then used to develop a numerical model implemented in Abaqus software using the UMAT code. The simulation covers two main aspects: martensitic phase transformation and anisotropic damage growth, with the code capable of predicting both phenomena at room temperature. Damage mechanics is a relatively new tool in mechanical engineering, complementing the theories of plasticity and fracture mechanics. This study experimentally examined the process of damage growth and phase transformation in 316 stainless steel. The innovation of this model lies in its simultaneous consideration of anisotropic damage growth and austenite-to-martensite phase transformation at room temperature. The damage model used in this study is the Limiter model. Experimental tests, including tensile and torsion tests, were conducted to assess damage in different dimensions, involving both loading and unloading conditions. The model by Shin and colleagues was utilized to determine the phases present in the material. For greater accuracy in phase transformation testing, the samples were prepared using a water jet and then subjected to X-ray diffraction to measure the extent of martensite phase development. Finally, the numerical simulation was calibrated against experimental results for 316 stainless steel, ensuring the model's accuracy. Austenitic stainless steels transform into the martensite phase under strain, where the unstable austenite phase converts into stable martensite due to plastic deformation. This martensitic phase transformation hardens the austenitic steels. This study examines the anisotropic damage growth resulting from plastic strain and the martensitic phase transformation in austenitic stainless steels, specifically AISI-316, at room temperature. Initially, tensile and torsion tests are conducted on the samples at various displacements. Subsequently, these samples undergo X-ray diffraction tests to determine the existing phases and the martensite volume fraction in the samples. Using the obtained results, an empirical model is created from numerical tests using the UMAT code in Abaqus software. This simulation includes both the martensitic phase transformation and anisotropic damage growth. The code can predict any phenomenon under environmental conditions. Finally, the effectiveness of the proposed model is compared and analyzed against experimental results for AISI-316 steel.

Key Words: Anisotropic damage, X-ray diffraction tests, transformation phase, numerical analysis.

Key Words: Droplet formation, numerical simulation, fabrication, capillary microdevice.

A NONLINEAR MODEL FOR VIBRO-ACOUSTIC ANALYSIS OF A SUBMERGED AXIALLY MOVING CYLINDRICAL SHELL

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Abstract
Investigating the acoustic vibrations of moving cylindrical shells in fluid is of interest to researchers due to their many applications in marine structures. Underwater vehicles, submarine pipelines, and oil and gas industries are examples of shells used in the marine industry. Analyzing the acoustic vibration of submerged structures and investigating the effect of various parameters on their sound energy absorption is of great importance. If most of the radiated sound intensity is transferred to the structure due to its reflection, the possibility of identifying it will decrease. For this reason, much research has been conducted to investigate the acoustic behavior of submerged structures, especially cylindrical shells, due to their many uses in underwater vehicles. In this study, the nonlinear vibro-acoustic dynamics and stability of doubly-clamped axially moving cylindrical shells are investigated. The exterior surface of the shell is in contact with the fluid and subjected to oblique incident plane sound waves. Donnell's nonlinear shallow shell theory is used to derive the nonlinear partial differential equation of the cylindrical shell for the radial motion. Also, the pressure on the cylindrical shell is calculated from Bernoulli's equation for unstable fluid. The Galerkin method is employed to discretize the equations of motion into the set of coupled nonlinear, nonhomogeneous ordinary second-order differential equations. Considering both driven and companion modes, the Multiple Scales Method is used to obtain the response of the system. The effects of sound level, incident angle, and axial velocity on the frequency response of the system are studied. Comparing the frequency response of the nonlinear model presented in this article with the frequency response of the linearized model shows that for the high intensity and high angle of the incident sound and also the low speed of the shell movement in the depth of the fluid, the error of the linear model in determining the resonance frequency and the stable response range of the cylindrical shell is large.

Key Words: Nonlinear vibro-acoustics, submerged moving cylindrical shell, transmission loss, method of multiple scales.

NUMERICAL AND EXPERIMENTAL ANALYSIS OF ANISOTROPIC DAMAGE GROWTH AND MARTENSITIC PHASE CHANGE DUE TO PLASTIC STRAIN AT AMBIENT TEMPERATURE

