TiAlN coated by physical vapor deposition (PVD) method HSS twist drills with different diameters were used. Experiments were conducted on a CNC vertical machining center under dry condition with different cutting speeds and feed rates. The hole depth was 17 mm to ensure $L < 3D$ condition. After each experiment, hole properties such as surface roughness, dimensional accuracy, circular deviation, and axial misalignment between inlet and outlet holes (cylindrical deviation), all of those that show the hole quality, were measured, and the results were evaluated. In addition to experimental analysis, a statistical analysis was carried out to indicate the effects of drilling parameters on test results. Process parameters such as tool type, drill diameter, feed rate, and cutting speed were optimized with consideration of multiple performance characteristics using desirability functional analysis. As a result, coated tools compared with uncoated tools gave positive results for each evaluation criterion. As the most important parameter on surface roughness (Ra) was drill diameter, the most effective parameter on dimensional accuracy, and circular and cylindrical deviations was cutting speed for both uncoated and coated tools except from cylindrical deviation occurring in uncoated drill.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3745-3758

Prediction of Kinematic Viscosities of Biodiesels Derived from Edible and Non-edible Vegetable Oils by Using Artificial Neural Networks

- Tanzer Eryilmaz , Murat Kadir Yesilyurt , Alper Taner , Sadiye Ayse Celik

Abstract:

In the present study, the seeds named as wild mustard (*Sinapis arvensis* L.) and safflower (*Carthamus tinctorius* L.) were used as feedstocks for production of biodiesels. In order to obtain wild mustard seed oil (WMO) and safflower seed oil (SO), screw press apparatus was used. wild mustard seed oil biodiesel (WMOB) and safflower seed oil biodiesel (SOB) were produced using methanol and NaOH by transesterification process. Various properties of these biodiesels such as density (883.62–886.35 kgm^{-3}), specific gravity (0.88442–0.88709), kinematic viscosity (5.75–4.11 mm^2s^{-1}), calorific value (40.63–38.97 $MJkg^{-1}$), flash point (171–$175^\circ C$), water content (328.19–412.15 $mgkg^{-1}$), color (2.0–1.8), cloud point [5.8–$(-4.7)^\circ C]$, pour point [(–3.1)–(–13.1)$^\circ C)$, cold filter plugging point [(−2.0)–$(-9.0)^\circ C)$], copper strip corrosion (1a–1a) and pH (7.831–7.037) were determined. Furthermore, kinematic viscosities of biodiesels and euro-diesel (ED) were measured at 298.15–373.15 K intervals with 1 K increments. Four different equations were used to predict the viscosities of fuels. Regression analyses were done in MATLAB program, and R^2 , correlation constants and root-mean-square error were determined. 1–7–7–3 artificial neural network (ANN) model with a back propagation learning algorithm was developed to predict the viscosities of fuels. The performance of neural network-based model was compared with the performance of viscosity prediction models using same observed data. It was found that ANN model consistently gave better predictions (0.9999 R^2 values for all fuels) compared to these models. ANN model was showed 0.34 % maximum errors. Based on the results of this study, ANNs appear to be a promising technique for predicting viscosities of biodiesels.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3627-3639

Performance and Optimization of Air Gap Membrane Distillation System for Water Desalination

- Atia E. Khalifa , Dahiru U. Lawal

Abstract:

Membrane distillation is a developing thermally driven membrane separation technology used for water desalination. The air gap membrane distillation (AGMD) is one of the important basic configurations for applying this technology. The performance of AGMD system is experimentally investigated at different operating and design variables, including feed temperature, feed flow rate, coolant temperature, coolant flow rate, and air gap width. Taguchi method and applied regression were employed to model and optimize the performance of the AGMD system, by obtaining the best parameters combination based on three different levels of significant variables. Analysis of variance was performed to determine the effect of each factor on the system's performance. A regression model was subsequently generated for calculating the performance of the AGMD system. Feed temperature and the air gap width are the most effective parameters on the performance of AGMD system. The measured and calculated optimal fluxes were found to be 76.0457 and 74.5916 kg/m^2 hr; respectively. The percentage difference between model calculations and the experimental results at optimum conditions is 1.95 %.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3657-3663

Effects of Fe Content on Microstructures and Properties of AlCoCrFe $_x$ Ni High-Entropy Alloys

- Qiushi Chen , Kaiyao Zhou , Li Jiang , Yiping Lu , Tingju Li

Abstract:

The influences of added Fe element on the microstructures and properties of AlCoCrFe $_x$ Ni high-entropy alloys (*x* denoted the atomic fraction of Fe element at 0.2, 0.4, 0.6, 0.8, 1.2, 1.4, 1.6, 1.8, and 2.0) were investigated. When $x = 0.2$, the alloy exhibited dendrites morphology, but as the Fe content increased, the AlCoCrFe $_x$ Ni HEAs transformed to equiaxed grains morphology. Inside the equiaxed grains and dendritic grains, spinoidal decomposition microstructure could be clearly observed. The microstructures changed from Cr_3Ni_2 + B2 + BCC structures to B2 + BCC mixed structures as *x* exceeded 0.6, the hardness declined from HV637.2 to HV460.2, and the compressive fracture strength showed a slight decrease, whereas the plastic property showed a distinct improvement with the addition of Fe element. The maximum compression strength was 2335MPa when $x = 0.2$, and the maximum compression ratio was 36% when $x = 2.0$. The alloys transformed from paramagnetic to ferromagnetic as the content of Fe element increased, and all of the alloys exhibited soft magnetic behaviors.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3665-3674

CFD Modeling of Toxic Element Evolved During Coal Combustion

- Esam I. Jassim

Abstract:

The combustion of coal is a complex series of reactions, dominated by the transport mechanism. An aspect that is poorly understood is the influence that the evolution of trace elements has on the environment and the pollution level. To explore this impact, a mathematical model of arsenic was incorporated into a computational fluid dynamics code to predict the behavior of its evolution during the combustion of pulverized coal inside a Drop Tube Furnace. Coal particles are treated as non-interacting spheres with full coupling of mass, momentum and energy with the gaseous phase. The eddy dissipation model is coupled with Arrhenius-type expressions for devolatilization, char combustion, and CO_x production. The simulation employs the $k-\varepsilon$ turbulence model, the eddy dissipation model for the gas mixture phase, and the discrete transfer model for particle radiation. The char remaining after devolatilization is considered to be pure carbon, and its reaction is governed by external diffusion of oxygen to the particle surface. The simulation outcome showed a fair prediction of the flame progress, as the flame base was found to be close to the fuel feed source. Flow recirculation was shown to be very lean, resulting in no coal and/or ash particulates near the furnace walls, hence keeping the by-product gas streams flow smoothly toward the furnace exit. The simulation results have also proved that complete combustion in the combustion zone was obtained for the prescribed coal/air ratio. Hence, less NO_x gasses are emitted. Arsenic oxide, the product of oxidization of the evolved arsenic, is observed to concentrate at high temperature spots, while the trioxide arsenic spreads out through the combustion zones. The conclusion obtained from the simulation could be used as a benchmark for comparison with available experimental data for agreement.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3641-3655

Numerical Investigation of Heat Transfer, Pressure Drop and Wall Shear Stress Characteristics of Al_2O_3-Water Nanofluid in a Square Duct

- Okyar Kaya

Abstract:

Turbulent heat transfer, pressure drop and wall shear stress behavior of the nanofluid Al_2O_3-water mixture in a square duct under constant wall heat flux are investigated numerically. Single-phase approach is taken into account during the simulations. All of the nanofluid properties depend on the temperature and the nanoparticle volume concentration. The renormalization group theory RNG $k-\varepsilon$ model is employed in order to model turbulence. Validation tests of the numerical results are done by using water as the first working fluid. Similar models and methods are chosen for the simulation of nanofluid (Al_2O_3-water) flow and heat transfer. A very good agreement is realized with the previous water and nanofluid related theoretical-empirical heat transfer and pressure drop correlations. The rate of heat transfer is increased by the presence of nanofluids when compared to that of water. Increasing Re number and particle's volumetric concentration increases the convection heat transfer coefficient, pressure drop and wall shear stress along the duct. On the other hand, this study confirmed that single-phase model approach is appropriate for the simulation of Al_2O_3-water flow and heat transfer.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3675-3695

Optimization of Combustion Performance of Bioethanol (Water Hyacinth) Diesel Blends on Diesel Engine Using Response Surface Methodology

- Akhilesh Kumar Choudhary , C. Kannan

Abstract:

In the current study, an attempt has been made to use water hyacinth plant (*Eichhornia crassipes*) as a raw material for production of bioethanol which is then blended with diesel to obtain biodiesel. To investigate the combustion performance, combustion simulation model was developed and compared with experimental results. Further, the combustion performance of bioethanol–diesel blends in diesel engine was evaluated using response surface methodology technique. Bioethanol extracted from water hyacinth is blended with commercial diesel fuel (BED) in different proportions (volume by volume (v/v)), i.e., 5, 10, 15, 20 and 25BED. This study illustrates the investigation of various compression ratio, loads and fuel injection pressures with different proportion of diesel bioethanol blends. The results show that single-cylinder diesel engine is capable to run up to 25 % bioethanol mixed with diesel by volume. The in-cylinder combustion pressure (P_{max}) reduces while increasing bioethanol–diesel ratio. At higher engine loads, compression ratio and fuel injection pressure, bioethanol blends produce higher combustion pressure in comparison with pure diesel fuel. At lower load, compression ratio and fuel injection pressure, ignition delay increases and P_{max} reduces. The 5BED (5 % bioethanol + 95 % diesel) and 10BED (10 % bioethanol + 90 % diesel) gave better combustion performance among all the bioethanol–diesel blends.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2015, Volume 40, Issue 12, pp 3697-3707

Upstream and Downstream Step Curvature Effects on Film Cooling Effectiveness and Flow Structures

- Fifi N. M. Elwekeel, Antar M. M. Abdala , Diangui Huang

Abstract:

In this study, computational simulations were made using ANSYS CFX to predict the influence of upstream and downstream step curvature radii on the film cooling effectiveness. Five upstream steps and four downstream steps with different curvature radii were studied. The curvature radii of these steps of *R* = 1.64D, 2D, 3D, 4D, and 5D were used. The film cooling effectiveness (η) of these steps was investigated and compared with experiment. The near-field flow phenomena such as the pressure coefficient and the jet trajectories were discussed. Results indicate that the step position in the upstream of a film hole has a higher effect on the film cooling effectiveness compared with the downstream position. The film cooling effectiveness increases in the case of the upstream curved steps at lower radii due to entrapping more coolant in the region upstream of a hole. The results show that the pressure difference has an important effect to draw the coolant in the upstream region of a film hole compared with the case without step.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 569–576

Optimization of Experiments for Microwave Drying of Hydrometallurgy Mud Using Response Surface Methodology

- Guo Lin, Tu Hu, Jinhui Peng, Shaohua Yin, Libo Zhang

Abstract

Microwave heating has been applied to improve the drying efficiency and reduce energy consumption in the dehydration of hydrometallurgy mud. Experiences of microwave drying of hydrometallurgy mud are optimized using response surface methodology. The effects of each factor and their interaction on the dehydration ratio are investigated, and a second-order polynomial model for dehydration ratio is established. The optimized microwave drying conditions are as follows: sample mass 28.89g, microwave power 630.56W and drying time 3.17min. The predicted dehydration ratio of hydrometallurgy mud is 99.62%, which is closed to the averaged experimental value of 99.36% under the optimal conditions, indicating that regressive equation is fit for the dehydration ratio perfectly. Particle analysis suggests that the size distribution of materials using microwave heating is more even than that in an oven. The technology has great significance to shorten drying time and to reduce the energy loss for the industrial application.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 577–590

Free Vibration Analysis of a Rotating Mori–Tanaka-Based Functionally Graded Beam via Differential Transformation Method

- Farzad Ebrahimi, Mohadese Mokhtari

Abstract

In this paper, free vibration analysis of a rotating Mori–Tanaka-based functionally graded (FG) beam is investigated based on Timoshenko beam theory. The physical neutral axis position for the mentioned FG beam is determined. By using a semi-analytical differential transformation method (DTM), the governing differential equations are transformed into recurrence relations and the boundary conditions are converted to algebraic equations. The material properties of the rotating FG beam are supposed to vary across the thickness direction based on Mori–Tanaka micromechanics model. In the classical beam theory, the effects of transverse shear deformation and rotary inertia are not taken into consideration, while the Timoshenko beam model takes these effects into account. It is demonstrated that the DTM has high precision and computational efficiency in the vibration analysis of rotating FG beams. The good agreement between the results of this article and those available in the literature validated the presented approach. The detailed mathematical derivations are presented, and numerical investigations are performed, while the emphasis is placed on investigating the effect of functionally graded microstructure, mode number, slenderness ratios, rotational speed and hub radius and boundary conditions on the normalized natural frequencies of the rotating FG beam in detail. It is explicitly shown that the vibration behavior of a rotating FG beam is significantly influenced by these effects.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 591–598

Effect of Electrophoretic Deposition Parameters on the Corrosion Behavior of Hydroxyapatite-Coated Cobalt–Chromium Using Response Surface Methodology

- Mostafa Rezazadeh Shirdar, Sudin Izman, Mohammad Mahdi Taheri

Abstract

Cobalt–chromium (Co–Cr)-based alloys have been used extensively as medical implants, but the ion release and the corrosion products can affect their mechanical integrity and biocompatibility. One of the solutions is to surface coat the substrate with hydroxyapatite via electrophoretic deposition technique. Two variables—pH of electrolyte and current density—were used to examine the electrochemical behavior of the coated sample. An experimental strategy was developed based on the response surface methodology together with the analysis of variance to verify the precision of the mathematical models and their relative parameters. Close agreement was observed between the predicted models and the experimental results. The pH value of electrolyte was a more significant factor than current density in increasing the corrosion potential (E_{corr}) of the substrate. The maximum E_{corr} was obtained with a current density of 12 mA cm^{-2} and a pH value of 4.71.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2,

