ABSTRACTS

Emil Szymczyk, Maciej Rećko, Kazimierz Dzierżek, Karol Sapiołko
An Innovative Approach to Fabrication with Photo-Cured Resins by Shell-Printed-Core-Casting

Modified LCD-based method was used to print three-dimensional (3D) elements. This innovative method combines printing the external shell and filling, thus obtaining mould by casting resin. In order to compare the properties of prints obtained with this method with the ones fabricated in a standard procedure, we conducted bending tests of vertically/horizontally printed and shell-printed cast specimens. The shell-cast samples showed higher flexural strength and larger values of apparent Young's modulus. The presented results also concern the kinetics of curing samples obtained with different fabrication routes.

Mariusz Leus, Paweł Gutowski, Marta Rybkiewicz
Effectiveness of Friction Force Reduction in Sliding Motion Depending on the Frequency of Longitudinal Tangential Vibrations, Sliding Velocity and Normal Pressure

The article presents the results of experimental research and simulation analyses of the influence of slip velocity, normal pressures and vibration frequency on the effectiveness of friction force reduction carried out in sliding motion in the presence of forced tangential vibrations. In experimental studies, changes in the driving force were measured during the slip of the upper body over the vibrating lower body. The direction of these vibrations was parallel both to the contact plane and to the direction of movement of the shifted body. The simulation tests were carried out in the Matlab/Simulink environment through the use of numerical procedures that were specially created for this purpose. Dynamic friction models considering the tangential compliance of contact and the phenomenon of pre-sliding displacement were used for calculations. The paper presents the designated values of the so-called coefficient of average friction force reduction in sliding motion for the following friction pairs: steel C45–steel C45, steel C45–cast iron GGG40 and steel C45–polytetrafluoroethy-lene PTFE (Teflon). The results of numerical analyses were in good agreement with those of experimental tests. A significant dependence of the level of average friction force reduction on the frequency of forced vibrations, sliding velocity as well as the kind of sliding pair material, and normal pressures was shown.

Wojciech Sikora
Experimental Investigation of a Uniaxial Dielectric Elastomer Generator

The widespread use of battery-powered electronic devices creates the need to develop methods to extend their maximum oper-ating time. This can be achieved by using ambient energy, which would otherwise be dissipated. The conversion of energy, usually mechanical energy, into electric energy takes place in energy harvesters. Energy harvester systems based on a dielectric elastomer (DE) are a relatively new field that is being constantly developed. Due to their features, dielectric elastomer generators (DEGs) may complement the currently dominant piezoelectric harvesters. The major feature of employing a hyperelastic material is that it allows relatively large displacements to be utilised for generating energy, which is impossible in the case of piezoceramics. This article presents a DEG designed to operate under uniaxial tensile loads and which has a multilayer structure, describes the general operating principles of a DEG, explains the construction and assembly process of the investigated design and shows the electric circuit necessary to properly direct current flow during the DEG operation. The experimental part consists of two series of tests based on a central composite design (CCD). The objective of the first part was to map a capacitance response surface of the DEG in the selected range of the cyclic mechanical load. The second part concerned the amount of generated energy for the specific load case as a function of operating voltages. The result of the work is the formulation of regression models that allow the characteristics of the presented DEG design to be identified.

Ahmed Kechra, Ahmed Bouzidaine
Semi-Analytical Analysis of a Rigid Rotor Mounted on Four-Pad Hydrostatic Squeeze Film Damper with Single-Action Membrane-Type Restrictors

The current study is a semi-analytical analysis of the vibratory behaviour of a rigid vertical rotor, supported by a new hydrostatic squeeze film damper (HSFD), consisting of four hydrostatic pads fed through four single-action membrane-type variable-flow restrictors. The Reynolds equation based on the Newtonian theory of lubrication is used and then adapted to our work, which is solved semi-analytically. In this paper, we study the effect of different parameters, the eccentricity, membrane geometry coefficient, pressure ratio and rotational speed, on the main characteristics of a four-pad HSFD. From the simulation results, we observed that at the critical speed, the rigid rotor fed by membrane restrictor shows a decrease in transmitted forces, a decrease in vibration response and good system stability as compared with a similar rotor fed by capillary restrictor. From the results reported in this work, we observed good agreement between our study and other works.