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Abstract
This study investigates the anisotropic damage growth and martensitic phase transformation in AISI-316 austenitic stainless steel at room temperature. Initially, tensile and torsion tests were performed on samples at various displacements. Following these tests, the samples were analyzed using X-ray diffraction (XRD) to identify the present phases and determine the martensite volume fraction. The experimental data obtained were

using a steel tool mounted on a milling machine. The pin of the tools consists of cylindrical and conical profiles. Due to frictional heat and severe displacement, fusion weld occurs. Welding experimentation was designed by using the DoE theorem and welded in a universal milling machine. Significant factors of the welding process and their levels were obtained during pretests, and then weld runs were carried out successfully. Each weld bead was divided into three zones, and sampling was taken from them. The tensile strength of the welded joint is considered as a response to the process. ASTM D638 for plastics tensile test method sample preparation defined and type IV test coupons cut and installed on tensile test machine. Results were taken through standard tensile tests and analyzed using the ordered weighting average technique. Besides studying the improvement of the joint and determining optimal conditions of input parameters of the welding process, one could evaluate the stability of the response. For this purpose, an analytical approach to risk assessment is employed, which is based on the weighting of ordered input variables. The obtained results are presented in both qualitative and quantitative graphs. The Focus is on the quality of stability of response followed by workability and acceptance of the process as an industrialization method. In the current article, attention to high orness and the goal of stabilizing the maximum yield strength of the joint is achieved by selecting high levels of the aspect ratio of diameters and linear velocities with medium levels of rotational speed as well as low levels of the tilt angle of the tool. Conical tools lead to the most stable joint with a 10% variation on the weld line (for run #20) and the most strengthened one with an 18% variation on the weld line (for run #30) with 80% and 100% efficiency compared to the base material, respectively.

Key Words: Mechanical behavior, experimentation, riskability, Friction Stir Welding (FSW), Ordered Weighted Averaging (OWA).

EXPERIMENTAL INVESTIGATION AND SIMULATION OF CONTROLLED SIZE DROPLET FORMATION IN A CAPILLARY MICRODEVICE

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Abstract
This study focuses on the precise production of droplets in a droplet-based microfluidic device, where monodisperse oil-in-water emulsions with controlled droplet sizes are generated. The primary objective is to achieve uniform emulsions by examining key parameters such as additives in the continuous aqueous phase, internal phase flow rates, and the microfluidic device's geometric characteristics. Initially, the geometric parameters of the microchip for emulsion formation were selected using numerical simulations, and the results were validated through experimental tests of emulsion production with the microchip. The precision of the outcomes is enhanced using an innovative 3D printing method for microchip manufacturing, enabling the creation of identical microdevice copies. In the experimental phase, the optimal conditions for producing uniform droplets were identified by examining the effects of various additives in the external aqueous phase, different internal phase flow rates, and the geometric parameters of the microfluidic device. The results demonstrate that the distance between the two capillaries can control droplet size and frequency, the internal phase flow rate, and the type of additive in the external phase, allowing for emulsions with droplet sizes ranging from 500 to 1000 microns. Specifically, the distance between the capillary tubes significantly affects droplet size, contributing to 30% of the variation when this distance is increased sixfold. Additionally, the study reveals that the increase in droplet diameter due to a higher internal phase flow rate varies with different additives in the external phase. For instance, sodium dodecyl sulfate (SDS) results in a 6.65-fold increase in droplet production frequency with a sixfold increase in the internal phase flow rate. Furthermore, the type of additive in the external phase can independently control droplet size. For example, with a specific internal-to-external phase ratio, oil droplets measure 600.8 μm in an external phase containing SDS, 582.2 μm with polyvinyl alcohol (PVA), and 615.4 μm with Triton X-100. This method can precisely control droplet size and frequency, making it suitable for generating precursor emulsions for engineered micro- and millimeter-sized polymer particles aimed at drug delivery or cell culture applications. The study successfully ensures consistent and uniform emulsions by manipulating these critical parameters through this combined approach of numerical simulations and experimental validation.

Key Words: Condition monitoring, intelligent fault diagnosis, convolutional neural network, rolling element bearing, variable operating conditions, vibration analysis.

EXPERIMENTAL ACOUSTIC STUDY OF SMALL HORIZONTAL AXIS WIND TURBINES BASED ON COMPUTATIONAL FLUID DYNAMICS AND ARTIFICIAL INTELLIGENCE APPROACHES