Forced Convective Heat Transfer of MWCNT/Water Nanofluid Under Constant Heat Flux: An Experimental Investigation

- Munish Gupta, Rajesh Kumar, Neeti Arora, Sandeep Kumar, Neeraj Dilbagi

Abstract

This research article investigates the effect of multi-walled carbon nanotubes (MWCNT)/water nanofluid on convective heat transfer in a uniformly heated copper tube under laminar flow regime. The MWCNT were synthesized using chemical vapor deposition method and characterized using transmission electron microscope. These nanoparticles were dispersed (with 0.05, 0.1, 0.3 and 0.5 % weight concentrations) in distilled water to form stable suspensions of nanofluids. The heat transfer coefficients (HTC) of nanofluids and distilled water (base fluid) were evaluated and compared using constant velocity basis. The thermophysical properties of nanofluids change with the addition of nanoparticles; thus, we have considered the constant velocity criteria which provide the true comparison in contrast to constant Reynolds number used by earlier researchers. The effect of flow velocity (0.166–0.232 m/s) and nanoparticles weight concentration on the HTC considering constant heat flux boundary conditions was studied. It is observed that with the increase in the weight concentration of nanoparticles or flow velocity, the HTC increases. Nanofluids show higher HTC with respect to distilled water at all the concentrations of nanoparticles. At 0.5 wt.% weight concentration and flow velocity of 0.232 m/s, the maximum HTC obtained is 77.60 % in comparison with distilled water.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 611–622

Adaptive FEM with Domain Decomposition Method for Partitioned-Based Fluid–Structure Interaction

- Aizat Abas, Razi Abdul-Rahman, Aizat Abas

Abstract

A numerical assessment on the solution performance of adaptive finite element methods for fluid–structure interaction (FSI) is presented in this paper. The partitioned-based approach involving separate fluid and structure solvers is considered for adaptive finite element computation with triangular mesh. The performance of the *hp*-adaptivity, in which error in energy norm is reduced by way of mesh refinement (*h*) and polynomial order extension (*p*), is of particular interest. In addition, parallel solution process based on the domain decomposition method is also assessed due to the complexity of two way coupling scheme. Based on its numerical convergence, the *hp*-adaptive procedure for the FSI problem is shown to yield the fastest convergence as generally expected. Moreover, our domain decomposition parallelization scheme shows reduction in the computation time by up to order 2. Subsequently, the convergence performance is highly dependent on the aspect ratios of the triangular elements. The solution performance strongly suggests the viability of the parallel *hp*-adaptive method in partitioned-based FSI formulation.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 623–637

Thermal Enhancement in Storage Silos with Periodic Wall Heating

- N. Himrane, D. E. Ameziani, K. Bouhadef, R. Bennacer, N. Himrane

Abstract

In this paper, unsteady natural convection problem in vertical, open-ended, porous cylinder has been numerically investigated to simulate the transient heat and mass convection in the grain storage in silos. The medium is the seat of a chemical reaction, and the enclosure lateral wall is submitted to a varying temperature profile. Time-dependent boundary temperature is presented as sinusoidal function which can approximate real weather conditions. In the case of constant temperature, a map diagram comprising several characteristic parameters such as Rayleigh number, aspect ratio, buoyancy ratio and lumped effective reaction rate of the two observed flow types, with and without fluid recirculation, was obtained. In order to approve that heat exchanges are dependent of reversal flow and control parameters, the phase diagrams connecting heat transfer (Nu) to the recirculation flow rate (Q_r) are proposed. The observed relative difference between sinusoidal and constant wall temperature increases with increasing Rayleigh number (Ra) and dimensionless temperature amplitudes (X_A), and it is particularly sensitive to the buoyancy ratio values (N) and the reaction rate (A_k). This difference passes from 18.7 % in the only thermal case to 8.15 % in the thermo-solutal case.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 639–652

Determination of Optimal Small Ball-Burnishing Parameters for Both Surface Roughness and Superficial Hardness Improvement of STAVAX

- Quoc-Nguyen Banh, Fang-Jung Shiou

Abstract

In this study, a novel load cell embedded small ball-burnishing tool with a double spring mechanism was designed and fabricated to conduct the burnishing process on STAVAX material. The influences of process parameters, namely burnishing lubricant, burnishing force, step-over, burnishing speed, and number of passes, on the surface roughness and superficial hardness of the workpiece were investigated. The hybrid grey-based Taguchi method with the weighting coefficients estimated by principal component analysis and grey entropy was employed for experimental design and data analysis. After conducting two sets of experiments, the optimal small ball-burnishing condition on STAVAX material was determined.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 653–660

Stability of Aqueous Nanofluids Containing PVP-Coated Silver Nanoparticles

- S. Iyahraja, J. Selwin Rajadurai, S. Iyahraja

Abstract

Nanofluids have opened a new arena for researchers in the field of heat transfer with their exceptional heat transfer characteristics. Enhanced thermal conductivity and improved stability are the principal advantages of nanofluids for its applications in heat transfer. This paper presents an experimental investigation on the stability of silver–water nanofluids prepared by dispersing 0.1 % volume fraction of polyvinylpyrrolidone-coated silver nanoparticles in distilled water with and without the addition of surfactants. The surfactants used in the present study are polyvinylpyrrolidone and sodium dodecyl sulfate. The stability of the nanofluids was estimated from sedimentation time, pH value, zeta potential and particle size distribution. Thermal conductivity of the nanofluids was measured by thermal property analyzer. It has been found that the stability of nanofluids is influenced predominantly by the size of the particle and the surfactant characteristics. The stability of nanofluid increases with the decrease in the size of nanoparticles. Also, the stability increases with sodium dodecyl sulfate as surfactant as against polyvinylpyrrolidone. However, enhancement in the thermal conductivity is found to be higher with polyvinylpyrrolidone than with sodium dodecyl sulfate.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 661–668

Analysis of Contact Phenomena and Heat Exchange in the Cutting Zone Under Minimum Quantity Cooling Lubrication conditions

- Radoslaw W. Maruda, Eugene Feldshtein, Stanislaw Legutko,

Abstract

The paper critically investigates about the influence of emulsion mist cooling on the conditions of heat absorption from the machining zone. The cooling conditions under which the total number of drops falling on the hot surfaces of the machining zone evaporate have been studied. The state of cutting wedges made of P25 sintered carbide after finish turning of two-phase pearlite-ferrite AISI 1045 steel with the presence of an anti-seizure and anti-wear additive has been subjected to scanning inspection. In the contact area, the content of surface active compounds is much larger as compared to the areas beyond the contact. It has been observed that the concentration of active compounds on the surface grows by about three times. This phenomena provides confirmatory evidences of favourable machining conditions.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 669–676

Investigation on Machinability and Damping Properties of Nickel–Phosphorus Coated Boring bar

- S. Chockalingam, U. Natarajan, M. Selvam

Abstract

Chatter or self-excited vibration during machining process is always a serious problem which reduces intended dimensional accuracy. This investigation is mainly about reducing induced vibration through the electroless coating of nickel–phosphorus (Ni–P) on high carbon steel (EN 31) boring bar. The high carbon steel (EN31) substrate has been electroless coated with nickel–phosphorus at varying pH values (4, 5 and 6), and the damping effect of pH values on material deposition has been investigated. The coated substrate was subjected to heat treatment process and the influence of pH values and heat treatment process on structural stabilities of the coated specimens were analyzed using impact hammer test, and scanning electron microscope, energy-dispersive X-ray micro analysis and X-ray diffraction technique were used to study the structural changes in the Ni–P-coated boring bars. The pH values and heat treatment processes were found to play a significant role in improving the damping properties of the boring bars. The boring bar coated at 4 pH values resulted in better deposition of nickel and phosphorous over the substrate and offered better damping properties to the substrate. The heat treatment process on the coated specimen was found to render a crystalline structure to the substrate, thus offering improved damping proprieties to the materials.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 677–689

Intelligent Ratio Control in Presence of Pneumatic Control Valve Stiction

- Puneet Mishra, Vineet Kumar, K. P. S. Rana, Puneet Mishra

Abstract

The presence of hard nonlinearities, such as control valve stiction, may severely degrade the plant profitability by introducing limit cycles in the process variable. This paper presents an innovative use of a recently developed intelligent controller for effective ratio control in the presence of a sticky control valve. The intelligent controller, stiction combating intelligent controller (SCIC), is inherently a fuzzy controller which makes use of Takagi–Sugeno model and changes its gain in run time to deal with stiction nonlinearity. Some of the various advantages which SCIC controller offers are, its simple structure, non-requirement of process parameters' estimation and its capability to provide standalone solution to stiction nonlinearity. These qualities of SCIC controller make it a front runner among other solutions, for the effective ratio control in the presence of a sticky pneumatic control valve. The efficacy of the SCIC controller in ratio control is experimentally verified on a laboratory scale plant with uncertain parameters. A performance comparison between SCIC and linear proportional integral (PI) controller is also made for their setpoint tracking, disturbance rejection and trajectory tracking capabilities at various operating points. Based on extensive experimental studies, it can be concluded that SCIC controller, undoubtedly, outperformed the linear PI controller for all investigated cases and also efficiently handled uncertainties in the plant parameters.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
February 2016, Volume 41, Issue 2, pp 691–709

Thermo-environmental Analysis of Recuperated Gas Turbine-Based Cogeneration Power Plant Cycle

- Anupam Kumari, Sanjay

Abstract

Two of the most prominent techniques to improve energy conversion efficiency of a gas turbine-based combined heat and power plant are the use of "recuperation" and "cogeneration". Thermodynamic and environmental analysis of this type of cycle has been reported in the article. Exergy analysis of the proposed recuperated gas turbine–triple pressure Rankine combined cycle has been presented in comparison with traditional basic gas turbine-based combined cycle. Analysis of emission of oxides of nitrogen from power plant based on the proposed cycle has been carried out to estimate its environmental impact. The results of exergy analysis show a higher gas turbine rational efficiency = 37.32% in case of recuperated gas turbine-combined cycle as compared to 34.41% for basic gas turbine-combined cycle configuration due to a relative decrease in fuel requirement. Results also show that power-to-heat ratio and cogeneration energy efficiency of recuperated gas turbine cogeneration configuration is 0.8246 and 56.28% respectively, while cogeneration exergy efficiency for basic gas turbine-based cycle has been found to be 47.67% and power-to-heat ratio is 0.6749. Emission of oxides of nitrogen from the proposed cycle has been observed to increase with increase in compression pressure ratio and has been found to be around 5.30 g/kg of fuel at compressor pressure ratio of 23.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1585–1594

Theoretical Investigation of a Planar Rack Cutter with Variable Diametral Pitch

- Chia-Hung Lai, Hsueh-Cheng Yang

Abstract

We propose an imaginary planar rack cutter with variable diametral pitch to manufacture the spherical gears of a wrist mechanism. The concept of the imaginary planar rack cutter is derived from the imaginary rack cutter. In general, the diametral pitch of the imaginary rack cutter is constant. In using the imaginary planar rack cutter with constant diametral pitch to cut a spherical blank material, the teeth generated will interfere with each other. Therefore, two matched imaginary planar rack cutters with a variable diametral pitch are proposed. One of the imaginary planar rack cutters consists of convex teeth and is utilized to generate a spherical blank material with concave teeth. The other consists of a concave one and is used to generate a spherical blank material with convex teeth. Through the two-parameter envelope theory and a software package, mathematical models of the spherical gear pairing were determined. Using a developed mathematical model, an investigation on the undercutting analysis of the proposed imaginary planar rack cutter is performed by tooth contact analysis. Finally, a numerical example is used to demonstrate the geometric model of a spherical gear generated by the imaginary planar rack cutter.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1595–1608

Numerical and Experimental Investigation of the Hydrostatic Pump in a Battery Cell with Mixing Element

- Abdallah Bouabidi, Zied Driss, Mohamed Salah Abid

Abstract

Lead acid battery with mixing element is a new battery technology adopted for micro-hybrid vehicles. This battery technology is based on the use of the mixing element. The aim of this paper was to study the hydrostatic pump created using the mixing element. A numerical simulation is performed to predict the pumping phenomenon occurred under the liquid sloshing in the battery cell subjected to sinusoidal excitation. The volume of fluid method based on the finite volume method is used to simulate two-phase flow in the battery cell partially filled with liquid. The distribution of the static pressure and the velocity in whole volume of the cell are presented and analyzed to understand the operating mode of the hydrostatic pump. An experimental setup with sinusoidal movement is developed, and the hydrostatic pump in the battery cell partially filled with liquid is studied. The comparison between the numerical and the experimental results shows a good agreement. In addition, an initially stratified lead acid battery cell is prepared. The effect of sinusoidal acceleration on the stratified cell is investigated. The experimental results show that hydrostatic pump can eliminate the liquid stratification under the acceleration effect.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1609–1615

Entropy Generation and Optimization Analysis for Gas Flow in Rectangular Ducts with Volumetric Radiation

- D. Makhanlall, A. Z. Sahin

Abstract

Entropy generation of a radiative participating gas flow in rectangular ducts is studied. The thermodynamic efficiency for high-temperature flow is also defined. The critical thermodynamic regions for absorption, emission, and scattering processes in the rectangular ducts are identified, and the aspect ratio for minimum entropy generation is determined. The study is extended by considering the thermodynamic effects of Reynolds number, Boltzmann number, and average transverse Nusselt number. It is shown that the total entropy generation rate and the transport efficiency of duct flows can be controlled through Reynolds number, Boltzmann number, and Nusselt number.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1617–1633

Effect of Transverse Aspect Ratio and Distinct Ventilation Techniques on Convective Heat Transfer from a Rectangular Enclosure: Experimental and Numerical Study

