Abstracts of Papers in English

INVESTIGATION OF THE EFFECT OF SHAPE MEMORY ALLOY ON BUCKLING AND POST-BUCKLING OF COMPOSITE PANELS IN SUPERSONIC FLOW WITH THERMAL HEATING

Z. Zabihi
zabiha.zabih@yahoo.com
M. Dardel(corresponding author)
dardel@nit.ac.ir
Dept. of Mechanical Engineering
Babol Noshirvani University of Technology
A.R. Fathi
a.fathi@um.ac.ir
Dept. of Mechanical Engineering
Ferdowsi University of Mashhad
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Abstract
In the present work, the effect of smart shape-memory alloys on thermal buckling and post-buckling of monoclinic and unidirectional composite panels has been investigated. The aerodynamic pressure applied to the system was modeled using the piston theory method. The effect of thermal heating for ultrasonic flows was also estimated from the reference temperature method. The panel is modeled nonlinearly with large deformations based on Van Karmen's theory. The obtained results show that the shape-memory alloy was able to increase the critical temperature of thermal buckling. The effect of the arrangement of composite layers on increasing the thermal buckling temperature was also studied. The results show that the amount of thermal deflection is greatly reduced due to the use of this alloy. Also, in the higher temperature differences, the rate of reduction of the panel increases.

In this work, the effects of thermal stress on buckling and thermal buckling in a rectangular composite panel with hinge-hinge boundary conditions were investigated. Also, the effect of shape retention alloy in controlling these two phenomena has been studied. The shape memory alloy wire was placed in martensitic mode to apply a compressive force to the panel to control the heat-

ing and aerodynamic forces after changing the phase to austenite. The governing equations of the system were extracted through the layer theory method to show the effects of in-plane displacements better.
Investigations on the effect of different layers (symmetry effects and arrangement angle of composite sheets) were performed to investigate thermal buckling. According to the obtained results, the layer arrangement of plates (0.90 / 0.90), (-45.45), (30/60), and (0.90 / 90.0), respectively, had the greatest effect on raising the critical temperature of thermal buckling in dimensional ratios equal to or greater than one. This shows that the symmetry of the arrangements has a greater effect than the angle of the arrangements. Examining the buckling diagrams for the effect of a shape memory alloy, it can be concluded that by placing this alloy in the composite panel, in addition to raising the buckling temperature, this alloy has a greater effect on displacement control by increasing the temperature after the critical buckling temperature.

Key Words: Shape memory alloys, composite, supersonic flow, thermal buckling, thermal post-buckling.

DESIGN AND COMPARISON OF COMBINED, PARABOLIC, AND FLAT PLATE REFLECTORS ON THE PERFORMANCE OF A SOLAR MODULE

M. Asvad
mostafaasvad75@gmail.com
M. Gorji(corresponding author)
gorji@nit.ac.ir
A. Mahdavi
arashmahdavi93@gmail.com
Faculty of Mechanical Engineering
Babol Noshirvani University of Technology
DOI:10.24200/J40.2022.60438.1642

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Abstract
Solar energy is the most abundant source of energy among renewable energies, which can be directly converted into electricity by solar modules. To tackle the low energy output of solar modules in places where there are not enough spaces to install many solar modules, the use of reflectors is recommended. The use of reflectors increases the solar radiation on the surface of the module, hence will boost its power output. In this study, two-dimensional simulations were performed using ANSYS Fluent 2021 R2 package software in which the effects of a flat plate, parabolic, and hybrid reflectors on the temperature and efficiency of the module were investigated. The numerical simulation of the current study was validated against an experimental case study. Although there were so many simplifications and assumptions for the validation, the maximum deviation between the present numerical result and the experimental was less than 3.86%, which certifies the results of this paper. Based on the output, the surface temperature of the solar module with °85 flat plate reflector and °85 parabolic reflector reached 360.82 (K) and 371.11 (K), respectively, while the temperature with °50 reflector for both parabolic and flat plate modes reached 345.94 (K) and 346 (K), which are approximately equal. It was also observed that with increasing the angle of flat and parabolic reflectors, the module temperature increased, and parabolic reflectors had higher temperatures at higher angles. The module temperature using a type 6 reflector increased by 7.14% and 0.92% compared to the °80 flat plate reflector and °80 parabolic reflector, respectively. In terms of efficiency, since reflectors will intensify the solar radiation on a solar module surface, it will enhance the operating temperature of the module so that in all cases with reflectors, the efficiency will drop from an initial maximum value to a certain minimum value. This drop is more significant in the parabolic reflectors compared to the flat plate reflectors.