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Abstract
In modern wind turbine design, two significant challenges arise: achieving optimal aerodynamic performance while minimizing acoustic noise emissions. However, the extensive numerical computations required for accurate evaluation often hinder the implementation of multi-objective optimization strategies. This paper introduces an innovative approach to address this issue, leveraging a combination of neural network-based reduced order modeling and a multi-objective genetic algorithm. This methodology aims to optimize the aerodynamic and aero-acoustic characteristics of an S8xx-series airfoil, including the trailing edge serration geometry. Utilizing Class-Shape Transformation to parameterize various serrated airfoil geometries, the method minimizes the need for costly computational fluid dynamics (CFD) simulations. Instead, a feed-forward neural network (NN) is trained with a minimal dataset to predict airfoil behavior within a specified range. Comparisons between CFD results and NN predictions validate the accuracy of the neural network. Significantly, this approach substantially reduces optimization time by approximately 95%, maintaining high levels of accuracy. In conducting multi-objective optimization for both the airfoil and serration shapes, the study demonstrates notable improvements: a 5 to 7% enhancement in aerodynamic performance alongside a simultaneous 1-4% reduction in noise compared to benchmark airfoils. Then, in the second step, experimental methodology is employed to investigate the aeroacoustic attributes of a small horizontal-axis wind turbine with optimized blades. Conducted within a semi-anechoic chamber, this investigation meticulously positions both original and optimized geometry models to measure sound pressure levels (SPL) across various rotational speeds and positions. The results reveal subtle enhancements in aerodynamic performance with the optimized serrated blade configuration, accompanied by a remarkable reduction in noise levels across the frequency spectrum, culminating in an impressive overall sound pressure reduction of approximately 10 dB. Additionally, intriguing observations highlight the impact of turbine rotational speed on noise production, particularly in the downstream domain. Notably, the noise emission reduction for the serrated optimized blade is more dispersed in the plane of rotation compared to the original blade, which exhibited nearly uniform noise distribution. Overall, these findings offer valuable insights into the intricate interplay between aerodynamics and aeroacoustics in the context of small wind turbines with optimized blades.

Key Words: Wind turbine, aeroacoustics, optimization, computational fluid dynamics, large eddies simulation.

INVESTIGATING THE STABILITY OF THE YIELD STRENGTH OF THE FRICTION STIR WELDING JOINT OF SIMILAR AMORPHOUS THERMOPLASTIC BASED ON THE ORDERED WEIGHTED AVERAGING OPERATORS

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Abstract
This paper presents an investigation of the yield strength of welded ABS thermoplastics. Welding is carried out

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Abstract

In recent decades, thermal-fluid specialists have made considerable efforts to investigate the boiling heat transfer process. Pool boiling of pure liquids and nanofluids has been widely studied in the last decade, but the existing knowledge on modeling of nanofluids pool boiling process is still limited. The boiling of fluids containing tinny solid particles is very complicated due to the interaction between the existing phases, their interface, and the heating surface. Some new research shows that many factors are effective in pool boiling of nanofluids. Among these factors, we can mention particle size, concentration, the structure of the boiling surface, and the dynamics of bubbles. In this research, the film pool boiling process of pure ethanol was numerically simulated. Then, the film pool boiling of nanofluids including two types of nanoparticles Al_2O_3, SiO_2 and ethanol base fluid with two volumetric concentrations of 0.1% and 0.3% have been simulated. The results show that the presence of nanoparticles in film boiling in the base fluid has increased the heat transfer coefficient. The highest value coefficient for alumina and silica nanofluids with a volumetric concentration of 0.3, was obtained, respectively 0.32($kW/m^{2\circ}C$) and 0.3 ($kW/m^{2\circ}C$). In addition, the presence of nanoparticles in the boiling process has significantly increased the minimum heat flux. According to the results of numerical simulation, the minimum heat flux value in boiling of pure ethanol is 28.99 (kW/m^2), in boiling of alumina-ethanol nanofluid with volumetric concentrations of 0.1% and 0.3%, is 37.11 (kW/m^2) and 38.84 (kW/m^2), respectively and in boiling of silica-ethanol nanofluid with volumetric concentrations of 0.1% and 0.3%, is 35.81 (kW/m^2) and 38.31 (kW/m^2), respectively. The highest heat transfer coefficient is achieved by alumina nanofluid with 0.3% concentration, while the highest minimum heat flux is achieved by silica nanofluid with 0.3% concentration. The numerical results are in good agreement with the experimental results. By comparing these values with the experimental results, there is a good consistency between the results.

Key Words: Film boiling, minimum heat flux, nanofluid, heat transfer coefficient.