Paulina Pietruś, Piotr Gierlak
Influence of the Manipulator Configuration on Vibration Effects

Vibration analysis of industrial robots is one of the key issues in the context of robotisation of machining processes. Low-frequency vibrations result from flexibility in manipulator joints. Within the scope of the article, a model of a two-link robot manipulator was built. Dynamic equations of motion were formulated to study the influence of the robot arm configuration on vibration effects. Based on numerical simulations, the frequency spectrum of vibrations of the robot's links was determined, and tests were carried out in a number of configurations, obtaining a map of resonant frequencies depending on the configuration of the manipulator. Experimental studies were then carried out, which confirmed the conclusions from the simulation studies. The results obtained confirm that the positioning of the manipulator's links has a significant effect on vibration effects. Tests conducted using a vision system with a motion amplification application made it easier to interpret the results. The formulated mathematical model of the manipulator generates results that coincide with the results of experimental studies.

Khaled Kharrati, Madiha Salhi, Abdelmoumen Hidouri, Ridha Abdeljabar
Effect of Luffa Sponge Fibre Mats Embedded in the Plaster Matrix

The present experimental research work aims to elaborate a new composite material (CM) composed of plasters reinforced with mats of long unidirectional luffa sponge fibres, treated chemically by 1% NaOH solution during 90 min at a temperature of 50°C, in orderto improve its thermomechanical and physical properties. The influence of fibre mat and fibre napping numbers of luffa sponge on density, porosity, flexural strength, thermal conductivity, thermal diffusivity, thermal effusivity and specific heat capacity properties was investigatedto lower building energy consumption. As far as our case is concerned, we processed a composite using single, double and triple-layer luffa sponge fibre mats. In our study, we are basically confined our experiments to three-layer mats. The experimental results revealed that the networking structure of fibres increases the flexural strength and decreases the thermal conductivity for a two-layer fibre wire mesh imbedded in the plaster matrix as compared with the neat plaster. However, there is a decrease in strength for a triple-layer composite, which referred to poor wetting of the fiber with the matrix material.

Ghazanfar Mehboob, Kashif Nadeem, Amjad Iqbal, Gohar Mehboob, Shahnawaz Hussain, Mohamed Ragab, Mazhar Iqbal, Sohaib Ajmal, Adel El-Marghany
The Study of Temperature Dependent Magnetic Properties Variation in CoCr2O4 Nanoparticles with (y = 0.8) and without Coating Concentration of Non-Magnetic (SiO2)y

The present study investigates the temperature-dependent magnetic (MT) properties of CoCr2O4/(SiO2)y (y = 0 and 0.8) nanoparticles. Nanoparticles were synthesised by using the conventional sol–gel technique. The X-ray diffraction (XRD) method confirmed the normal spinel structure of CoCr2O4 nanoparticles. The main peak analysis of the XRD pattern using Debye–Scherrer's formula probes the mean crystallite sizes for coated and uncoated nanoparticles, and the sizes based on which the probes have been carried out amount to 19 nm and 28 nm, respectively. The transmission electron microscopy (TEM) image showed the non-spherical shape of these nanoparticles. Field-cooled (FC) and zero field-cooled (ZFC) MT plots were taken by using a superconducting quantum interference device (SQUID) magnetometer. Pure CoCr2O4 nanoparticles showed the ferrimagnetic transition at Curie temperature (Tc = 99 K) on an applied field (H) of 50 Oe. Tc decreased up to 95 K with the increase in 80% SiO2 concentration in CoCr2O4 nanoparticles. For pure samples, conical spiral temperature (TS) and lock-in transition temperature (TL) remain unchanged with increasing magnetic field because of strong spin–lattice coupling. However, for 80% SiO2 impurity, the decrease in Tc was attributed to the reduction in surface disorder with a minor decline in TS and TL. The Ms declined with a decrease in temperature because of the existence of stiffed/strong conical spin-spiral and lock-in states in pure CoCr2O4 nanoparticles, while nanoparticles with 80% coating SiO2 concentration showed abnormal behavior. The coercivity increases with a decrease in temperature due to a decrease in thermal fluctuations at low temperatures for both samples. The fitting of coercivity (Hc) versus temperature plot by using Kneller's law has given the values of coercivity constant (α) and coercivity at average blocking temperature (TB) for both samples, which are α = 0.54, TB = 75 K and α = 1.59, TB = 81 K, respectively. Hence, the increase in the concentration of SiO2 decreased nanoparticles size and surface disorder in CoCr2O4 nanoparticles while enhancing Ms below spin-spiral state ordering.