Key Words: Solar energy, solar module, reflector, module temperature, efficiency.

THE SMART DESIGN OF HEAT EXCHANGERS WITH EXPANDED SURFACES BY GENETIC ALGORITHM AND IMAGE PROCESSING

B. Abolpour(corresponding author)
bahadorabolpor1364@yahoo.com
Dept. of Chemical Engineering
Sirjan University of Technology
R. Hekmatkhah
ramtin.hekmatkhah@ut.ac.ir
Faculty of New Sciences and Technologies,
University of Tehran
A.B. Ansari
a.b.ansari@kgut.ac.ir

Dept. of Energy Graduate University of Advanced Technology, Kerman
DOI:10.24200/J40.2022.60770.1649

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Abstract

The analysis of heat transfer in the channel in many types of heat exchangers, such as electric cooling equipment, solar collectors, heat exchanger systems, high-performance boilers, gas turbine blade coolers, etc., is the basis of the design, construction, and optimization. Controlling heat transfer to increase the rate of heat transfer in such systems by improving the cooling method is an effective energy engineering from the point of saving energy. Increasing the heat transfer performance in the scales of macro and microchannels is crucial. The use of expanded surfaces in the channel is a practical method to increase the heat transfer coefficient. In the upcoming article, the smart design of a two-dimensional nanofluid heat exchanger has been studied numerically in order to achieve optimal performance conditions in terms of heat transfer rate, the amount of deposition of nanoparticles in the structure of the exchanger, as well as the fluid pressure drop while passing through it. It can be seen that the geometric structure optimized by the combination of genetic algorithm and computational fluid dynamics of this channel causes an increase of 1.14% in the enthalpy of the passing nanofluid, a decrease of 11.21% in the pressure drop of the passing nanofluid, and a reduction of 8.44% percentage in the deposition of nanoparticles inside the channel and a total increase of 24.82% in the fitting function defined in terms of these three variables, compared to the channel designed in previous studies. Therefore, this optimal channel has a higher heat transfer rate with a pressure drop and a lower amount of nanoparticle deposition compared to the previous channel, which proves the ability of the genetic algorithm with computational fluid dynamics in the optimal design of all types of heat exchangers.

Key Words: Nanofluid heat exchanger design, expanded surfaces, computational fluid dynamics, genetic algorithm, image processing.

EXPERIMENTAL STUDY OF MULTI-POINT INCREMENTAL FORMING FOR CONICAL PARTS

S. Faraji(corresponding author)
sadeghbizaki@gmail.com
Y. Rostamian
yasser.rostamiyan@iausai.ac.ir
A.A. Shamsi-Sarband
ali.shamsisarband@iausai.ac.ir
Faculty of Mechanical Engineering Azad University, Sari
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Abstract

The development of rapid prototyping methods has been very drastic in recent years. One of these methods, with a nature similar to sheet-forming processes, is the incremental forming method. In the last two decades, this technique has attracted much attention in industrial applications. The incremental forming process has been able to play a major role in advancing industrial projects in the production of low-volume prototypes. This process is a suitable alternative to conventional forming processes in the single production of conical geometries because of the low cost of machinery, equipment, and tools. In this paper, the two-point incremental forming of conical parts by three multi-point matrix designs, including single, double, and three-step cylinders, were investigated. For this purpose, the feed rate (400-1000 mm/min) and the penetration step of the tool (0.5-1.1 mm) were investigated in three levels to form the aluminum sheets with a thickness of 0.5 mm. In the following, the effect of the input parameters on the limiting height of the formed specimens, thickness distribution, surface roughness, and geometric accuracy of longitudinal cut specimens was assessed. According to the results, using the multi-point matrixes, despite increasing the final geometric accuracy, friction was reduced compared to the conical matrix. Using a two-step matrix, deeper pieces were formed by increasing the formability of the sheet, in which the average height was improved by an average of 12%. However, no significant change was observed in the roughness of the samples formed by all three types of matrixes. Therefore, the design of the proposed matrix had almost no tangible effect on the final surface roughness output. From the view of geometric accuracy, the matrix design with three steps created the highest geometric accuracy, as well as the least deviation relative to the planned path.