INTELLIGENT FAULT DETECTION OF ROLLING ELEMENT BEARING UNDER VARIABLE OPERATING CONDITIONS BY CONVOLUTIONAL NEURAL NETWORK USING TIME AND FREQUENCY DOMAIN SIGNALS

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Abstract

Intelligent detection of rolling element bearing faults is a critical aspect of rotating equipment condition monitoring. Early detection of faults holds significant economic value for industrial units in terms of maintenance and planning. Traditional intelligent fault detection algorithms, which rely on a combination of feature extraction and signal classification, are time-consuming and require a high level of expertise. In comparison to traditional methods, Convolutional Neural Networks (CNNs) can process a large volume of data with high accuracy and automatically extract features from vibration signals. Therefore, in this research, an attempt has been made to use a simple and shallow CNN to not only determine the health state of rolling element bearings but also identify the defective element. For this purpose, a CNN model has been employed to investigate three common faults in rolling element bearings. In order to achieve the best performance, various inputs, including time waveforms, spectra, and envelopes, have been utilized. To implement and validate the algorithms, a laboratory setup was designed and constructed. After creating artificial faults on the bearings, experiments were conducted under 36 different operating conditions, comprising 9 different speeds, each at 4 different loads, encompassing four healthy states, including healthy, inner race fault, outer race fault, and rolling element fault. The obtained results have illustrated that the fault detector model with the frequency spectrum input is more accurate, with an accuracy of 95% than the models receiving the other two inputs.

teger order sliding surface cannot be used. Therefore, the fractional sliding surface has been used for this purpose. The results show that in the presence of considerable uncertainties in each of the four parameters of the dynamical system, and considering the effects of sensor noise and the saturation element for the control signal, this controller can overcome it and follow the reference signal.

Key Words: Fractional-order transfer function, fractional order sliding mode control, attitude control of satellite, coupled rigid-flexible structures, uncertainty.

INVESTIGATING THE EFFECT OF TEXTURE INTENSITY ON THE FORMING LIMIT DIAGRAM OF MAGNESIUM MICROTUBES USED IN STENTS USING CRYSTAL PLASTICITY FINITE ELEMENT MODELING

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Abstract
Metal microtubes are usually made using the extrusion method, eventually creating a special texture in the tube. The way tissue is created in the microtube has a significant effect on its mechanical properties, which is very effective in the quality of the fabricated stents. In this research, the effect of texture intensity caused by the extrusion process to make magnesium microtubes is extracted using the crystal plasticity finite element simulation process. First, to validate the modeling, the hydroforming process for aluminum has been simulated in Abaqus finite element software and compared with similar results in the literature. After confirming the modeling process, using the criterion of the second derivative of the maximum large strain for the hydroforming process, the forming limit diagram is drawn for magnesium without texture intensity. In order to confirm the modeling of crystal plasticity, the representative volume element was subjected to tension and compression, and the strain stress curve in tension and compression was compared with the experimental strain stress curve. Then, the representative volumetric element was subjected to tension in three directions of extrusion, perpendicular to extrusion and forty-five degrees, and by calculating the ratio of transverse strain to thickness strain, the anisotropy coefficient for the random state in these three directions was obtained. In the following, the anisotropy coefficient was obtained in three different tissue intensities as in the random state. The results show that the relative activity range of hard slip systems such as pyramidal slip and prismatic slip is greater in the direction of extrusion than in other directions, so the anisotropy coefficient obtained in the direction of extrusion is greater than in other directions. As the texture intensity decreases, the anisotropy coefficients approach one, and the formation limit curve increases. As the texture intensity increases, the formation limit curve shows a lower safe zone.

Key Words: Forming limit diagram, magnesium microtube, anisotropy, representative volume element, crystal plasticity.

NUMERICAL SIMULATION OF FILM POOL BOILING OF ETHANOL-BASED NANOFLUIDS

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Abstracts of Papers in English

FRACTIONAL ORDER SLIDING MODE CONTROLLER (FOSMC) DESIGN FOR ATTITUDE CONTROL OF A SATELLITE WITH COUPLED RIGID-FLEXIBLE STRUCTURES USING FRACTIONAL ORDER TRANSFER FUNCTION

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Abstract
One of the critical problems in controlling mechanical systems is the structural interactions. Obviously, all the bodies have elastic behavior, and rigidity is assumed to reduce the modeling complexity, which is not applicable to many situations. For example, gravity gradient booms and solar panels used in satellites have considerably large deflections relative to their basements. These such systems are recognized as Coupled Rigid-Flexible structures. In these cases, it is possible to consider the more flexible part of the structure as elastic and the other as rigid. With the development of fractional order calculus and more accurate modeling of physical phenomena, the problem of controlling these systems by considering the uncertainties in the system will become necessary and inevitable. In this paper, the fractional order transfer function model of a satellite with coupled rigid-flexible structures is used as the reference work of the research. The sliding mode control method, which is one of the robust control methods, has been used to control this dynamic system. It is not possible to design a sliding mode controller directly for a transfer function. For this reason, a fractional order pseudo-state space model is first obtained from the fractional order transfer function model. Then, a controller is designed for it. On the other hand, considering the dynamics of the system is used in the design process of the sliding mode controller and proving its stability. Since the state space model is fractional, it is clear that the in-