# Abstracts of Papers in English

## PROPOSING AN EMPIRICAL MOTION-TIME PATTERN FOR HUMAN GAZE BEHAVIOR IN DIFFERENT SOCIAL SITUATIONS

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**DOI:10.24200/J40.2023.61604.1664**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 3-13, Original Article



- Received 24 December 2022; received in revised form 27 June 2023; accepted 16 July 2023.

Abstract

Social robots that are fabricated to interact with humans and to help them in education, healthcare, etc., are required to have an interactive behavior similar to humans. One of the important interactive behaviors of humans is social eye gaze. Eye gaze is significantly more important than other nonverbal signals; it is shown that eyes are special cognitive stimuli with unique hardwired pathways in the brain dedicated to their interpretation. Studying the literature, we found out that in previous research conducted to control the social robots' gaze behavior, human gaze behavior was investigated in some limited situations, such as two- or three-way conversation, in order to extract the pattern of this behavior. Therefore, increasing the variety of studied social situations is a way to fill this gap. In order to design a gaze control system for a social robot, details about human gaze behavior must be found. The purpose of this research is to propose an empirical motion-time pattern for human gaze behavior in a number of different social situations; these situations include scenes with 2 to 4 people in a prepared video where the people in the scene show the social behaviors of "talking", "waving", "pointing", "entering the scene" and "exiting the scene" in a structured way. Fifteen normal adults (mean age: 24 and std: 3.3 years) watched this movie, and their gaze positions were recorded using an eye tracker system (SR-Research EyeLink 1000 plus). Next, by using

the genetic algorithm (which is an optimization process), we were able to extract the relative coefficient of each of the mentioned social behaviors in our proposed model. The results of reconstructing the participants' gaze on the test data are very similar to the real performance of the subjects. Finally, the ability to implement this model was successfully tested by implementing it on a Nao robot, and its positive performance was confirmed using a survey. The model showed significant differences between the two studied situations in 3 questions out of the whole survey's 10 questions.

**Key Words:** social robot, social eye gaze, eye tracking, motion-time pattern, genetic algorithm.

## FLEXIBILITY AND GEOMETRIC OPTIMIZATION OF A NEW STRUCTURE FOR A POLYMER STENT WITH THE FINITE ELEMENT METHOD

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**DOI:10.24200/J40.2023.60261.1637**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 15-23, Original Article



• Received 10 January 2023; received in revised form 5 March 2023; accepted 9 May 2023.

Abstract
Cardiovascular diseases cause many problems for patients, and the main reason is associated with arteriosclerosis. According to the American Heart Association, atherosclerosis is a condition caused by the accumulation of a substance called plaque in the walls of arteries. Today, special methods are used to help the patient survive in the event of a heart attack and diagnose the patient's condition. One of the safest methods in medical science is to use a stent. Despite all the innovations in the design of cardiovascular stents, the metal stents that are commonly used cause various problems such as corrosion, infection, and restenosis, which lead to physical problems or even death of patients. In order to minimize the problems associated with metal stents, new materials such as polymers are now being developed. On the other hand, the development of polymer-based vascular scaffolds requires a new structural geometry, because these polymeric materials have significantly less radial strength than metal alloys. In this study, the stiffness and flexibility of commercial polymer stents were investigated using analytical relationships and the finite element method, and it was shown that there is a good correlation between these two methods. Then, a new design for a zigzag stent is introduced to make it less sensitive to changes in thickness to and increase its radial strength. Finally, the Taguchi method and analysis of variance were used to design the experiment and determine the effect of stent geometric parameters, including strut width, bridge width, and stent thickness, on the flexibility of this type of stent. The results showed that the width of the bridge and the strut have the greatest effect on the flexibility of the stent, respectively, and the change in stent thickness, which is an effective parameter in the radial strength of the stent, has no significant effect on the flexibility of this type of stent.

**Key Words:** Stent, optimization, analysis of variance, finite element.

## A DESIGN ALGORITHM AND NUMERICAL INVESTIGATION OF A WATER-JACKET COOLING SYSTEM FOR A HIGH-ALTITUDE SIMULATOR DIFFUSER

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**DOI:10.24200/J40.2023.61692.1668**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 25-37, Original Article



• Received 15 January 2023; received in revised form 20 April 2023; accepted 9 May 2023.