Key Words: Incremental forming, supporting die, geometry deviation, thickness distribution, surface roughness.

ROTOR DESIGN AND PERFORMANCE STUDY OF AN AIRBORNE WIND ENERGY SYSTEM WITH FLIGHT DYNAMICS SIMULATOR

M. Ahmadi
mahdiahmadi@modares.ac.ir
S. Karimian Aliabadi(corresponding author)
karimian@modares.ac.ir
Faculty of Mechanical Engineering
Tarbiat Modares University
DOI:10.24200/J40.2022.60848.1651

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Abstract
Airborne wind energy system (AWES) is a novel approach in wind energy harvesting. It has several advantages against conventional horizontal axis wind turbine (HAWT), like using less material and thus lower manufacturing cost, higher efficiency, stable electricity output and higher capacity for energy harvesting. It is obviously embedding a complex control system which makes the appropriate flight trajectory for the vehicle. These systems need to be carefully designed so using virtual flight simulators in design process is crucial. The main components of a typical AWES are: tether, flyer, and rotors. The flyer is designed to have a tether-constrained flight across the wind in a circular path. Consequently, the mounted rotors on the flyer's wings will capture energy and this mechanical/electrical energy would be sent back to the ground via the same tether. It is notable that the flight path and the special design of the flyer, would make it capable to have a sustained motion in the circular loop with no energy consumption. A tethered drone equipped with several rotors is an example of such devices, already has been built and tested. In previous literature, the flight simulators usually contain some simple aerodynamic models for predicting the forces and moments generated by the rotors. It is derived by constant aerodynamic coefficients. In the current study, it has been developed a flight simulator for a typical AWES having onboard rotors. To make this flight simulator more accurate and to improve its fidelity in different environmental conditions, proper estimation of the external forces, particularly the aerodynamic forces and moments, seems to be necessary. Therefore, toward developing a high-fidelity simulator, Lagrangian dynamics and a new algorithm for estimation of the rotor aerodynamics, has been utilized. This new method is shown to have more accurate approximations of the system performance and also better description of the vehicle trajectory. By this framework, one could design optimized blades of the rotors and also the rotors arrangement. Implementing the new simulator, a single drone, as the flyer in AWES, having 3m wing span, would experience 40 percent improvement in the average power extracted which is near 2 KW.

Key Words: Airborne wind energy system (AWES), lagrangian flight simulator, tethered flight, aerodynamic coefficients, rotor section.

LOCALIZATION AND CONTROL OF AN ENDOSCOPIC CAPSULE USING STOKES FLOW EQUATIONS

P. Sadeghi Boroujeni
sadeghi_pouria@mech.sharif.edu
H. Nejat Pishkenari(corresponding author)
nejat@sharif.edu
H. Moradi
hamedmoradi@sharif.edu
Gh. Vossoughi
vossough@sharif.edu
Dept. of Mechanical Engineering
Sharif University of Technology
DOI:10.24200/J40.2023.61340.1657

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Abstract
Small magnetic robots are now widely used in the treatment of a variety of ailments. Capsule endoscopy is a non-invasive procedure used to examine the digestive tract. Wireless capsule endoscopy is a significant innovation in this century to diagnose gastrointestinal tract disorders with minimal pain for the patient. This technology facilitates the inspection of the digestive system and avoids the risks of conventional endoscopy. Determining the exact position and placement of this capsule can help the doctor determine the exact location of the lesions in the digestive tract. In addition, once the exact position is determined, it can be used as input for control systems. The ability to determine the position and orientation of the capsule and control its movement can greatly assist the treating physician in detecting the disease. Moreover, the active endoscopic capsule allows the doctor to control the capsule in any desired position and direction, leading to a more accurate diagnosis of

the illness. This paper describes a method for predicting the position and orientation of a magnetic capsule in a fluid environment, as well as controlling it. In the suggested approach, it is assumed that the capsule moves at a low speed in the stomach; hence, the Stokes equations are used for the motion, and the equations of motion of a capsule were extracted. The position and orientation of the capsule are determined using a non-linear Kalman filter with the help of external magnetic sensors. A method has also been provided for controlling and positioning this capsule simultaneously using a duty cycle. The actuation fields and magnetic sensors are not used concurrently in this method, and the sensor data is used for localization when the actuation is turned off. The performance of the proposed methods was investigated using simulation.