Piotr Radomski, Paweł Ziółkowski, Dariusz Mikielewicz
Energy Conversion in Systems-Contained Laser-Irradiated Metallic Nanoparticles – Comparison of Results From Analytical Solutions and Numerical Methods

This work introduces the theoretical method of metallic nanoparticles' (NPs') heat and mass transfer where the particles are coated on a surface (base), together with considering the case wherein nanoparticles move freely in a pipe. In order to simulate the heat transfer, energy and radiative transfer equations are adjusted to the considered issue. NPs' properties are determined following the nanofluidic theories, whereas absorption and scattering coefficients are described using either Mie-Lorenz theory or Rayleigh-Drude approximation. Thermal boundary conditions are implemented based on the microscale heat transfer and Smoluchowski theory. Results are compared with the classical Fourier transport differential solutions that have been adjusted to laser irradiation.

Katarzyna Falkowicz
Linear Analysis of Thin-Walled Composite Profiles Weakened by Holes

The paper presents the results of the numerical analysis of the stability of C-section profiles together with the determination of the influence of the geometrical parameters of the holes and their arrangement on the strength properties of the profile, made of multilayer composite materials in a symmetrical arrangement of layers, which is deformed under the influence of the compressive force. Numerical calculations were carried out in the linear range (solution of the eigenvalue problem - critical state) using the finite element method (FEM) using the ABAQUS calculation package. Based on the obtained results, it was possible to determine the influence of the type and number of holes, their arrangement and geometric dimensions on the values of critical loads as well as the buckling modes of the profiles.

Michał Ptak, Jerzy Czmochowski
Using Computer Technique for Developing Method for Vibration Damage Estimation under Combined Random and Deterministic Loading

This paper is focusses on developing a novel method for vibration damage estimation for military helicopters, fighter aircrafts and any other aircraft exposed to combined stochastic and deterministic loading. The first stage of the research focused on frequency domain damage prediction, which is the legacy method proposed by Bishop and developed by Sweitzer, Schlesinger, Woodward, Kerr, Murthy, Datta and, Atkins. The mentioned frequency domain-based method is used in commercial software, e.g., MSC CAE Fatigue. Frequency domain damage prediction is based on superposition of spectral moments and Dirlik method of Rainflow Cycle Counting algorithm in frequency domain. The first phase of the research showed the legacy algorithm based on transfer function developed using FEM (Finite Element Method) method in Abaqus environment and is very conservative. The second stage of the research aims to develop a novel method which allowing for more robust and accurate damage estimation. For this purpose, the Monte Carlo method for retrieving random signal in the time domain from signal in frequency domain was used. To obtain the system transfer function, – the 1 g load harmonic system response was obtained using FEM analysis. It was subsequently scaled linearly by the PSD input curve for random loading and sine wave, or sine sweep function for deterministic loading to calculate the cumulative system response of the linear system. The research allows the development of a novel method to precisely estimate vibration damage using combined time and frequency domains approach, based on effective frequency domain FEM analysis of the linear system. The new proposed method can be also used for precise replication of test conditions via considering signal clipping and frequency resolution used for real testing.

Ewa Pawłuszewicz
Avoidance Strategies for Fractional Order Systems with Caputo Derivative

A control strategy is derived for fractional-order dynamic systems with Caputo derivative to guarantee collision-free trajectories for two agents. To guarantee that one agent keeps the state of the system out of a given set regardless of the other agent's actions a Lyapunov-based approach is adopted. As a special case showing that the given approach to choosing proposed strategy is constructive for a fractional-order system with the Caputo derivative, a linear system as an example is discussed. Obtained results extend to the fractional order case the avoidance problem Leitman's and Skowronski's approach.

Yaşar Sert, Tevfik Küçükömeroğlu, Hojjat Ghahramanzadeh Asl, Levent Kara
The Effect of "B" Target Voltage on Wear Properties of TiCrNb-hBN Coatings

The present study aims to determine the effect of target voltage of boron on elevated temperature wear behaviour of newly de-signed (Ti, Cr, Nb)-hBN PVD coatings. For this purpose, this layer is grown on the AISI L6 (55NiCrMoV7) at various target voltages (600 V, 700 V) using a high-power impulse magnetron sputtering setup. The coating layer has a graded design and has been coated on the substrate surface in adherence with the following order: Cr – CrN – TiCrN – TiCrNbN and finally TiCrNb-hBN (constituting the working layer). The surface properties of the layer were determined using SEM and an optical profilometer. It is seen that the coatings were deposited on the surface in a granular structure pattern away from the deposition defect (such as a droplet or hole), and the roughness values increase as the target voltage increases. Phase analysis is determined using XRD, and average grain size calculations are performed using the XRD data. The coating layer has grown on the surface at TiN (112), CrN (311), NbN (111) and h-BN (001) orientations. Then, mechanical tests including microhardness and scratch tests were conducted on the specimens. Although the layer that is produced with both different parameters improves the hardness of the substrate (4.7 GPa), the hardness of the coating layer at the voltage of 700 V (24.67 GPa) is higher than that of others. Based on scratch tests, scratch crack propagation resistance (CPR) values were determined as 40 N2 and 1,650 N2 for coatings produced at 600 V and 700 V, respectively. The wear behaviours of specimens are specified using a ball-on-disc type tribometer at 450°C. It is seen that the coating with high hardness and scratch resistance offers unique contributions to the wear performance of the substrate. The optimum value of the target voltage to be used in the production of this innovative coating has been introduced into the literature.