- Satish Kumar Ajmera, A. N. Mathur, Satish Kumar Ajmera

Abstract

Our objective in this study was to investigate the convective heat transfer in a cavity with ventilation ports. The study has been divided into experimental and numerical sections and under the experimental study the enclosure considered with two exit ports at roof and one inlet opening with varying aspect ratio. Under the numerical study, the model validation is done at AR = 5, and then the study continued for one exit port each on the left side and right side. The enclosure is equipped with three discrete heat sources at the bottom wall and with an exhaust fan at the exit port. The ranges of parameters considered under experimental study as $1.25 \leq AR \leq 2.5$, $3224 \leq Re \leq 6579$, $8.5 \times 10^6 \leq Gr \leq 1.03 \times 10^8$, and as a consequence Richardson number obtained in the range 0.21–9.58. Experimental results set out that the heat source surface Nusselt number decreases with an increase in aspect ratio however; at higher aspect ratio, the values of Nusselt number remain almost unchanged. The enclosure bulk fluid Nusselt number increases with an increase in aspect ratio. The study revealed that for a given aspect ratio with an increase in Re, the heat source Nu increases. The numerical study divulged that the ventilation port arrangement at the right side of enclosure exhibits the better thermal performance among all the three orientations considered and the results are supported with the streamline and temperature contours. The study of varying inlet port height disclosed that as the inlet port height is increased, the heater surface temperature drops and the enhanced heat transfer is achieved.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1635–1645

Thermodynamic Analysis and Comparison of the Air-Standard Atkinson and Dual-Atkinson Cycles with Heat Loss, Friction and Variable Specific Heats of Working Fluid

- A. Hajipour, M. M. Rashidi, M. Ali

Abstract

Employing finite-time thermodynamics, the effects of irreversibility factors, i.e., friction, heat transfer of cylinder wall, compression and expansion efficiencies and variable specific heats (temperature-dependent specific heats of the working fluid) on the air-standard Atkinson and Dual-Atkinson cycles are analyzed. In addition, a numerical comparison between the Atkinson and Dual-Atkinson cycles is made. Moreover, numerical examples show the relations between the thermal efficiency and compression ratio and between power and compression ratio. As mentioned, compression ratio, r_c, initial temperature, T_1, specific heat defined by a_p, b_v and k_1, friction defined by b and heat transfer defined by α α and β β are some of the key parameters of the internal combustion engines. The effects of these on the performances of the Atkinson and Dual-Atkinson cycles are presented in this article. According to the findings, the thermal efficiency and the output power of the Dual-Atkinson are higher than those of the Atkinson cycle at the same condition. Also, these irreversibility factors must be considered to design and analyze the Atkinson and Dual-Atkinson cycles. The obtained results also will provide guidance for the design of internal combustion engines.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1647–1655

Impact Toughness and Deformation Parameters of Fracture of Railway Axle Material

- P. O. Maruschak, A. P. Sorochak, T. Vuherer

Abstract

In the current paper, the main regularities in fracture of the railway axle steel have been found. It is established that the energy intensity of the steel fracture is connected with the deformational manifestations at the meso and macrolevels. As a part of the methodology of mesomechanics, the deformation behavior of the locomotive axis material has been described, taking into account the interaction between the processes that take place at different scale levels under the impact loading of Charpy specimens. A special role is given to the investigation of the local response of the material at the mesolevel, where the stress–strain state is characterized by a significant nonuniformity, and leads to the formation of shear lips. The shear lip parameters are found to be linearly and depend on the energy intensity of the impact deformation and fracture of the material. The additional evaluation parameters of the energy intensity of deformation and fracture of Charpy specimens can be tore out on the surface and micromechanisms of fracture.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1657–1678

Modelling of Machining Process While Turning Tool Steel with CBN Tool

- Mukund Dutt Sharma, Rakesh Sehgal

Abstract

For machining operations during the last few decades, there has been major progress in developing models for industries. This paper aimed to develop mathematical models using Design Expert 7.1 software to study the effect of cutting parameters on main cutting force, surface roughness and stress. Second objective of this research work was to optimize the machining process by finding the best parameters setting with defined goals for the variables. Results reveal that the value of main cutting force decreases with a decrease in the value of cutting speed and depth of cut. The most significant factors in case of surface roughness and stress are feed rate and depth of cut, respectively. Mathematical models have been developed for main cutting force, surface roughness and stress, and average errors of 3.87, 5.41 and 2.96 % were observed for the corresponding values and analogous trend lines of the plots, respectively. The optimal set of conditions possessing highest desirability value (0.617) and lowest surface roughness (out of eight solutions having the same desirability of 0.617) is as follows: cutting speed—138.29 m/min; feed rate—0.13 mm/rev; depth of cut—0.28 mm (input parameters) and main cutting force—219.273 N; surface roughness—0.439 μm µm ; stress—5128.18 N/mm^2 (responses for input parameters).

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1679–1690

A Nonlocal Higher-Order Shear Deformation Beam Theory for Vibration Analysis of Size-Dependent Functionally Graded Nanobeams

- Farzad Ebrahimi, Mohammad Reza Barati

Abstract

In this paper, free vibration characteristics of functionally graded (FG) nanobeams based on third-order shear deformation beam theory are investigated by presenting a Navier-type solution. Material properties of FG nanobeam are supposed to change continuously along the thickness according to the power-law form. The effect of small scale is considered based on nonlocal elasticity theory of Eringen. Through Hamilton's principle and third-order shear deformation beam theory, the nonlocal governing equations are derived and they are solved applying analytical solution. According to the numerical results, it is revealed that the proposed modeling can provide accurate frequency results for FG nanobeams as compared to some cases in the literature. The numerical investigations are presented to investigate the effect of the several parameters such as material distribution profile, small-scale effects, slenderness ratio and mode number on vibrational response of the FG nanobeams in detail. It is concluded that various factors such as nonlocal parameter and gradient index play notable roles in vibrational response of FG nanobeams.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Experimental Investigation of a Household Refrigerator Performance Using Chimney-Type Condenser

- Engin Gedik, Erdoğan Kılıçaslan, Bahadır Acar

Abstract

In this study, the condenser unit was investigated experimentally in order to search for the effect of using chimney on the performance of a household refrigerator charged with 139 g of R134a refrigerant. An experimental design based on chimney-type condenser has been developed, and three chimneys having different size were produced. A series of measurements were conducted over the climatic conditions of Karabük/Turkey, and results show that the efficiency and energy consumption of the refrigerator vary with the chimney height. Results showed that the best performance observed was for the 170 cm chimney height. Energy consumption of natural convection with chimney was found less than that of natural convection by 5 and 10 % for the loaded and unloaded situations of the refrigerator.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1699–1711

Optimizing the Welding Parameters of Reinforcing Steel Bars

- Tamer Moustafa, Waleed Khalifa

Abstract

Welding is highly recommended for splicing concrete reinforcing bars in all concrete structures. SMAW lap-welded and butt-welded joints made from Tempcore and hot-rolled reinforcing steel bars were studied. The results give an insight into the effect of metallurgical structure and the chemical composition on the effective lap weld length of reinforcing steel bars. It was found that the hot-rolled bars gave shorter acceptable lap length than the Tempcore bars. This was because of the higher amount of pearlite/bainite phases in weld area. In the other hand, the HAZ hardening resulted in the most pronounced changes in ductility of hot-rolled joints. Preheating the hot-rolled bars up to 200 °C was insufficient to prevent the formation of HAZ hard phases.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1713–1722

Torsional Vibration and Static Analysis of the Cylindrical Shell Based on Strain Gradient Theory

- Hamid Zeighampour, Yaghoub Tadi Beni, Iman Karimipour

Abstract

In this paper, the free vibration and torsional static analysis of cylindrical shell are developed using modified strain gradient theory. In doing this, the governing equations and classical and non-classical boundary conditions are derived using Hamilton's principle. After obtaining equations governing the problem, the differential quadrature method is used to discretize the equations of motion of the vibration problem and to examine the single-walled carbon nanotube (SWCNT) with two clamped-free and clamped–clamped supports as a special application of this formulation. Also, torsional static analysis is carried out for the clamped–clamped SWCNT. Results reveal that SWCNT rigidity in strain gradient theory is higher than that in couple stress theory or the classical theory, which leads to increase in torsional frequencies and decrease in torsion of SWCNT. Results also demonstrate that the effect of size parameter and SWCNT torsion in different lengths and diameters is considerable.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1723–1733

Optimization of Biofuel Blends and Compression Ratio of a Diesel Engine Fueled with *Calophyllum inophyllum* Oil Methyl Ester

- G. Antony Miraculas, N. Bose, R. Edwin Raj

Abstract

The twin crises in depletion of fossil fuels and environmental degradation have motivated researches to consolidate the use of biofuels for internal combustion engine applications. In the present study, the performance and emission characteristic of *Calophyllum inophyllum* oil-based methyl ester and its diesel blends are analyzed at various compression ratios. Comprehensive optimization by considering the performance parameter along with emission characteristic is rather involved and is done carefully with designed set of experiments and analyzed statistically using design expert software. Higher compression ratio (CR) induces high cylinder temperature which enhances vaporization and thereby better performance only to a certain extent, that is, up to a CR of 19. However, due to high operating temperature, the oxides of nitrogen emission increase with CR and also for high biofuel blends, but better combustion phenomenon at these conditions reduces the emissions of carbon monoxide and unburned hydrocarbon. The designed empirical statistical model for optimum performance with lower emission is found to be B30 (30 % biofuel) at a CR of 19, which is then tested and validated.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Optimal Design of Orifice Pulse Tube Refrigerator Based on Response Surface and Genetic Algorithm

- Sachindra Kumar Rout, Ranjit Kumar Sahoo

Abstract

The modeling and optimization of a pulse tube refrigerator is a complicated task, due to its complexity of geometry and nature. The present work aims to optimize the orifice type pulse tube refrigerator (OPTR) using the response surface methodology (RSM). The influence of operating condition like frequency, charging pressure, orifice opening, and geometrical dimensions of pulse tube and regenerator on cold end temperature and input compressor power in the OPTR is investigated. For a fixed reservoir volume and regenerator size and porosity, the optimized value of the above parameters suggested by the response surface methodology has been solved using available one-dimensional code. It is reported that the cold head temperature varies due to variation in dimension of the pulse tube and regenerator in between 44 and 160 K, and compressor work varies from 265 to 1288 W. Using the results from the simulation, RSM is conducted to analyze the effect of the independent variables on the responses. To check the accuracy of the model, the analysis of variance method has been conducted. A quadratic model for cold end temperature and compressor input power has been developed. Based on the proposed mathematical RSM models, a novel multi-objective optimization study, using the non-dominated sorting genetic algorithm, has been performed to optimize the responses by generating the pareto frontiers. To avoid subjectiveness and imprecision, maximum deviation theory is used to rank the pareto frontiers based on composite scores.

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Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1757–1769

Fabrication of In-Situ Al–Cu Intermetallics on Aluminum Surface by Friction Stir Processing

- Essam R. I. Mahmoud, Ali M. A. Al-qozaim

Abstract

In-situ Al–Cu intermetallic metal matrix composites (MMCs) surface layer has been fabricated on an A 1050-H24 aluminum plate by friction stir processing (FSP). Pure Cu powder of 5μ 5µ m in size was packed into a groove cut on the aluminum plate and covered with an aluminum sheet. A FSP tool of square probe shape, rotated at a rate of 750–1500 rpm, was plunged into the plate through the cover sheet and the groove and moved along the groove at traveling speed of 0.83 and 1.66 mm/s. Double and triple passes were applied. After the surface MMCs were fabricated on the Al plate, the type and homogeneity of the distributed particles inside the Al matrix have been evaluated from the macro-/microstructure and hardness distribution. As a result, it was found that the copper particles reacted with the aluminum matrix at almost all the processing conditions even during the first pass. Also, at a traveling speed of 1.66 mm/s, most of the resulted intermetallics were $CuAl_2$ at a rotation speed of 750 rpm, while the Cu-rich intermetallics (Al–Cu and Al_4Cu_9) appeared at rotation speeds of 1000 and 1500 rpm. Moreover, when the traveling speed was decreased to 0.83 mm/s, the amounts of the resulted intermetallics were increased. At a rotation and traveling speeds of 750 rpm and 0.83 mm/s, respectively, the nugget zone matrix consisted of nano-sized $CuAl_2$ intermetallics distributed in aluminum which increase the hardness to almost five times of the aluminum matrix adjacent to the nugget zone.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Research on the Aerodynamic Characteristics of the Ahmed Body with a Modified LRN $k-\varepsilon$ k−ε Turbulence Model Using a Transition-Code-Based Method

- Zhengqi Gu, Zhen Chen

Abstract

In light of the fact that computational results based on commonly used turbulence models are unsatisfactory, a modified LRN $k-\varepsilon$ k−ε turbulence model is proposed. The modified concept includes the introduction of the total stress limitation idea and separation-aware model. With the help of this concept, the transport effects of total turbulent shear stress are taken into consideration and the boundary separation is detected. Thus, the model's ability to simulate laminar-turbulent transition, which is an essential feature of the flow field around vehicles, is improved. The Ahmed model and its corresponding experimental data are introduced to validate and evaluate the modified LRN $k-\varepsilon$ k−ε model. Several commonly used turbulence models are also introduced as comparisons. Computations are carried out by the ISIS-CFD flow solver. This work shows that predictions achieved by the modified LRN $k-\varepsilon$ k−ε model give a better agreement with experimental data than other solutions.

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Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1781–1796

The Effect of Flake Powder Metallurgy on the Microstructure and Densification Behavior of B_4C Nanoparticle-Reinforced Al–Cu–Mg Alloy Matrix Nanocomposites

- A. Canakci, T. Varol, F. Erdemir

Abstract

When mechanical milling technique is used as a production method of metal matrix composites (MMCs), the problem of excessive work hardening adversely affecting product properties is observed, whereas the composites with homogeneous particle distribution without the use of further milling times in a ball mill can be fabricated by a new method called "flake powder metallurgy." In this study, B_4C nanoparticle-reinforced Al–Cu–Mg alloy matrix nanocomposites (MMCs) were produced by flake powder metallurgy method. The effect of flake powder metallurgy on the morphology, particle size, apparent density, nanoparticle distribution, density and hardness of B_4C nanoparticle-reinforced Al–Cu–Mg alloy matrix composites was investigated. Flake powder metallurgy was assisted by using a short-term ball milling, which resulted in improved homogeneity of the B_4C nanoparticle distribution. For fine Al–Cu–Mg matrix powders (FNP group) and 1 h of flake time, as the B_4C nanoparticle content gets smaller from 1 to 5 wt %, density reduces from 2.7733 to 2.7350 g/cm^3 and hardness increases from 117.11 to 125.21 BHN. Moreover, as the initial particle size of Al–Cu–Mg alloy matrix increases, density and hardness decrease due to agglomeration effect.