Abstract

Usually, in a high-altitude test facility, an exhaust diffuser is applied to create and maintain a vacuum condition in the motor test chamber utilizing the energy of the exhaust gases. In this system, the temperature of the exhaust gases, which directly hit the diffuser's inner walls, is much higher than the tolerable temperature of the diffuser metal body. In the current research, a new algorithm has been developed to design the cooling system to remove high heat fluxes from the vacuum simulator diffuser walls. In this algorithm, the three parameters of coolant mass flow rate, channel height, and cooling channel length are calculated based on the heat flux distribution along the diffuser, in such a way that, in addition to satisfying the temperature conditions of the metal body and maintaining the ease of implementation of the design, the total pressure drop also is in the desired range. Due to the error of empirical and semi-empirical relationships used to estimate convection heat transfer coefficients in concentric annular flows with large wall surfaces and high heat flux, a numerical simulation technique has been used to find suitable correlations and evaluate the design. The present studies show that the experimental correlations of Meyer and Kaneda are suitable for estimating the Nusselt number (with a maximum error of 3.81 %) and the friction coefficient (with a maximum error of 1.06 %) in the conditions of the present problem, respectively. Furthermore, the high capability of the algorithm is shown by presenting design results with different heat flux distributions. So, by distributed heat flux attributed to the stable working conditions of the vacuum simulator, a single cooling channel with a height of 3.2 mm and a mass flow rate of 8.025 kg/s has been designed, while for a critical heat flux of about 2.5 $MW/m^2$, a two-channel cooling system with different mass flow rates and channel heights has been designed.

**Key Words:** Metal diffuser, multi-channel cooling, water-jacket method, high heat flux.

## NANOCARS ASSEMBLY ON A SURFACE: COARSE-GRAINED MOLECULAR DYNAMICS STUDY

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**DOI:10.24200/J40.2023.61727.1669**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 39-46, Original Article


- Received 15 January 2023; received in revised form 10 April 2023; accepted 19 April 2023.

Abstract

Using coarse-grained molecular dynamics (CGMD), the simulations of the nanostructures are performed considerably faster and with low computational costs. In the present study, a coarse-grained model is proposed for describing the surface assembly of a molecular machine called a nanotruck. In this model, we assumed that the interactions of fullerene wheels have the main role in the nanocars interactions. The analysis of the potential energy reveals three stable configurations in the interaction of two nanocars. The stable configuration of nanocars obtained from the coarse-grained model is in agreement with the results of the all-atom molecular dynamics simulations. Simulating the stable configurations at temperatures of 200, 400 and, 600 K, we examined the thermal stability and separation of nanocars. Since each stable configuration shows a specific radius of gyration, we employed this parameter to study the thermal stability of configurations at different temperatures. At 200 K, the nanocars maintain their stable configurations, and at the temperature of 400 K, the nanocars are able to change their relative orientations. The thermal energy supplied at 600 K and higher temperatures is sufficient to break the cluster of two nanocars, and the molecules are separated at this temperature range. The potential energy of the interaction of two molecules finds zero value during the simulation time, which refers to the separation of nanotrucks at this temperature. In the next step, we evaluate the surface arrangement of larger clusters, including four and eight nanocars. Considering the relative orientations of each pair of neighboring nanocars, it is concluded that the stable orientations of nanocars are similar to those observed in the cluster of two nanocars. The results of the coarse-grained model on the assembly of nanocars are consistent with the conclusions of the all-atom simulations of nanocars. The proposed coarse-grained model can be employed to study the assembly of other fullerene-based nanocars.

**Key Words:** Molecular dynamics simulations, coarse-graining, nanocars, molecular machines, self-assembly.

# NANOPARTICLES IN THE TURBULENT FLOW BEHIND THE BACKWARD STEP BY EULERIAN-LAGRANGIAN METHOD

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Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 47-60, Original Article


- Received 22 January 2023; received in revised form 29 April 2023; accepted 30 May 2023.

Abstract
Turbulent backward step flow, including air and copper nanoparticles, has been simulated using the Computational Fluid Dynamics (CFD) method by the Eulerian-Lagrangian method. The simulation was done using two- and three-dimensional methods with CFX and FLUENT software. The obtained results were compared with each other and with the experimental results. The two-way coupling discrete phase model (DPM) was used for simulation. The Saffman lift force, pressure gradient, and turbulence effects on nanoparticles are considered. Numerical results obtained with Eulerian-Lagrangian models and single-phase models in steady and transient have been compared with experimental data. The effect of the turbulence model on the trajectory of particles and in terms of different diameters of 10, 20, 30, 50, 70, 100, and 200 micrometers have been investigated. The effects of particle diameter on the trajectory and behavior of particles and the effect of Stokes number on the presence of particles in the vortex created behind the step have been investigated. The results have been presented as various contours and graphs for two- and three- dimensional, steady, and transient states. Particle trajectories are shown as contours for different Stokes numbers and particle diameters. The continuous phase velocity variation across the channel for different distances of step are presented as graphs. Standard, RNG, and Realizable k-e and standard and SST k-w models are considered for the modeling of turbulent flow. The results show that SST k-w is more accurate than the experimental data. Furthermore, simulation was done using CFX software. Variations of velocity profile are compared with experimental and Fluent data. The results show that the Stokes number and the turbulence model have a significant effect on the trajectory of particles. Three-dimensional modeling of the flow increases the accuracy of the results. The maximum error in the single-phase method is equal to 25% and for the Eulerian-Lagrangian method is equal to 19%. Particles with a Stokes number smaller than 1.2 (equivalent to a diameter of 35 micrometers in this study) sense the presence of the vortex and enter the vortex. Among the turbulence models, the lowest error for the sst model is equal to 6.25, and the highest error for the standard K$\varepsilon$ model is equal to 18.75.