Key Words: Localization, control, kalman filter, capsule endoscopy, magnetic field.

NUMERICAL SIMULATION OF ENERGY HARVESTING FROM A FLEXIBLE PLATE BEHIND A CYLINDER USING FLOW-INDUCED VIBRATIONS

M. Poormomeni Firoozabadi
poormomenimahnaz@gmail.com
A. Tayebi(corresponding author)
tayebi@yu.ac.ir
Y. Shekari
shekari@yu.ac.ir
Faculty of Engineering
Yasouj University
DOI:10.24200/J40.2023.60966.1653

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Abstract

Energy harvesting is the process of converting different kinds of energy, such as solar, thermal, kinetic energy of fluid, etc., to a usable form of energy. Different kinds of transduction mechanisms are used for energy harvesting. The piezoelectric mechanism has received considerable interest because of its advantages, such as ease of application and working over a wide range of frequencies. Simulation and investigation of energy harvesting from a piezoelectric plate, which is mounted on an elastic beam and located behind a cylinder through flow-induced vibrations, is the subject of the present research. First, the results of the lift and drag coefficients in the fluid flow around a stationary cylinder at Reynolds 200 are compared and validated with the previous studies. After that, by placing an elastic beam and a piezoelectric behind the cylinder, flow around the cylinder, and the fluid-solids interactions are investigated. Due to the vortex shedding phenomenon, which happens in the fluid flow past the cylinder, the elastic piezoelectric beam deforms periodically, and thus, the mechanical energy of the flow is converted into electrical energy. In this problem, the beam effect on both the drag/lift reduction and the amount of voltage extracted from the piezoelectric layer were investigated, and the optimal mode obtained was selected based on the extraction of more energy. In this regard, the process of finding the most optimal energy harvesting mode for the location of the elastic beam, the length of the beam, and the fixed point of the elastic beam in different geometries are carried out. The results of the optimal investigations are as the length of the elastic beam of 2D, the distance of the beam from the back of the cylinder 2.5D, and the state in which the beam is fixed from the right side, where D is the diameter of the cylinder.

Key Words: Energy harvesting, piezoelectric, flow-induced vibrations, flexible plate.

PROCESSING OF THIN MAGNESIUM TUBES BY TUBULAR CHANNEL ANGULAR PRESSING (TCAP) PROCESS WITH TRAPEZOIDAL GEOMETRY

M. Kamran Masouleh
mohsenkamran7394@gmail.com
A. Assempour(corresponding author)
assem@sharif.edu
Dept. of Mechanical Engineering
Sharif University of Technology
DOI:10.24200/J40.2023.61457.1660

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Abstract

Due to the compatibility of Magnesium with the body, it is a suitable material for making biodegradable stents, although its mechanical properties are not desirable for

stent application. Accordingly, lately, microstructure and mechanical properties of magnesium have been improved using various methods, including Severe Plastic Deformation (SPD). Many SPD methods have been introduced for the fabrication of ultrafine grain tubes until now, and the process of Tubular Channel Angular Pressing (TCAP) is the most effective one. In this research, by optimally designing the geometrical parameters of the trapezoidal channel, the process force in TCAP has been reduced, and for the first time, magnesium tubes with a thickness of 1 mm have been processed using this process. At the beginning of the research, using the finite element model, the process was simulated in Abaqus software, and the effect of the geometric parameters on the process force was investigated. To investigate the performance of the process with optimal geometric parameters, magnesium tubes with an outer diameter of 5 mm and a thickness of 1 mm were processed at a temperature of 200°C in three passes. The results of metallographic, microhardness, and tensile tests show that the TCAP process with trapezoidal geometry and optimal geometrical parameters is a suitable process for modifying the microstructure and improving the mechanical properties of magnesium tubes with a thickness of one millimeter. The values of yield strength and ultimate strength in the second pass are 1.6 and 1.26 times the initial sample, respectively, and have reached 60 and 92 MPa. The average grain size and hardness have reached from 200μm and 30 HV in the initial sample to 3μm and 40 HV after the third pass, respectively. The ductility and strength of processed samples have improved compared to the initial sample.