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Research Article - Mechanical Engineering
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Experimental Investigation and Optimization of Cutting Force and Tool Wear in Milling Al7075 and Open-Cell SiC Foam Composite

- Şener Karabulut, Henifi Çinici, Halil Karakoç

Abstract

In the present study, aluminium alloy-based metal matrix composites were fabricated by infiltrating Al7075 into a three-dimensional open-cell silicon carbide (SiC) foam using the liquid metallurgy method. The effects of machining variables on the milling force and tool wear during milling of both Al7075 and the open-cell SiC foam metal matrix composite (MMC) using an uncoated carbide cutting tool were studied. The milling experiments were performed based on the Taguchi L 27 L27 full-factorial orthogonal array, and the milling variables were optimized for cutting force and tool wear. The test results showed that the cutting depth was the most significant cutting parameter affecting milling force in the milling of both workpiece materials. Cutting tool wear was directly affected by the cutting depth in the milling of MMC, and the feed rate was the most influential factor on the tool wear in the milling of Al7075. Uncoated carbide tool showed an excellent machining performance below a machining speed of 220 m/min in finish milling Al7075 workpiece material, but excessive edge chipping was observed on the cutting tool surface in the milling of MMCs. Second-order mathematical models with respect to milling parameters were created for prediction of cutting force and tool wear.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1813–1823

Backward Compatibility Solder Joint Formation at High Peak Reflow Temperature for Aerospace Applications

- F. Che Ani, A. Jalar, R. Ismail

Abstract

This study investigates the backward compatibility solder joint formed at high peak reflow temperature in aerospace industries. The backward compatibility solder joint is made up of lead-free ball grid array mounted on printed circuit board using tin–lead solders at a maximum reflow temperature ranging from 241.9 to 242.45 °C. The reflow process was conducted under a nitrogen atmosphere in a full convection reflow oven for 80.12–81.27 s. The scanning electron microscopy cross section of the solder ball depicts fairly uniform composition and phase distribution of the Pb-free plastic ball grid array and the tin–lead solder paste across all joints. Nanoindentation tests showed better mechanical properties with higher elastic modulus at 68.64 GPa and acceptable hardness value at 0.26 GPa as compared to those of Sn–Pb and Pb-free solder balls. Intermetallic compound formation at both joints seen in the scanning electron microscopy shows a scallop shape and randomly directed growth because of the uniformly distributed Pb-rich phase on the solder ball. The average intermetallic compound thickness measured by scanning electron microscopy equipped with energy-dispersive X-ray analysis was 3.633 μm, which was less than the specified thickness of 12 μm from the laboratory request.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1825–1834

Explicit Solution to Predict the Temperature Distribution and Exit Temperatures in a Heat Exchanger Using Differential Transform Method

- Bagyalakshmi Morachan, Madhu Ganesh

Abstract

In this paper, a simple mathematical model based on energy transfer between the hot and cold fluids in a single-pass cross-flow plate-type heat exchanger is considered and the governing equations are solved using the differential transform method (DTM). DTM transforms the governing equations and its boundary conditions into a set of recurrence relations with some algebraic equations. These relations are further reduced, and then from the inverse transform, the dependent variable (temperature distribution) is obtained as a series solution in explicit form. The temperature distribution and the exit temperatures inside a single-pass cross-flow heat exchanger under steady state are obtained successfully for a single channel. The results obtained are then compared with those derived from Laplace Adomian decomposition method, finite difference method and the effectiveness-NTU approach. The comparison of the solution by DTM with other widely used industrial solutions is also shown, and the merits of the proposed method are presented. The predicted temperature distribution by the DTM is accurate, and it has excellent agreement with the effectiveness-NTU results and other well-known published results.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1835–1846

Performance Study of a Dual-Function Thermosyphon Solar Heating System

- K. Velmurugan, W. Christraj, N. Kulasekharan

Abstract

The present study aims at enhancing the performance of a novel solar collector heating system and its usage. A dual-function solar heating system (DFSHS) that could be used to heat water or air individually or in a combined fashion was designed and fabricated. Experiments were conducted during winter season to highlight the DFSHS performance, using thermosyphon effect with a collector tilt angle of 25 deg. The DFSHS consists of a solar water heater, a solar air heater and a heat exchanger connected in series. The performance of the DFSHS was calculated for different collector fluid (water) flow rates. The maximum efficiency obtained from the solar water heater (SWH) was 73.68% with a flow rate of 0.0225 kg/s at 13.30 h. The solar air heater (SAH) attains a maximum efficiency of 69.18% with a flow rate of 0.0361 kg/s. The heat removal factor as well as the collector efficiency factor for different mass flow rates was estimated and reported.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1847–1856

Simulation of HDPE Mold Filling in the Injection Molding Process with Comparison to Experiments

- Saad M. S. Mukras, Fahad A. Al-Mufadi

Abstract

In this paper, 3D simulation of mold filling for high-density polyethylene in the injection molding process using ANSYS-CFX is conducted. In addition, injection molding experiments involving deliberate short-shots done for various percentages of the optimum dosage to enable for melt front tracking were performed. Comparison between simulation and experimental results showed reasonable agreement with regard to the shape of melt front. The locations of the melt front obtained from the experiment were observed to be slightly ahead of the locations predicted by the simulation with discrepancy being attributed to the nature of the injection molding experiments.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1857–1865

Experimental and Numerical Study of Axial Turbulent Fluid Flow and Heat Transfer in a Rotating Annulus

- Jalal M. Jalil, Abdul-Jabbar Owaid Hanfash

Abstract

The present work is an experimental and a numerical investigation of the turbulent fluid flow and heat transfer in an annular channel between two concentric cylinders with heated stationary outer cylinder (constant heat flux) and adiabatic rotating inner cylinder. Numerically, the governing equations are discretized in a finite volume fashion using a non-staggered (collocated) arrangement of the variables. The solutions were obtained using the SIMPLE algorithm with upwind scheme. A computer program in FORTRAN 90 was build to solve a set of partial differential equations that govern the fluid flow and heat transfer in annular channels. The experimental results are obtained for an inlet air velocity range of 2–6 m/s, for a wall heat flux range of 600–1200 W/m^2 and a rotational speed range of inner cylinder of 0–1500 rpm with a gap width of 1.5 cm. Finally, the relationships between the average Nusselt number and the effective Reynolds number for experimental and numerical results were proposed and compared with those in the existing literature.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1867–1882

The Numerical Simulation of Double-Diffusive Mixed Convection Flow in a Lid-Driven Porous Cavity with Magnetohydrodynamic Effect

- C. G. Mohan, A. Satheesh

Abstract

In this paper, the numerical investigation of double-diffusive mixed convection with magnetohydrodynamic flow in an enclosed cavity is presented. The uniform temperature and concentration are imposed along the vertical walls and the horizontal walls which are considered as insulated. The flow behaviour is analysed for two different conditions. In first case, the top wall moves towards left at a constant velocity (U_o), while the other walls remain stationary. In the second case, the top wall moves towards right with constant velocity (U_o), while the other walls remain stationary. The convective flux in the transport equations is discretized using finite volume technique with third-order deferred quadratic upwind interpolation for convection kinematics scheme at the inner nodes and the second-order central difference scheme at the outer nodes. The pressure and velocity terms are coupled by SIMPLE algorithm. The present numerical simulation is compared with the reported literature and is found to be in good agreement. The Hartmann number ($1 \leq Ha \leq 25$), Lewis number ($1 \leq Le \leq 50$) and aspect ratio ($1 \leq A \leq 2$) are varied over a wide range to analyse the non-dimensional horizontal (U) and vertical velocities (V), stream line contours, temperature and concentration gradients. The present analysis is carried out at constant Buoyancy ratio (N = 1) and Prandtl (Pr = 0.7), Richardson (Ri = 1.0), Darcy (Da = 1.0) and Reynolds (Re = 100) numbers. The effect of Ha, Le and A on the average Nusselt (Nu) and Sherwood (Sh) numbers is also presented.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1883–1894

Study of the Effect of Matrix, Fibre Treatment and Graphene on Delamination by Drilling Jute/Epoxy Nanohybrid Composite

- V. Sridharan, T. Raja, N. Muthukrishnan

Abstract

Natural fibre-reinforced composites are being widely employed in many fields. These composites are preferred for their specific properties and eco-friendly nature. Natural fibres do not bond well with resin readily. Alkali treatment of these fibres has been reported to be effective in achieving better bonding. Addition of nanofillers has been reported to enhance the performance of composites. The current work investigates the machinability of jute fibre-reinforced nanophased polymer composite. Machinability is expressed in terms of delamination factor, which has been obtained using image processing technique. The influence of matrix, fibre surface modification and nanofiller on delamination is reported. Machining was done using high-speed steel tool. ANOVA has been performed to identify the parameter that significantly influences the delamination factor. Fibre surface modification and graphene as nanofiller have improved the machinability.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1895–1905

A Techno-economic Model for Heating of a Greenhouse Site Using Waste Heat

- Mehmet Z. Başak, Süleyman H. Sevilgen

Abstract

Considering a greenhouse site, a waste-to-heat greenhouse heating techno-economic model is presented in this study. The contribution of the parameters affecting the heating costs in the total expenses has been put forward. The economic model can be used for different types of heat sources and allows making a comparison easily. According to the results, the main operating cost is the heating cost. According to the parametric study, the effect of the cover material on the heat losses is very little but the effects of the night temperature set points have an important effect on the heat losses.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1907–1919

Numerical Investigation on the Effect of Pressure and Temperature on the Melt Filling During Injection Molding Process

- M. S. Rusdi, M. Z. Abdullah, A. S. Mahmud

Abstract

Molding development and fabrication is costly and always involves part modification. The cost-effective pre-molding analysis is advantageous to engineer and designer prior to the mold design and before mass production. Computer-aided techniques are identified as virtuously cost-effective for pre-molding analysis. The numerical simulation analysis of the injection molding process using ANSYS FLUENT 14 was carried out in the study. The setting pressure and operating temperature were considered for investigation. Influence of these two process parameters to the injection molding process in terms of filing time, flow front advancement, velocity profile were studied. The injection molding and rheological experiments were carried out to substantiate the predictions of ANSYS FLUENT 14 in solving injection molding problems. The results revealed the system pressure is dominant to filling time, flow front advancement and velocity profile. Inversely, operating temperature only vaguely affects the current injection molding process, due to the small variations of polypropylene viscosity at temperature 185–195 ∘ C ∘C . The discrepancies of the simulation and experimental results were only 4.35 and 2.21% for system pressure and temperature, respectively.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1921–1939

Saturated Flow Boiling Heat Transfer Correlation for Small Channels Based on R134a Experimental Data

- Oğuz Emrah Turgut, Mustafa Asker

Abstract

In the literature, the modeling of saturated flow boiling heat transfer characteristics of R134a flowing through small channels is still questionable since it is based on very limited operational data. This study proposes a new evaporative heat transfer model based on R134a for micro- and macro-tubes. The proposed correlation is developed from 3594 data points, which are obtained from 19 different studies. Ranges of the database cover mass fluxes between 50.0 and 1500.0 kg/m^2 s, heat fluxes between 3.0 and 150.0 kW/m^2, hydraulic diameter between 0.5 and 13.84 mm, saturation temperatures between −8.8 and 52.4 ∘ C 52.4∘C , and vapor qualities up to 1.0. Findings of the proposed method are compared with those of the most quoted flow boiling heat transfer correlations developed for micro- and macro-tubes. Results of the comparison indicate that new method, which has a mean absolute deviation of 19.1 % and captures 66.7 and 83.2 % of the experimental data within ±20 and ±30 % error bands correspondingly, outperforms the available flow boiling correlations in the literature in terms of prediction accuracy.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1941–1953

Unsteady MHD Mixed Convective Flow of Chemically Reacting and Radiating Couple Stress Fluid in a Porous Medium Between Parallel Plates with Soret and Dufour Effects

- Odelu Ojjela, N. Naresh Kumar

Abstract

This article attempts to analyze the chemical reaction, Soret and Dufour effects on an incompressible magnetohydrodynamic mixed convection flow of radiating couple stress fluid between parallel porous plates. It is assumed that the flow is generated due to periodic suction or injection at the plates, and the non-uniform temperature and concentration of the plates are assumed to be varying periodically with time. The governing partial differential equations are reduced to nonlinear ordinary differential equations using similarity transformations; then, the resulting equations are solved numerically by the quasilinearization technique. The effects of various fluid and geometric parameters on non-dimensional velocity components, temperature distribution, concentration, skin friction, heat and mass transfer rates are discussed in detail through graphs and tables. It is observed that the temperature of the fluid is enhanced, whereas the concentration is decreased with the increasing of Soret and Dufour parameters. Also, it is noticed that the magnetic field and porous medium exhibit the similar effect on velocity components, temperature distribution, and concentration. It has been noticed that the present results have the better agreement with the existing literature.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1955–1960

The Effect of the Elastic Fields Caused by a Networks of Dislocations Placed at Interfaces of a Three-Layer Material Cu/Cu/(001) Fe in the Case of Anisotropic Elasticity