**Key Words:** Nanofluid, turbulence model, eulerian-lagrangian method, backward step flow, fluent, cfx.

# RELIABILITY-BASED MULTIDISCIPLINARY DESIGN OPTIMIZATION UNDER UNCERTAINTY FOR REUSABLE FLEXIBLE SPACE LAUNCHER UTILIZING NSGA-II

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**DOI:10.24200/J40.2023.61713.1667**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 61-74, Original Article


- Received 25 January 2023; received in revised form 30 June 2023; accepted 16 July 2023.

Abstract
Complex systems design problems entail a suitable structure in which all disciplines, including their coupled relationships, have been considered and modeled at the same time. These types of design problems involve time and computational cost challenges. Multi-Disciplinary Design Optimization (MDO) methods have been developed to address these issues simultaneously. This article aims to provide a proper design structure for an uncertainty-based re-entry trajectory design optimization problem under the control restrictions and structural constraints of a Reusable Flexible Space Launch Vehicle (RFSLV) alongside the determination of optimal skin thickness and thermal protection system thickness concerning the design criteria of the flexible structure in such a way that the final design would meet the desired reliability. Trajectory, structure, aerodynamics, aeroelasticity, and thermal protection systems are con-

sidered to be involved disciplines in the design problem. The study's purpose will be to obtain an optimal trajectory to meet all the control and structure restrictions while estimating optimal body skin and thermal protection thicknesses based on structural design criteria evaluating the re-entry trajectory, which is in process. The flexible space launcher body has been considered as a free-free Bernoulli-Euler beam for bending variation and D'alembert's principle for inertia force in static model with the aim of assessing structural design standards. The 3DOF longitudinal dynamic equations plus the first bending mode have been considered. By Chebyshev polynomial interpolation, the angle of attack scope has been achievable, and then the trajectory optimization problem has been transformed to a discrete nonlinear programming problem (NLP), which leads to numerical integration of state equation and satisfying all path constraints in Bolza optimal control problem. All highly nonlinear uncertainty-based constraints in the model have led to taking advantage of the evolutionary optimization algorithm that has been implemented here by Non-Dominated Sorting Genetic Algorithm (NSGA-II). Finally, epistemic and aleatory uncertainties have been applied through Probability Theory to estimate the reliability of constraints that had been affected by uncertainties. The result shows a 75 percent decrease through utilizing the evolutionary multi-objective technique against the gradient-based algorithm in design space optimization regarding computational cost in recalling objective functions. The other conclusion is that the sequential reliability analysis structure modeling efficiency is much better compared to the parallel one.

**Key Words:** Flexible reusable space launch vehicle, uncertainty, reliability analysis, multidisciplinary design optimization, re-entry trajectory, aeroelasticity.

# INVESTIGATING OF SIZE-DEPENDENT BUCKLING AND INSTABILITY CAUSED BY SUPPORT FORCES AND ELECTROSTATIC FIELD IN POROUS ANNULAR MICROPLATES

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**DOI:10.24200/J40.2023.61768.1673**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 75-84, Original Article


- Received 5 February 2023; received in revised form 11 March 2023; accepted 14 March 2023.

Abstract
In this paper, the static behavior, instability and buckling in porous micro plates under electrostatic field are investigated based on the modified couple stress theory and with regard to modeling, determining equations and solution methods. The plate is considered to be porous and the porosity distribution is considered to be non-uniform. The equations are obtained considering the distributed support load. By using the definition of dimensionless parameters such as load, voltage and length scale, the equations of motion become dimensionless. It can be seen that in the special case, by removing the dimensionless non-classical parameters, the equation of the classical plate under the electrostatic field is obtained. Galerkin mode summation and numerical methods are utilized to solve the static deformation equation and assess the pull-in instability voltages and buckling loads. Convergence analysis is done and the number of approximation functions and elements required for both methods are calculated and the compatibility of the results obtained from the two methods is examined. In the results section, the difference between classical and non-classical theories is examined and the effect of dimensionless parameters of length scale and porosity ratio on maximum displacement, pull-in instability voltages and buckling load is studied. The results show that the use of modified stress couple theory leads to a very large stiffness prediction compared to classical theory. This result highlights the necessity of using the modified couple stress couple theory for the micro-scale. It is observed that the length scale parameter plays the role of stiffening. The change of porosity ratios also shows that as this ratio increases, the displacement increases and the stable areas decrease. Variations in this ratio lead to uniform changes in buckling load and pull-in instability voltage, and linear relationships are obtained to calculate buckling load and pull-in instability voltage versus porosity ratio. Also, in small values of support load, it is shown that the relationship between the instability voltage and the compressive load of the support is linear, but in the buckling range, this relationship is not linear.