Key Words: Severe plastic deformation, tubular channel angular pressing (TCAP) process, ultrafine-grained thin tubes, magnesium.

BOUNDARY FEEDBACK TRAJECTORY TRACKING CONTROL OF RIGID BODIES WITH INTERIOR SHALLOW-WATER SLOSHING

M. Jokar
meysam.jokar@mech.sharif.edu
H. Salarieh(corresponding author)
salarieh@sharif.edu
H. Nejat Pishkenari
nejat@sharif.edu
Dept. of Mechanical Engineering
Sharif University of Technology
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Abstract
The problem of tracking control is addressed for rigid bodies with interior shallow-water sloshing. The liquid motion is modeled by the Saint-Venant equations, coupled with the ODE of the rigid body, leading to a global system with an ODE-hyperbolic PDE cascade structure. The paper aims to design an innovative boundary feedback framework for a pre-specified position to deal with rigid body tracking errors. Using only one control force applied to the rigid body, the formulated strategy efficiently stabilizes both the finite- and infinite-dimensional states. The main complexity lies in the fact that no sensor can be implemented in the liquid domain. Indeed, the proposed stabilizing feedback law simply requires measurements of (i) the rigid body position error and velocity and (ii) the liquid pressure at the cavity walls (liquid boundary). The asymptotic stability of the closed-loop system is analyzed using the Lyapunov direct method and LaSalle's invariance principle without any discretization, reduction, and linearization. Additional controller features are highlighted by simulation results, including its benefits in contrast to the corresponding PD controller and its robustness to time delay and system uncertainty.

Key Words: Rigid body, shallow-water sloshing, saint-venant model, hyperbolic PDE-ODE cascade, Boundary feedback control.

SIMULATION AND THEORETICAL ANALYSIS OF THE NANOFLUID-BASED OIL TRANSFORMERS FOR IMPROVING THE COOLING PERFORMANCE OF THE TRANSFORMER

S.A.H. Zamzamian(corresponding author)
azamzamian@merc.ac.ir
S. Rezazade Mofradnia
srezazadeh69@gmail.com
M.R. Pazouki
pazoukim.reza@gmail.com
Dept. of Energy Materials and Energy Research Center (MERC)
Solar Energy Group
M. Pazouki
m.pazouki@merc.ac.ir
Dept. of Energy Materials and Energy Research Center (MERC)

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Abstract

Transformers are one of the most important and expensive equipments in industries whose optimal performance has been influenced by various parameters such as weather conditions (temperature, humidity, etc.) and consumption patterns of the region. Transformer oils are one of the most vital materials used in this equipment. The oil of the transformer coils has been controlled by two factors: First, it acts as an electrical insulator between the coils and the body. Second, the heat created in the parts and the core of the transformer is transferred to the outside. In the electrical industry, many problems may be caused by transformers. Most of these cases have been affected by the performance of oils. In case of improper operation of the oil, it will cause disruption in electricity distribution and even damage and destruction. The oil should perform both tasks of cooling the transformer and insulating the body with electricity at the ideal level. However, due to the low thermal conductivity of such mineral oils, transformers cannot provide optimal performance.

In this research by the simulation study, sufficient and acceptable information has been obtained to create the most optimal nano-oil in the operational range with comprehensive library reviews. On the other hand, according to the theoretical analysis, it has been presented that metal oxide nanoparticles, such as CuO, TiO_2, Al_2O_3, SiO_2, and MWCNT as hybrid NMs, have been used so far. The most important result of this study, in addition to the type of hybrid nanoparticles, is to find the best combination to increase thermal conductivity and the principles of electrical conductivity and standard indicators of transformer industries. To start the experimental design, the best and most optimal instruction is simulating the function of the transformer using different nano-oils by a computer. Then, in the next step, this simulation has been done by COMSOL software. So, first of all, precise prioritization for using different nanoparticles can be obtained.

Key Words: Transformer oil, nanofluid based on oil, hybrid nanoparticles, heat transfer, cooling.