- Rafik Makhloufi, Mourad Brioua, Rachid Benbouta

Abstract

The importance of crystal interfaces in the assessment of the effects of elastic fields Eshelby et al. (Acta Meta 1:251–259, 1953) for nanoscale multilayer materials is a topical area that has been the focus of many researchers. This work focuses on the characterization and modeling of interfacial defects on both microscopic and macroscopic scales. From a design perspective, considering such elastic fields has become a critical element in the development of multilayer's in the industry due to their effect on the properties of materials. The description of elastic fields associated with misfit dislocations in a multilayer involving hetero fields is possible thanks to the inversion of a single set of linear equations. Thus, the aim of this investigation is to evaluate the effects of elastic fields at the level of crystal interfaces for a nanoscale three-layer material under the effect of two-way networks of unidirectional dislocations. These are placed at interfaces accommodating a parametric mismatch which accounts for the particular anisotropic elasticity for each crystal.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1961–1968

The Corrosion Resistance Behaviors of Metallic Bipolar Plates for PEMFC Coated with Physical Vapor Deposition (PVD): An Experimental Study

- H. Kahraman, I. Cevik

Abstract

Durability of polymer electrolyte membrane (PEM)-type fuel cells is the most challenging problem preventing commercialization. There are several sources corroding the membrane and the catalyst layer or oxidizing the bipolar plate of fuel cells. There are several reasons for performance drop in PEM-type fuel cells, and degradation of the bipolar plates is one of the most important one. Graphite-based bipolar plates are usually resistant to corrosion, but because of their slow and costly manufacturing process metallic bipolar plates step forward for commercialization. Among other materials, metal nitride-coated stainless steel materials are good candidates for bipolar plate material of commercial applications. In this study, different stainless steel materials, such as 304, 316L, 316Ti and 321, coated with titanium nitride (TiN) and chromium nitride (CrN), using the physical vapor deposition (PVD) method, were tested in terms of corrosion. Corrosion resistance improvement was observed with both TiN and CrN coatings. As the best result, corrosion current value, as low as 0.2 μ μ A/cm 2 2 , was obtained with CrN-coated SS316Ti specimen. Small titanium and molybdenum content in stainless steel improved the corrosion resistance of CrN coating.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1969–1980

Natural Convection Heat Transfer of a Nanofluid into a Cubical Enclosure: Lattice Boltzmann Investigation

- Abdelkader Boutra, Karim Ragui

Abstract

Through this paper, the hydrodynamic and thermal characteristics of Ag–water nanofluid, filling a differentially heated cubic enclosure, are numerically investigated. To do so, a developed computer code based on the lattice Boltzmann approach coupled with the finite-difference method is used. The later has been validated after comparison between the obtained results and experimental and numerical ones already found in the literature. To make clear the effect of main parameters such as the Rayleigh number, the nanoparticle volume fraction, and the enclosure inclination angle, the convection phenomenon was reported by means of streamlines, temperature iso-surfaces, and velocity and temperature profiles. A special attention was paid to the Nusselt number evolution. Compared to a 2D investigation, and when the convection mode dominates, taking into account the third direction leads to significant modifications on the nanofluid motion and heat transfer as well. As the conductive regime dominates, the use of a 2D configuration is found to be valid to predict the studied phenomenon. It is to note that the three-dimensional D3Q19 model was adopted based on a cubic lattice, where each pattern of the later is characterized by 19 discrete speeds.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1981–1993

Buckling of Laminated Carbon Nanotube-Reinforced Composite Plates on Elastic Foundations Using a Meshfree Method

- Sh. Shams, B. Soltani

Abstract

The buckling behavior of laminated composite plates reinforced by carbon nanotubes (CNTs) resting on Winkler–Pasternak elastic foundations under in-plane loads is investigated using reproducing kernel particle method (RKPM) based on first-order shear deformation theory. The minimum potential energy approach is utilized to obtain the governing equations and the stiffness matrices. The single-walled CNTs and poly-co-vinylene are used for the fibers and the matrix, respectively. The carbon nanotube fibers are uniformly distributed in the polymer matrix. The material properties of a carbon nanotube-reinforced composite (CNTRC) plate are estimated through a micromechanical model based on the extended rule of mixture. Full transformation approach is employed to enforce essential boundary conditions. The accuracy and convergency of the RKPM method is established by comparing the obtained results with the available literature. Then, the effects of volume fraction and orientation of CNTs, plate aspect ratio, plate width-to-thickness ratio and the elastic foundation parameters on the critical buckling load are investigated. The obtained results demonstrate that the geometric and mechanical properties and boundary conditions have noticeable effects on the buckling behavior of laminated CNTRC plates.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 1995–2009

Numerical Study of the Hydrodynamic and Thermal Proprieties of Titanium Dioxide Nanofluids Trapped in a Triangular Geometry

- Seif-Eddine Ouyahia, Youb Khaled Benkahla

Abstract

In the present work, we investigate numerically the fluid flow and heat transfer inside an entrapped cavity, which has an isosceles triangular cross-section and is filled with TiO_2–water nanofluid. The base wall is maintained at high constant temperature, while the two other sides are kept a lower constant temperature. The length of the cavity is large enough to assume that the flow is two-dimensional. The governing equations are discretized by the finite volume method and solved numerically via the SIMPLER algorithm. In the present work, we investigate the effect of some parameters including the Rayleigh number, the solid volume fraction, the cavity aspect ratio and the inclination angle on both the thermal performance and the flow structure. The obtained results show that the thermal performance of the cavity and the flow structure are most sensitive to Rayleigh number and solid volume fraction. On the other hand, the aspect ratio of the cavity and its inclination also affect considerably the heat transfer and fluid flow pattern. We notice the occurrence of a pitchfork bifurcation phenomenon, which is a function of both Rayleigh number and cavity aspect ratio. Our results provide information that may be useful for design optimization as well as for thermal performance enhancement of energy systems such as solar water heaters.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 2011–2021

Multiple Quality Characteristics Prediction and Parameter Optimization in Small-Scale Resistance Spot Welding

- Xiaodong Wan, Yuanxun Wang

Abstract

This study focuses on prediction and optimization of multiple quality characteristics in small-scale resistance spot welding of titanium alloy. Grey relational analysis was first conducted to roughly estimate the optimum welding parameters combination. Multiple regression analysis was then implemented for a local parameter optimization. Optimum welding parameters were determined by desirability function and multi-objective genetic algorithm approach separately. A back propagation neural network model was also performed to simulate relationship between welding parameters and single output of the first principal component. Performance of the particle swarm optimization was better than genetic algorithm in obtaining optimum welding parameters. The neural network-based model was very effective in global optimization. A good agreement could be found between experimental results and predicted weld quality characteristics. Weld quality could be found significantly improved with the proposed methods.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
May 2016, Volume 41, Issue 5, pp 2023–2030

Effect of Magnetite Ferrofluid on the Performance and Emissions Characteristics of Diesel Engine Using Methyl Esters of Mustard Oil

- D. Yuvarajan, M. Venkata Ramanan

Abstract

This present work is intended to find out the additional information on using methyl esters of mustard oil as a substitute for diesel. Higher NO_X emissions and lower brake thermal efficiency are the main drawbacks of methyl esters of mustard oil when fueled in diesel engine. In this work, magnetite ferrofluid is added to methyl esters of mustard oil to view its influence on performance and emission characteristics. The possible reason for choosing magnetite ferrofluid is that unlike another additive it can be removed from exhaust gas. Magnetite also releases abundant heat when exposed to higher combustion temperature which in turn reduces the ignition delay and NO_X emissions of mustard oil. Experimental tests were carried out in constant speed diesel engine fueled by diesel, methyl esters of mustard oil and methyl esters of mustard oil by adding magnetite ferrofluid. It has been experimentally found that by adding magnetite ferrofluid (1 % by volume) to methyl esters of mustard oil, 5.122 % increase in brake thermal efficiency and 4.72 % reduction in fuel consumption were observed. Further, 5.8, 2.66 and 7.74 % reductions in HC, CO and NOx emissions were also observed. From this work, it is concluded that methyl esters of mustard oil subjected to addition of magnetite ferrofluid have a positive impact on reducing various drawbacks associated with it.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4247–4262

CFD Simulations of Film Cooling Effectiveness and Heat Transfer for Annular Film Hole

- Antar M. M. Abdala, Fifi N. M. Elwekeel

Abstract

The increasing turbine entry temperature has placed demands for improvements in engine cooling, and the work described in this paper is the development of a new film cooling configuration to meet this demand. In this study, numerical simulations were performed to predict the improvement in film cooling performance with novel film hole called an annular film hole. The film cooling performance parameters such as heat transfer coefficient (h), film cooling effectiveness (η) η) and the net heat flux reduction (NHFR) over flat plate were investigated and compared with other configurations. Velocity profiles, pressure coefficient and turbulence kinetic energy contours were discussed. Four mass flow rates of secondary flow fluid were used to investigate the effects of film coolant velocity on the film cooling performance behavior. Results indicate that an annular film hole gives high film effectiveness, low heat transfer coefficient and higher NHFR compared to rectangular and circular film holes. The average values of laterally averaged film cooling effectiveness of the annular film hole increased to 106 and 328.5% compared with the rectangular and circular film holes at moderate flow rate, respectively. This difference is attributable to decreasing the jet vertical velocity component in a case of the annular hole. Also the low and high heat transfer coefficient regions were described for annular hole in detail.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4263–4272

The Effect of Fiber, Opacifier Ratios and Compression Pressure on the Thermal Conductivity of Fumed Silica Based Vacuum Insulation Panels

- Metin Davraz, Hilmi Cenk Bayrakçi

Abstract

Vacuum insulation panels (VIPs) provide high thermal resistances properties that can enhance the energy efficiency of the insulating systems and provide savings in energy consumption. They are generally made with porous core materials wrapped, under vacuum, in airtight barrier films. The properties of the core materials have big effect on the thermal insulation performance and mechanical properties of the VIPs. In this study, a novel VIP core formulation was developed by using a nano-powder, fiber and opacifier at different ratios. The VIP samples at various compression pressures with different vacuum levels were produced by using the obtained core formulations. Moreover, the relationship between compression pressure and density of VIP core samples was investigated; thermal conductivities of the samples were measured according to heat flow meter method at atmospheric and 0.1 mbar pressure levels. The findings were analyzed by using Datafit 7.1 software. As a result, the optimum fiber and opacifier ratio were determined as 13–20 and 15 %, respectively, for VIP prototypes obtained by using fumed silica (220 m 2 /g m2/g), glass fiber (avg. diameter; 10μm 10µm) and silicon carbide (575 cm 2 /g cm2/g). Furthermore, the effect of fiber and opacifier ratios on the VIP core densities was investigated and various equations were developed to estimate the thermal conductivity values of VIPs at atmospheric and 0.1 mbar pressure levels.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4273–4281

The Effects of Precipitate Size on the Hardness and Wear Behaviors of Aged 7075 Aluminum Alloys Produced by Powder Metallurgy Route

- Musa Yildirim, Dursun Özyürek

Abstract

In this study, the effects of precipitate size, which occurred on the microstructure by applying T6 heat treatment at different temperatures and different time intervals, were investigated on hardness and wear behaviors of 7075 Aluminum alloys produced by powder metallurgy route. Aging heat treatments were performed at three different temperatures (110–130 °C) and four different times (16–28 h). The results show that $MgZn_2$ precipitates were formed in the microstructure by aging heat treatments and their sizes were changed depending on aging temperature and time. The precipitate size was increased by increasing aging temperature and time. The largest size of the precipitate was measured from SEM images of the samples aged at 130 °C for 24 h. The highest hardness values were measured at 120 °C for 24-h aged samples. The wear test results revealed that the weight loss was increased with increase in sliding distance and the minimum weight loss was observed at 120 °C for 24-h aged samples.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4283–4289

Theoretical Study on Working Mechanics of Smith Expansion Cone

- Deng Kuanhai, Lin Yuanhua, Zeng Dezhi

Abstract

The deformation failures of many casings are in urgent need of one reliable repair technology recently. Smith expansion cone (SEC) repair technology is high efficient to repair deformed casing. However, the reshaping force is a very important parameter for designing and optimizing the SEC and construction parameters. Hence, the mechanical mechanism of SEC repair technology is studied, and one mechanical model of SEC used to repair deformed casing is proposed based on twin shear unified strength theory in this paper. In this model, the effects of material hardening and the ratio of yield strength to tensile strength on casing repair were taken into full account. The mechanical model can calculate reshaping force that is used to repair the deformed casing under any confining pressure, and there is a good agreement between calculated results and experimental data. Based on this model, the effects of expansion amount every time, friction efficient, cone angle and length of equal diameter section on the reshaping force were analyzed in detail, by which the correlations between the reshaping force and the expansion amount every time, friction efficient, cone angle and length of equal diameter section were obtained. Research results can provide theoretical guidance for design and optimization of the structure and construction parameters of SEC.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4291–4302

Fluid Flow and Heat Transfer in a Channel with Noncircular Obstacles

- Omer F. Can, Omer F. Can

Abstract

Fluid flow and heat transfer in the presence of noncircular obstacles placed in a channel are investigated numerically. Study was performed as three dimensional. Ansys Cfx software was used for numerical study. k–ε ε model was used for solving of turbulence model equation. Average Nusselt numbers were investigated for six different obstacles (vertical bar, horizontal bar, square, angular square, triangle, and hexagonal) with Reynolds numbers of Re = 10,000, Re = 20,000, and Re = 40,000, and compared with a channel with no obstacle. The largest increase in the average Nusselt number occurred when a vertical bar was placed in the channel. We fitted the average Nusselt number using $Nu=mRe^{n}Pr^{1/3}$ Nu=mRenPr1/3 , where n and m are parameters, to achieve $Nu=0.0285Re^{0.787}Pr^{1/3}$ Nu=0.0285Re0.787Pr1/3 for all geometries. Drag coefficients were investigated for any obstacle. The velocity profiles and streamlines at the channel output were examined at Re = 20,000 for seven different geometries. The velocity profile along the channel was investigated at Re = 20,000 with a hexagonal obstacle.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4303–4311

Experimental Evaluation of Process Parameters Effect on Mechanical and Machining Properties of Al6061–Cu–SiCp-Reinforced Metal Matrix Composite