Maryam Asgir, Muhammad Bilal Riaz, Ayesha Islam
Exact Analysis of Fractionalised Jeffrey Fluid in a Channel with Caputo and Caputo Fabrizio Time Derivative: A Comparative Study

The non-integer order derivatives, Caputo (C) and Caputo Fabrizio (CF), were employed to analyse the natural convective flow of magnetohydrodynamic (MHD) Jeffrey fluid. The aim is to generalise the idea of Jeffrey's fluid flow. The fluid flow is elaborated between two vertical parallel plates. One plate is kept fixed while the other is moving with the velocity $U_0 f(t)$, which induces the motion in the fluid. The fluid flow problem is modelled in terms of the partial differential equation along with generalised physical conditions. The appropriate parameters are introduced to the dimensionless system of equations. To obtain the solutions, the Laplace transform (LT) is operated on the fractional system of equations, and the results are presented in series form. The pertinent parameter's influence on the fluid flow is brought under consideration to reveal interesting results. In comparison, we noticed that the C approach shows better results than CF, and graphs are drawn to show the results. The results for ordinary Jeffrey fluid, second-grade and viscous fluid are obtained in a limiting sense.

Beata Maciejewska, Sylwia Hożejowska, Mirosław Grabowski, Mieczysław E. Poniewski
Numerical Analysis of the Boiling Heat Transfer Coefficient in the Flow in Mini-Channels

This paper deals with boiling heat transfer in the flow of water through an asymmetrically heated horizontal rectangular mini-channel. The mini-channel was made by gluing three transparent glass plates and a copper block. Through the glass window, the variable along the length of the mini-channel two-phase flow structures were recorded to determine local values of the void fraction. Four resistance heaters were attached to the copper block, powered by direct current, generating the heat initiating the flow boiling inside the channel. During the experiment, the following were measured: water volumetric flow rate, inlet pressure with pressure drop, inlet and outlet water temperature, copper block temperatures at three points inside its body, voltage and current supplied to the heaters. Stationary and laminar fluid flow with low Reynolds numbers were assumed in the mathematical model of heat transfer in selected elements of the measuring module. The temperature distributions in the copper block and flowing water were described by the appropriate energy equations: the Laplace equation for the copper block and the Fourier–Kirchhoff equation with parabolic fluid velocity for the flowing water. These equations were supplemented with a set of boundary conditions based on measurement data; moreover, data from experimental studies were the basis for numerical calculations and their verification. Two-dimensional temperature distributions of the copper block and water were calculated with the Trefftz method (TM). The main objective of this study was to determine the heat transfer coefficient on the contact surface of the copper block and water, which was calculated from the Robin boundary condition. The results of the calculations were compared with the results of numerical simulations performed using the Simcenter STAR-CCM+ software, obtaining consistent values. Computational fluid dynamics (CFD) simulations were verified based on experimental data including void fraction and temperature measurements of the copper block and flowing water.

Michał Kolankowski, Michał Banach, Robert Piotrowski, Tomasz Ujazdowski
A New Approach to Designing Control of Dissolved Oxygen and Aeration System in Sequencing Batch Reactor by Applied Backstepping Control Algorithm

The wastewater treatment plant (WWTP) is a complex system due to its non-linearity, time-variance and multiple time scales in its dynamics among others. The most important control parameter in a WWTP is the dissolved oxygen (DO) concentration. The tracking problem of the DO concentration is one of the most fundamental issues in biological wastewater treatment. Proper control of DO concentration is necessary to achieve adequate biological conditions for microorganisms in the WWTP. Aeration is an important process to achieve those conditions, but it is expensive. It was performed using an aeration system, which includes blowers, pipelines and diffusers. This paper presents a new approach to designing a non-linear control system for controlling DO concentration using an adaptive backstepping algorithm. A model of biological processes and aeration system were applied in designing the control system. Simulation tests of the control system were performed and very good results on control were obtained. The proposed solution has proved to be effective and computationally efficient.