- Serajul Haque, Akhtar Hussain Ansari, Prem Kumar Bharti

Abstract

The present analysis emphasizes on optimization of pouring speed, stirring speed and pouring temperature for mechanical properties and machining properties of aluminium metal matrix composites. In Al6061 aluminium, alloy presence of Mg improves the wettability with SiCp. Precipitation hardening was also achieved; furthermore, the addition of 4 % Cu is more or less admired to duralumin that has precipitation hardening phenomenon when it is added above 560°C. Precipitation hardening prevents dislocation at the molecular level and improves the strength of the material. Five levels of pouring speeds and two types of material meant that matrix alloy and metal matrix composites [i.e. Al6061 + 4 % Cu and Al6061–4 % Cu–5 % SiCp-reinforced metal matrix composite processed using stir-casting technique] are under consideration as an input parameter. In the second experimentation, five levels of stirring speed and five levels of pouring temperatures at a constant pouring speed of 2.5 cm/s were considered as an input parameter throughout. Outputs are: hardness, impact strength and metal removal rate through electron discharge machining of metal matrix composites casting for each experiment. It ought to be over that metal that metal matrix composite is best in terms of hardness, impact strength and machining ability, compared to base matrix alloy in any respect of pouring speeds. The optimum worth of hardness, impact strength and higher metal removal rate is ascertained whether the pouring speed varies from 2 to 3 cm/s for metal matrix composite. It is inferred from the second section of the experiments that a pouring temperature range of 700–750 °C and 400–600 rpm stirring speed offers higher worth of mechanical [hardness and impact strength] and machining properties. The scanning electron micrographs [SEM] shows the result of pouring speeds, stirring speed and pouring temperature of metal matrix composites.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4313–4326

Effects of the Dynamic Tapping Process on the Biocompatibility of Ti-6Al-4V Alloy in Simulated Human Body Environment

- Sergio Luiz Moni Ribeiro Filho, Carlos Henrique Lauro

Abstract

The use of biomaterials depends on the high quality of the manufacturing and processing technology. Thus, the goal of this study is to contribute to the field of manufacturing of biomedical devices used in the human body. The forming and machining microtapping process (M3 thread and pitch 0.5 mm) in Ti-6Al-4V alloy was investigated. The design of experiments (DoE) was performed to identify the effects of factors (speed and type of process) on the thrust force, torque, and ultra-microhardness. The biocompatibility of the formed and machined thread surfaces was evaluated through potentiostatic polarization and electrochemical impedance tests. A simulated body fluid was used as the electrolyte. The experimental results showed that the rate of passivation of titanium alloy was highest for machined threads. Furthermore, the low level of speed (2 m/min) presented better surface finish and more complete fill rate of thread profile.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4327–4336

Effects of *n*-Butanol Blending with Jatropha Methyl Esters on Compression Ignition Engine

- Naveen Kumar, Harveer Singh Pali

Abstract

The diminishing oil reserves, environmental degradation and increasing prices of petroleum-derived fuels have necessitated the search for cleaner and renewable alternative fuels, such as biodiesel. In this context, the objective of this research is to evaluate the suitability of *n*-butanol as a blending stock in jatropha methyl ester (JME) for use in a C.I. engine as substitute of diesel and to evaluate the performance and emission characteristics of an unmodified diesel engine. Three blends of *n*-butanol–JME (5, 10 and 20 % *n*-butanol with JME on volumetric basis) were prepared. Fuel properties including calorific value, kinematic viscosity and density of blends were found to decrease with increasing percentage of *n*-butanol in JME. The brake thermal efficiency of the engine was higher for blends and was found to increase by increasing the percentage of *n*-butanol in the blends. Carbon monoxide (CO), the oxides of nitrogen (NO_X) and smoke opacity of blends were found lower than JME during the whole experimental range. However, unburnt hydrocarbon (HC) emission was found to have slightly increased. The experimental results suggested that the engine performance had improved and emissions have significantly reduced (except HC) with blends of *n*-butanol and JME in comparison with neat JME. Therefore, it could be concluded that *n*-butanol is a potential alternative fuel to be blended with JME for diesel engine application.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4337–4346

Determination of Thermal Conductivity of Closed-Cell Insulation Materials That Depend on Temperature and Density

- Murat Koru

Abstract

The main purpose of temperature insulation is to increase the thermal transport resistance of structural materials. The products used for thermal insulation are usually classified as either open cell or closed cell. Expanded polystyrene (EPS), extruded polystyrene (XPS), expanded nitrile rubber (ENR), polyurethane (PUR), polyethylene (PE) and ethylene vinyl acetate (EVA) are examples of some basic closed-cell insulation materials. Thermal conductivity varies depending on density, pore structure and dimensions, as well as the moisture content and temperature of a material. According to the American Society for Testing and Materials ASTM-C518 standard, thermal conductivity is only given for a temperature value of 10 °C. However, climate conditions, environmental temperature and moisture values vary over the course of the day. Therefore, it is important to determine the thermal conductivity of insulation materials that depend on temperature for different climate conditions. In this study, *k* values of EPS, XPS, ENR, PUR and EVA insulation materials are measured depending on the temperature and density by using heat flow meter methods according to EN 12664, 12667 and ASTM C518 standards. Experimental measurements are taken for temperatures ranging between −10 and −50 °C. From the results, it is observed that *k* values increase when the temperature increases and decrease when the density increases, for all insulation materials measured. Also, the most rapid change of the *k* value varying with density is seen with EPS-8.9 (kg/m^3) material, while the most rapid change of the *k* value varying with temperature occurs with PE-35 (kg/m^3) material. In contrast, the least deviation of the *k* value from the nominal value occurs for EVA-60.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4347–4357

Investigation on Mechanical and Tribological Behaviors of PA6 and Graphite-Reinforced PA6 Polymer Composites

- S. Sathees Kumar, G. Kanagaraj

Abstract

In this paper, the effects of adding graphite on the mechanical and tribological properties of polyamide 6 (PA6)-based composites were investigated. PA6 was reinforced with graphite by varying the weight proportions. The test specimens for mechanical and tribological experiments were molded in an injection molding machine. The mechanical properties of PA6 and graphite-reinforced PA6 polymer composites were investigated in terms of tensile strength, impact and hardness tests. The PA6 composite containing 20 wt% graphite revealed the better mechanical behaviors. The wear test was observed by using a pin-on-disk machine under dry sliding conditions at 5, 10, 20 and 30 N applied load values and sliding speed of 1000, 1500 and 2000 rpm. Scanning electron microscopy was utilized to examine the worn surfaces microstructure and wear mechanisms before and after the tribological test. The results showed that the reinforced PA6 polymer composites with 20 wt% graphite enhanced the best tribological behavior. The addition of graphite enhances the life condition of normal PA6 to a greater extent. Also, this composite exhibits stronger interfacial bonding characteristics with improved wear resistance.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4359–4369

Wave Characteristics of Nanotubes Conveying Fluid Based on the Non-classical Timoshenko Beam Model Incorporating Surface Energies

- R. Ansari, R. Gholami, A. Norouzzadeh

Abstract

The aim of this paper was to investigate the wave propagation of nanotubes conveying fluid by considering the surface stress effect. To this end, the nanotube is modeled as a Timoshenko nanobeam. According to the Gurtin–Murdoch continuum elasticity, the surface stress effect is incorporated into the governing equations of motion obtained from the Hamilton principle. The governing differential equations are solved by generalized differential quadrature method. Then, the effects of the thickness, material and surface stress modulus, residual surface stress, surface density and flow velocity on spectrum curves of nanotubes predicted by both classical and non-classical theories are studied. The first three fundamental modes including flexural, axial, and shear waves of nanotubes are considered.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4371–4381

Performance Evaluation of Two Meta-heuristic Schemes in Airfoil Design

- L. Prabhu, J. Srinivas

Abstract

This paper presents an optimized design of airfoil cross section using two different meta-heuristic schemes with micro-population. Geometrical coordinates of airfoil section are obtained for achieving the desired target pressure distribution and minimum lift-to-drag ratio. The flow solution for a given angle of attack and free-stream velocity is obtained by using XFOIL and with coupled panel–boundary layer (viscous–inviscid interaction) method. Two optimization schemes namely micro-genetic algorithms and micro-differential evolution with five basic airfoil configurations are employed to achieve required objectives with certain constraints in each case. In minimizing the computation time and effort, a surrogate model based on three-layer perceptron neural network is developed and the results are also reported. The optimized section is analysed finally using computational fluid dynamics solution to know the correctness of the optimized data.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4383–4390

Optimization of Dry EDM Process Parameters Using Grey Relational Analysis

- N. Pragadish, M. Pradeep Kumar

Abstract

In this work, a modified tool design was adopted to drill holes in the dry EDM process. Experiments were conducted on AISI D2 steel using a copper electrode as the tool. Taguchi's L27 orthogonal array was used to design the experiments. Discharge current (*I*), pulse on time (T_{ON}), Voltage (*V*), pressure (*P*) and tool rotational speed (*N*) were chosen as the various input parameters. The grey relational analysis was used to determine the optimal level of parameters to achieve better results. The experimental data were also statistically analysed by using the ANOVA test. The current (*I*) was found to be the most influential parameter followed by the pressure (*P*). The surface morphology and microstructure of the machined surface were analysed, and it was found that better surface characteristics were exhibited on the surface machined using the optimal level of parameters.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4391–4395

Facile Synthesis and Characterization of Aluminum/Graphene Nanosheets Composites

- Nashmi H. Alrasheedi

Abstract

The strength and hardness of the composites were investigated. The present results showed that the strength and hardness of the composites increased with the addition of graphene nanosheets. Graphene nanosheets may act as obstacles for the dislocation movement and finally promote for the dislocations accumulation having an important role for the improvement of mechanical properties of the composites. The difference in thermal expansion coefficient was also responsible for the improvement of the strength and hardness of the composites.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4397–4410

A Nonlinear Model for Incorporating the Coupled Effects of Surface Energy and Microstructure on the Electromechanical Stability of NEMS

- Maryam Keivani, Ali Koochi, Hamid M. Sedighi

Abstract

Surface energy and size phenomenon can play significant roles in physical performance of nano-electromechanical systems. Herein, the static and dynamic pull-in behavior of nano-tweezers and nano-switch fabricated from conductive cylindrical nano-wires is studied. The Gurtin–Murdoch surface elasticity in combination with the couple stress theory is employed to incorporate the coupled effects of surface energy and microstructure dependency (size phenomenon). Using Green–Lagrange strain, the higher-order surface stress components are incorporated in the nonlinear governing equation. The effect of gas damping is considered in the model as well as structural damping. The governing equation is solved using the reduced order method. The effects of various parameters on the static and dynamic pull-in parameters, phase plans and stability threshold of the nano-structures are demonstrated.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4411–4430

A Hybrid Fuzzy MCDM Approach to Identify Critical Factors and CO_2 Capture Technology for Sustainable Iron and Steel Manufacturing

- M. Abdul Quader, Shamsuddin Ahmed, M. Abdul Quader

Abstract

The iron and steel industry is known as the largest energy-consuming and CO_2-emitting manufacturing sector in the world. Therefore, investigation, development and deployment of alternative energy-efficient iron-making breakthrough technologies along with CO_2 capture technology are receiving high priority to mitigate environmental concerns by reducing pollutants and greenhouse gas emissions of around level 50 % by 2050 compared to 2007. This research evaluates the CCS systems in the iron and steel industry considering four prominent aspects (engineering, economic, environmental and social) of sustainability using questionnaire with group of experts having relevant experience. A novel hybrid multi-criteria decision model is proposed integrating Delphi, 2-tuple decision-making trial and evaluation laboratory, and extent analysis method on fuzzy AHP to select the dimensions and critical factors for evaluating alternative iron-making technologies with CCS systems. Case studies are conducted in iron and steel industries in Malaysia and Bangladesh to illustrate the proposed framework and to demonstrate its usefulness and validity.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4431–4439

Experimental Study on Wire Electrical Discharge Machining of Tapered Parts

- G. Selvakumar, K. Bravilin Jiju

Abstract

This experimental work is intended to optimize the parameters of wire electrical discharge machining process by considering the influence of input parameters such as pulse on time, peak current, wire tension and the various taper angles on the performance measures namely cutting speed, surface roughness (Ra) and the taper error. The taper angle is an imperative control factor dictated by the job geometry. The taper error has been a critical response in view of tool and die making industry that has been addressed in this work. Experiments have been performed on AISI D3 tool steel by employing Taguchi's L9 orthogonal array. Later, parametric analysis has been performed. The analysis of the experimental results revealed that the pulse on time has been the most influencing factor for the cutting speed and surface roughness, while the taper angle to be cut on the workpiece has been the significant factor for taper error. Finally, Taguchi-based grey relational analysis has been employed for carrying out simultaneous optimization of the responses.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4441–4448

Application of Electric Resistance Heating Method on Titanium Hot Forming at Industrial Scale

- Fahrettin Ozturk, Remzi Ecmel Ece, Naki Polat

Abstract

In this study, hot forming of DIN WL 3.7024 commercially pure titanium with a sheet thickness of 0.6 mm was performed by electric resistance heating. The sheet materials were heated at 600, 650, and 680 °*C* and then hot formed with an industrial press. Grain size measurement and XRD analysis were performed for each forming temperature in order to investigate microstructure and phase changes. Results indicate that no microstructural changes have occurred at the mentioned temperature range. It was confirmed that heat treatment before deformation did not contribute any noticeable phase change. However, minor grain growth and traces of titanium oxides were observed. Electrical resistance heating method was found to be applicable for industrial size part production with effective elimination of springback.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4449–4462

Simulating the Manipulation of Various Biological Micro/Nanoparticles by Considering a Crowned Roller Geometry

- M. H. Korayem, M. Taheri

Abstract

Nowadays, many researchers have become interested in simulating the manipulation of biological micro/nanoparticles by means of the atomic force microscope. However, in practice, this matter has run into many obstacles, and there are still numerous unknowns and ambiguities regarding the interactions in bioenvironments between different biological micro/nanoparticles with complex and precise shapes. In the past, many simulation works have been performed on the manipulation of biological particles, and most of these works have been conducted on various particles with presumed spherical, and sometimes cylindrical, shapes. But, as we know, the real biological particles have different and complex forms. Therefore, in this paper, first, gold nanoparticles and three different biological particles such as yeast, deoxyribonucleic acid and platelet, which have different shapes, are introduced as the target particles in the manipulation process, and then, the simulations are performed by considering a crowned roller geometry for these particles, and the critical force and time of manipulation in air, water, alcohol and plasma environments are computed. Finally, by reducing the length of the cylindrical section of the crowned roller and bringing the shape closer to a sphere, the obtained results are compared with the existing results for the manipulation of spherical particles and validated.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4463–4476

Numerical Modeling of the Flow Inside a Centrifugal Pump: Influence of Impeller–Volute Interaction on Velocity and Pressure Fields

- Issa Chalghoum, Hatem Kanfoudi

Abstract

To analyze the centrifugal pump NS32 using numerical model and predicting the performance of a fluid flow in complexes geometry, we conduct several numerical simulation with different turbulence models. To evaluate the effect of turbulence model on the flow characteristics, the k-ε ε , SST and SST-CC turbulence models were tested. The simulations have been made using the multiple reference frames (MRF) technique to take into account the impeller–volute interaction. The computational domain is composed of two parts, a stator (volute) and a rotor (impeller). The impeller–volute interaction has been simulated using the frozen–rotor interface model for the steady-state calculations and the Rotor–Stator model for the unsteady ones. The distributions of velocity and pressure are computed using the Reynolds-Averaged Navier Stokes approach for a wide range of operating flow rates. To analyze the internal flow, simulation was carried out for several relative positions between the impeller blades and the volute tongue. In fact, the pressure fluctuations were numerically measured at five locations along the impeller and compared to experimental measurements. In addition, the unsteady pressure head evolution versus time was followed up. Then, an experimental validation of global and local characteristics of the pump was carried out.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4477–4486

Spaceborne Push-Broom Image Guidance, Attitude Realization Errors: A System Engineering Approach

- Erhan Topal, Orhan Akyılmaz

Abstract

During the preliminary phase of a satellite system design, a complete model of the satellite may not be available due to the uncertainties in the design. As a remedy, a simple methodology based on system engineering approach may be used to rapidly determine pointing requirements to initiate requirement analysis phase of the satellite design. For this purpose, the effects of the pointing accuracy and stability requirements on the spaceborne image acquisition are identified for the push-broom sensor applications. Further, image guidance algorithms are identified to obtain proper attitude profiles which are used in line of sight analysis. To determine the relationship between the geometrical properties/requirements of the images and the pointing requirements, line of sight analysis is carried out and implications for the selection of the specifications of the electro-optic payload equipment are discussed. Moreover, a simplified mathematical model is established in order to determine satellite stability requirement related to the scan speed of the electro-optic payload equipment. The method is applied to an Earth observation satellite with a push-broom electro-optic sensor which has a sub-meter level ground sampling distance. The presented analysis should also be of interest to optical Earth observation satellite system mission analysis and general satellite design, particularly attitude and orbit control sub-system design.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Dynamics Analysis and Robust Control for Electric Unicycles Under Constrained Control Force

- Pang-Chia Chen, Shih-Ming Pan, Hung-Shiang Chuang

Abstract

This paper investigates the dynamics analysis and robust control law design for the proposed schematic design of electric unicycles. The schematic design of the proposed unicycle possesses a supportive seat for the rider and is also equipped with a handling rod for maneuvering, similar to a Segway device. First, this paper conducts an analysis and comparison of the dynamics properties and derivation of the nonlinear governing equation for the unicycle. Next, it emphasizes the development of an input-constrained robust controller design for the proposed configuration of the electric unicycle. The issues investigated in this paper include the dynamics property analysis and comparison, nonlinear dynamics derivation, robust control diagram formulation, controller synthesis regarding linear matrix inequalities (LMIs), and time response simulations and discussions. In this control law design via LMIs, the desired performances of: (1) relative stability or decay rate for command tracking capability; (2) disturbance attenuation for robustness against uncertainty parameters; and (3) an accommodation of control effort constraints under the regulation or command tracking of certain initial state condition are investigated and demonstrated using time response simulations of the controlled unicycle dynamics.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Experimental Study on Thermal Performance of a Novel Solar Air Collector Having Conical Springs on Absorber Plate

- Mesut Abuşka, Mehmet Bahattin Akgül

Abstract

This study presents a thermal analysis for a novel type of solar air heater. The thermal performance of a solar air collector having conical springs on the absorber plate is determined experimentally. A flat absorber plate (Type I) and the absorber plate with mounted conical springs (Type II) are designed and constructed, and their thermal performance is tested in the collectors. Experiments are performed for air mass flow rates of 0.06 and 0.07 kg/s. Thermal efficiency and collector outlet temperature are the main indicator for determining thermal performance. The efficiencies and energy distribution ratios are determined and compared for the collectors. The results of the experiments show that a substantial enhancement in the thermal efficiency is obtained with conical springs. Also, to this thermal efficiency increases with the rise of mass flow rate.

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Research Article - Mechanical Engineering
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Heat Transfer and Friction Factor Study of a Solar Air Heater Having Multiple Arcs with Gap-Shaped Roughness Element on Absorber Plate

- Navneet Kumar Pandey, V. K. Bajpai

Abstract

In this study, effect of roughness parameter on heat transfer and pressure characteristics has been studied. Multiple arc-shaped roughness with gaps was used as roughness element in this study. This roughness geometry was created on the underside of plate. The selected parameters were based upon operating conditions and practical feasibility in solar air heaters. The experiments were done for Reynolds number (*Re*) varies from 2100 to 21,000, relative gap width (*g*/*e*) ranges from 0.5 to 2, relative gap distance (*d*/*x*) in the range of 0.25–0.85, relative roughness width (*W*/*w*) in the range of 1–7. The fixed parameters were arc angle (α) of 60°, relative roughness height (*e*/*D*) of 0.044, and relative roughness pitch (*p*/*e*) of 8. The thermohydraulic performance parameter was found maximum for *d*/*x*, *g*/*e* and *W*/*w* values of 0.65, 1.0 and 5, respectively.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Comparative Assessment on Machinability Aspects of AISI 4340 Alloy Steel Using Uncoated Carbide and Coated Cermet Inserts During Hard Turning

- Anshuman Das, Akash Mukhopadhyay

Abstract

This paper compares the performances of uncoated carbide and coated cermet inserts for varied machinability aspects throughout the machining of hardened steel (AISI 4340, 48 HRC) in the dry cutting surroundings. Cutting speed, feed, and depth of cut were thought of as major governing parameters. Workpiece surface temperature, machining forces, and tool flank wear were taken as measures to check the performance estimation of various cutting inserts during this work. All the three input variables were ascertained to possess influence over workpiece surface temperature, feed, and radial force in case of uncoated carbide and cermet. Cermets exceeded the performance of carbides for flank wear, cutting force, and workpiece surface temperature, although carbides outperformed cermets concerning feed and radial force. The depth of cut was found to be the most vital, once feed and cutting forces were involved, whereas it had been true for radial force using carbides. Cutting speed affected workpiece surface temperature and flank wear for carbides the most; in the meantime, this was the same once considering the radial force with cermets. The feed was the foremost vital parameter, while the flank wear of cermets was taken into account. ANOVA, regression analysis, and main effect plots were accomplished using the MINITAB-16 software.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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An Experimental Approach to Determine the Critical Depth of Cut in Brittle-to-Ductile Phase Transition During End Milling of Soda-Lime Glass

- A. K. M. Nurul Amin, Mst. Nasima Bagum

Abstract

Plastic deformation is a predominant material removal mechanism in machining of ductile materials, but it is a big challenge to achieve it in cases of brittle materials. Soda-lime glass is a very useful engineering material. Due to its favorable thermal, corrosion resistance and fine chemical properties, its common applications are in the manufacture of products like mirrors, lenses, semiconductor, and optical, bio-medical and microelectronics components. Nevertheless, owing to its brittleness due to its low fracture toughness, machining of soda-lime glass is practically impossible under normal cutting conditions. Though recent investigations have shown that machining of such brittle material is possible using ductile mode machining under controlled cutting parameters and tool geometry, it remains a challenging task. This paper focuses on identification of the critical axial depth of cut under specific feed per tooth and cutting speed in high-speed end milling of soda-lime glass. A two-fluted solid end mill of 4 mm diameter was used with cutting speed ranging from 377 to 628 m/min and feed rate from 5 to 20 mm/min to investigate the phenomenon of transition from plowing to ductile and ductile to brittle machining mode. The work piece was placed at a specific angle to facilitate machining at gradual increment in depths for different feed rates and cutting speeds combinations. At the highest available cutting speed, three phases (plowing, ductile, and brittle) were observed at a specific feed rate, resulting in a critical depth of cut 51.943 μ µ m and chip thickness approximately 198 nm.

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Research Article - Mechanical Engineering
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Optimization of Mechanical Properties of Friction Stir Spot Welded Joints for Dissimilar Aluminum Alloys (AA2024-T3 and AA 5754-H114)

- Muna Khethier Abbass, Sabah Khamass Hussein

Abstract

In this work, friction stir spot welding (FSSW) was performed for dissimilar aluminum alloys (AA2024-T3 and AA5754-H114) sheets of 2 mm thick at different tool rotational speeds (800, 1000 and 1250 rpm), plunging times (30, 60 and 90 s) and tool pin profile or geometry (threaded cylindrical with flute, tapered cylindrical and straight cylindrical). Process parameters were optimized by using Taguchi technique and depending on design of experiment (DOE), and data analysis based on the Taguchi method is performed by utilizing the Minitab 17 to estimate the significant factors of the FSSW and main effects using few experimental tests only. It was found that maximum shear force was (2860 N) obtained at best welding process parameters: 800 rpm of rotation speed, 60 s of plunging time and taper cylindrical pin which are obtained from the DOE. Pareto chart of the standardized effects of tensile shear results showed that the pin profile was the most effective parameter than other welding parameters (rotation speed and plunging time). Also it was found that the contribution percentage was 61.5% for pin profile followed by tool rotation speed 20.1% and plunging time 18.4%.

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Radiation and Diffraction Velocity Potentials for Multi-hulled Vessels in 2-D

- M. Saeed Khalid, Salman Nisar

Abstract

The blended approach has the potential to provide the engineering solutions for design optimization keeping in view the current demand of the extensive computer resources for fully nonlinear computations. This study investigates two-dimensional boundary value problem for multi-bodies radiation and diffraction velocity of multi-hulled vessels using blended method. In blended scheme, fully nonlinear Euler equations of motion are solved with nonlinear hydrodynamic forces acting on multi-hulled vessels. Lid is employed over the body segment to suppress the eigenvalue mode, thus eliminating singularities in source strength being used on multi-hull bodies presenting geometrical discontinuities. Comparison between the blended technique and its validation against analytical calculations and experimental work are presented and found in good agreement. It is concluded that blended technique is an efficient and accurate alternate method to provide time simulations of ship motion and other essential parameters for design optimization.

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Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4583–4596

A Study on Effect of Seepage Direction on Permeability Stress Test

- Cun Zhang, Shihao Tu

Abstract

Due to different pore or layer structures in different directions, reservoir rocks are often anisotropic in permeability, causing permeability tests to differ between vertical and radial permeability. Except for the anisotropy of rock mass, the seepage test direction may also have an impact on the connection between stress and permeability tests. In order to illustrate the reasons for the difference between vertical and horizontal permeability test results, this article comparatively analyses the simulation results between the vertical and horizontal direction, using the discrete element method with an isotropic model. A further permeability stress test experiment was carried out in a different direction with an improved multi-functional outburst research rig. The results show that the horizontal contact hydraulic aperture had a higher sensitivity to axial stress than the vertical contact, which made the axial permeability more sensitive to the confining stress than radial permeability. In contrast to the axial stress, as the confining stress increased, the vertical contact hydraulic aperture gradually decreased, while the horizontal contact hydraulic aperture only changed a small amount. This meant that the radial permeability was more sensitive to axial stress than axial permeability. Additionally, the reducing speed of the axial permeability was very slow or even zero, with the axial stress increasing when the axial stress was less than the confining stress. In general, the seepage test direction was a very important factor, and it should be considered in the study of the relationship between stress and permeability.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Application of the Independent Components Analysis in the Reconstruction of Acoustic Sources in Duct Systems

- Raja Dhief, Mohamed Taktak

Abstract

The development of new reconstruction methods of acoustic sources presents a domain of great interest seen its applications in reducing the noise, realizing the acoustic comfort and diagnosing systems. The duct systems are used in several systems such as building, ventilation and aeronautic systems. In this work, a new reconstruction technique of the acoustic sources in duct systems is presented. This technique is based on the multimodal scattering matrix that provides an estimation of the acoustic power dissipation and attenuation in the case of a point acoustic source. These energetic parameters are then injected into an identification technique based on the independent component analysis technique allowing the reconstruction of original sources. The method was applied to a cylindrical rigid-lined-rigid duct element. A comparison between the estimated and imposed acoustic pressures emitted by point sources is presented. This comparison showed that the proposed method gives good results, and the original signals are well reconstructed.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4607–4612

Parametric Optimization of Laser Beam Micro-Grooving of Hydroxyapatite

- Rajeev Ranjan, Ajay Mishra

Abstract

Hydroxyapatite is the most widely employed biomaterial for the reconstruction and repair of bone tissue defects. Besides, it is acknowledged that generating a three-dimensional micro-grooving on hydroxyapatite is a challenging task. Hence, this paper analyses the experimental results obtained after performing micro-grooving operation on bioceramics (hydroxyapatite) through Nd:YAG laser beam machine in order to derive optimal parametric settings for the said machining operation. Initially, it is observed from the machining responses obtained after the conduction of experiments that there is a group of process parameters which meet the challenges of machining hydroxyapatite. Single-objective optimization was performed to determine the optimum level of these process parameters. The setting of machining parameters has been determined by using L_9 orthogonal array.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4613–4624

Compact Modified Implicit Finite Element Schemes for Wave Propagation Problems with Superior Dispersive Properties

- Hafiz Abdul Wajid, Ayesha Sohail

Abstract

In this paper, we study in detail dispersive properties of the widely used implicit scheme called Newmark trapezoidal rule in conjunction with modified mass matrix to enjoy superior dispersive properties keeping the finite element stencil compact. We call such schemes *compact modified implicit finite element scheme*. In case of one-dimensional propagation, following contributions are made: (a) for modified finite element (MFE) scheme, we find an optimal value of dispersion controlling parameter depending on Courant–Friedrichs–Lewy (CFL) number which provides exact solutions at the nodes of spatial gird; (b) for standard finite element (SFE) scheme optimal value of CFL number is obtained which provides fourth-order accurate solutions. Moreover, in case of two-dimensional propagation following contributions are made: (c) we have found optimal value of CFL number for all angles in case of both SFE and MFE schemes; (d) superior dispersive behaviour is evident in case of MFE scheme in comparison with SFE scheme. Furthermore, the MFE scheme can be efficiently implemented using non-standard quadrature rules or just updating mass matrix which does not require to write brand new code and makes it computationally very attractive. Also for specific value of parameter, i.e. $\tau = 0$, the MFE scheme leads back to the SFE scheme.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4625–4634

Numerical Study of Flow Over Annular Elliptical Finned Tube Heat Exchangers

- H. Nemati, S. Samivand

Abstract

In the present study, performance of a tube row with annular elliptical fin was compared to the circular type. It was shown that heat transfer coefficient and pressure drop are functions of ratio of horizontal diameter to vertical diameter. It means that not only the diameter ratio, but also ellipse orientation affects heat transfer and pressure drop. Interestingly, it was found out that the pressure drop may be as low as one half of a circular fin tube. Moreover, with the same incoming air velocity, heat transfer coefficient on vertical fin is higher than circular type. Because of the lower pressure drop, higher incoming velocity may be applied, and therefore, higher heat transfer can be achieved. Altogether, tube with annular elliptical fin may be a good candidate for circular type when there is space restriction or severe limitation on pressure drop.

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Research Article - Mechanical Engineering
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Effect of Hydrogen–Oxygen Mixture Addition on Exhaust Emissions and Performance of a Spark Ignition Engine

- Mohamed Brayek, Mohamed Ali Jemni

Abstract

In the last decade, there has been a major ascending interest in reducing the polluting concentration and fuel consumption of internal combustion engines. The solution proposed in this research project was to integrate a hydrogen and oxygen mixture H_2/O_2 H2/O2 , obtained through an electrolysis process of water, as supplementary fuel, in a 93 cm^3 3 gasoline engine. Several experimental tests were carried out under different engine loads (0, 20, 50, 80 and 100 %) in order to investigate the effect of H_2/O_2 H2/O2 addition on the engine performance characteristics and the exhaust gas concentration. At engine loads more than 20 %, tests showed that adding H_2/O_2 H2/O2 reduced the brake-specific fuel consumption by an average of 7.8 %. They also showed that the alternative fuel was very efficient in reducing the concentration of pollutant emissions in the exhaust gases: hydrocarbon (HC) concentration diminished by an average of 18 %, carbon monoxide (CO) concentration decreased by an average of 31.8 %, and CO_2 CO2 concentration decreased up to 30 %. However, at low engine loads, NO_x NOx concentration decreased by an average of 26 %, but it increased significantly with the increase in engine loads (exceeding 80 %).

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Research Article - Mechanical Engineering
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Thermoeconomic Optimization of a 450 MW Natural Gas Burning Steam Power Plant

- Lucky Anetor, Edward E. Osakue

Abstract

The theory of thermoeconomics and local optimization were used to investigate how the cost of the resources consumed by a 450 MW power plant varies with the unit cost of the resources consumed, the technical production coefficients of the productive structure and/or the external demand for the products. In order to accomplish this, the costs of exergy of the productive structure were analyzed under three different conditions by using the relevant characteristic equations. In general, it was found that the thermoeconomic cost of a flow consists of two parts, namely the monetary cost of the fuel exergy (natural gas in the present study) needed to produce the flow, that is, its thermoeconomic cost and the costs due to the productive process (cost of capital equipment, maintenance, etc.). The results show that the steam leaving the boiler has the lowest exergy cost, while the condenser has the highest. The sequential quadratic programming (SQP) algorithm was used to obtain the optimized solutions of each major component of the plant. It was found that substantial operational and capital cost benefits were realized by optimizing most of the major plant equipment (boiler, turbines, feedwater heaters and the pumps). However, optimization of the condenser did not yield any cost benefit in capital equipment cost, but did produce some savings in operational cost.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4661–4667

Carburising of Low-Carbon Steel Using Carbon Black Nanoparticles

- Mohsin Ali Raza, Husnain Asgar, Ayman Abdullah

Abstract

Pack carburising is commonly used to increase wear resistance and impact toughness of low-carbon steels by increasing carbon content of the surface. Pack carburising is a time-consuming process which limits its commercial applications. The aims of present study were to increase the efficiency of pack carburising process and to decrease the time of carburising. Pack carburising of low-carbon steel was carried out by embedding low-carbon steel samples in carburising compound consisting of carbon black nanoparticles as carbonaceous matter and barium carbonate as energiser. The effect of time of carburising and carburising medium on microstructure, hardness and case depth of the samples was investigated. The samples carburised using carbon black nanoparticles showed higher hardness than the samples carburised using acetylene gas or charcoal-based carburising mixture. The case hardness of low-carbon steel increased from 140 to 275 HV after just 3 h of carburising in carbon black nanoparticles-based carburising mixture, which is 44 and 85 % higher than the samples carburised for 3 h using acetylene gas and charcoal-based carburising mixture.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Investigation of Boron Addition on Densification and Cytotoxicity of Powder Injection Molded 316L Stainless Steel Dental Materials

- Muhammad Aslam, Faiz Ahmad, Puteri Sri Melor Binti Megat Yusoff

Abstract

Powder injection molding (PIM) is a hybrid of powder metallurgy and plastic injection molding. It is used to develop metallic molded parts with intricate shapes and with improved properties compared with those offered by their wrought counterparts. PIM dental implants should exhibit biocompatibility, high density, good dimensional control, homogeneous properties and low manufacturing cost. In order to achieve these properties, the effect of boron (additive) addition on sintered density and of process effects on the biocompatibility of sintered implants was studied. In activated sintering, additives are used in small quantities to modify the sintering behavior of stainless steel. A constant amount of nanosize elemental boron (0–1.5 wt%) was admixed with 316L stainless steel and was compounded with complex binder to develop feedstocks using a z-blade mixer. Optimal solvent debinding parameters followed by an optimal sintering cycle played a vital role in the development of biocompatible and densified 316L stainless steel dental implants. Although all boron-containing formulations were injection-molded successfully, only PWA-0.5B-1230 samples were able to retain their shapes after sintering. It was concluded that 0.5 wt% addition of elemental boron favored the formation of 316L stainless steel with a sintered density of up to 98.5 % through the formation of a complex iron boride compound (B_6Fe_{23}) on the grain boundaries during the sintering process. The formation of a passive layer on the outer surface of implants was controlled using optimal sintering parameters. In in vitro analysis, the cytotoxicity assessment of sintered dental implants materials was determined using the direct and indirect contact techniques.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
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Study of Thermo-Mechanical Properties of HTPB–Paraffin Solid Fuel

- Yogesh Kumar Sinha, B. T. N. Sridhar, R. Kishnakumar

Abstract

The classic hybrid rocket which employs hydroxyl-terminated polybutadiene (HTPB) fuel is characterized by low ablation rate. To enhance the ablation rate, paraffin was added to the HTPB. The enhancement is due to the low viscosity and low surface tension of the surface melt layer of the paraffin during combustion. This paper reports the thermal properties, mechanical properties and ablation rate when HTPB was blended with different percentage of paraffin. The thermal stability of the blends was investigated using differential scanning calorimetry (DSC) and thermogravimetry analysis with constant heating rate $27 \mathrm{Kmin}^{-1}$ under argon atmosphere. The thermal stability of the blends decreased with the increase in paraffin content. The constant pressure specific heat capacities (C p) Cp) of the fuel blends were measured using DSC in the temperature range of 80–250∘ ∘ C. The theoretical model of the ablation rate of HTPB–paraffin blends using activation energy, pre-exponential factor and C p Cp was studied. The results indicated a higher regression rate of 6–33% with the increase in paraffin. The combustion enthalpy of HTPB blended with paraffin is determined by oxygen bomb calorimeter at a constant volume. The standard combustion enthalpy of pure HTPB and paraffin was found to be 37.9 and $41.9 \mathrm{MJkg}^{-1}$. The data revealed that blending of HTPB with paraffin, resulted an increase in the heat of combustion by 2–9%. The blending of the paraffin will reduce the mechanical strength. Studies were also carried out to find out the dynamic mechanical properties as the result of blending paraffin to HTPB using dynamic mechanical analysis. The temperature was held constant at room temperature and the frequency scan ranged from 1 to 10Hz in steps of 1Hz. The results show that the presence of paraffin in HTPB binder has considerable effect on the dynamic response of the material.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4691–4700

Transpiration and Thermophoresis Effects on Non-Darcy Convective Flow Past a Rotating Cone with Thermal Radiation

- B. Mallikarjuna, A. M. Rashad

Abstract

In this article, mathematical model is developed for transport phenomena in an incompressible viscous fluid regime adjacent to a rotating vertical cone with thermal radiation and transpiration effects. The governing equations for the pertinent geometry are non-dimensionalized by employing specified transformations. A set of resultant equations are solved by numerical method. The solutions of this model are carried out under physical realistic boundary conditions to compute velocities, temperature and concentration functions distributions. The results are compared with previously available existing results. The excellent agreement has been found. The effect of thermal radiation, transpiration (surface injection/suction) and Forchheimer parameters, thermophoretic coefficient and relative temperature difference parameter on flow characteristics is illustrated graphically. It is observed that substantial influence has been exerted on flow characteristics, heat transfer rate (Nusselt number) and mass transfer rate (Sherwood number) for various values of transpiration parameter. The wall thermophoretic velocity changes according to the variation of physical parameters.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
November 2016, Volume 41, Issue 11, pp 4701–4718

Modeling and Prediction of Effects of Time-Periodic Heating Zone on Mixed Convection in a Lid-Driven Cavity Filled with Fluid-Saturated Porous Media

- Fatih Selimefendigil

Abstract

In this study, the effects of time-dependent temperature boundary condition on the fluid flow and heat transfer characteristic in a lid-driven square cavity filled with fluid-saturated porous media were numerically investigated. The top horizontal wall of the cavity is moving with constant speed and maintained at constant cold temperature, while the bottom wall is at hot temperature with a sinusoidally varying time-dependent part. On the other walls of the cavity, adiabatic boundary conditions are assumed. The governing equations of mass, momentum and energy were solved with a commercial solver using finite element method. Numerical simulations were performed for various values of the Richardson number from 0.1 to 50, Darcy number from 10^{-4} to 10^{-2}, Prandtl number from 0.05 to 10, amplitude from 0.2 to 0.8 and non-dimensional frequency from 0.01 to 1 of the time-periodic heating zone. It is observed that increasing the Darcy number and Prandtl number enhances the heat transfer and flow strength, while the effect is opposite for Richardson number. Compared to steady case, there is negligible influence of periodic heating zone on the heat transfer enhancement for all values of Darcy number and Richardson numbers less than 1, Prandtl number less than 1.4 and non-dimensional frequency less than 0.5. It is observed that the fluid flow and temperature field within the cavity can be controlled with frequency and amplitude of time-dependent boundary condition. Furthermore, a reduced-order model of the system with nine modes and with dynamic boundary condition explicitly written based on proper orthogonal decomposition is proposed to predict the thermal performance of the system. This approach gives satisfactory results in terms of local and averaged Nusselt numbers.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Mechanical Engineering
December 2016, Volume 41, Issue 12, pp 5215–5231

Multi-objective Optimal Design of a 2-DOF Flexure-Based Mechanism Using Hybrid Approach of Grey-Taguchi Coupled Response Surface Methodology and Entropy Measurement

- Shyh-Chour Huang, Thanh-Phong Dao

Abstract

A large displacement and a high first natural frequency are two main concerns for any flexure-based positioning system. A two-degree-of-freedom (DOF) flexure-based mechanism (FBM) with a modified double-lever amplification mechanism is first designed. This study then proposes a multi-objective optimal design of the 2-DOF FBM using the hybrid approach of grey-Taguchi coupled response surface methodology and entropy measurement. The design variables of the 2-DOF FBM include the thickness of the flexure hinges and the length of lever amplification, both of which play vital roles in determining quality responses. The quality responses of the 2-DOF FBM are assessed by measuring the displacement and first natural frequency. The experimental plan is carried out using the Taguchi L 25 L25 orthogonal array. An integrated approach of grey-Taguchi- based response surface methodology and entropy measurement is then applied for the multi-objective optimization of the 2-DOF FBM. To illustrate the relation between the design variables and the output responses, mathematical regression models are developed. The entropy measurement technique is applied to calculate the weight factor corresponding to each response. Then, an analysis of variance (ANOVA) is conducted to determine the significant parameters affecting the responses. In addition, the ANOVA and experimental validations are conducted to validate the statistical adequacy and the prediction accuracy of the developed mathematical models, respectively. The results reveal that the regression models have good statistical adequacy and excellent prediction accuracy. The confirmation results of the grey relational grade fall within 95 % of the confidence interval. It is strongly believed that the proposed approach has great potential for the optimal design of related flexure-based mechanisms.