**Key Words:** Porous, buckling, size dependent theory, numerical method, instability.

# EXPERIMENTAL STUDY OF THE EFFECT OF OIL-BASED NANOFLUID ON HEAT TRANSFER CHARACTERISTICS IN DIFFERENT ARRANGEMENTS OF WAVY MICROCHANNELS

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**DOI:10.24200/J40.2023.62014.1676**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 85-96, Original Article


- Received 24 April 2023; received in revised form 29 October 2023; accepted 29 October 2023.

## Abstract
The development of microchannel manufacturing technology has led to a growing interest in using them as heat exchangers. Microchannels are used to control the temperature of equipment and components that generate a high amount of heat flux. Heat transfer can be further increased by dispersing particles (nano-sized particles) with a low volume fraction into the base fluid (nanofluid). A nanofluid can change the thermophysical properties of a base fluid and improve its thermal performance. The purpose of this study was to examine the heat transfer characteristics of oil-based nanofluid within wavy microchannels in series and parallel arrangements of microchannels. In order to examine the performance of each microchannel separately and to make it easier to draw their diagrams, they are named 1 and 2. Experiments were performed on $TiO_2$ and $SiO_2$ oil-based nanofluids in volume fractions of 0.05 and 0.1, flow rates of 0.5, 1.0, and 1.5 lit/min, and inlet temperatures of 40°C, 45°C, 50°C, 55°C. The results show an increase in the Nusselt number of the base fluid up to 41.8% in the series arrangement and also a decrease in the surface temperature in the series arrangement compared to the parallel arrangement. Also, $TiO_2$ and $SiO_2$ nanofluids with a volume fraction of 0.1 caused the highest increase in heat transfer, up to 56% and 52.7% in parallel arrangement and up to 45.8% and 42% in series arrangement compared to the base fluid, respectively. The pressure drop of the test section in series arrangement was up to 82.1% higher than parallel.

**Key Words:** Microchannel, oil-based nanofluid, convective heat transfer, nusselt number, laminar flow, pressure drop.

# DEVELOPING AN INTERFACE TRACKING COUPLED SOLVER FOR SOLVING TWO PHASE FLOW FIELDS AT LOW REYNOLDS NUMBERS IN FOAM-EXTEND PLATFORM

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**DOI:10.24200/J40.2023.62339.1681**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 97-110, Original Article


- Received 30 April 2023; received in revised form 28 August 2023; accepted 18 September 2023.

## Abstract
In the present study, for the first time, a finite volume coupled solver is developed for the simultaneous numerical solving of two-phase incompressible fluid flow equations at low Reynolds numbers, and for solving the the interface position equation by applying interface boundary conditions using the foam-extend platform. The studied flows with interface and mesh motion are considered to be laminar and in the range of Reynolds numbers less than 100. The Foam-extend is a fork of OpenFOAM, an opensource object-oriented C++ library for computational continuum mechanics. This solver is based on the interface tracking algorithm, which is developed using an innovative technique called zero-thickness cell. This technique removes the distance effect for the cell adjacent to the interface, and the interface is modeled with zero thickness cells. The main advantage of the present coupled solver compared to the previously developed solvers is that in this solver, all the equations in both phases are coupled with each other by cells adjacent to the interface and with an the interface position equation. All the governing equations and the interface position equation are assembled in a single linear system of equations and simultaneously solved. In fact, unlike the usual segregated procedure of solving two phase flows, where the phases are solved with lagged value boundary conditions, in the present solver ،the phases are solved

simultaneously with the interface conditions in an implicit manner and in the same block matrix system. The movement of the interface was done separately, and in another step. For this purpose, the kinematic condition was implemented. The computational performance of the coupled solver was evaluated by solving the equations of two-phase fluid flow inside a channel and on a backward-facing step. In the beginning, a preliminary investigation was done for the case, where both phases were completely independent and decoupled. Matching the interface with the streamlines, as well as the reasonable and justifiable movement of the surface, has been observed from the physical point of view. Also, the damping of the numerical oscillations generated on the interface and changing the flow variables will be investigated. The present results are in excellent agreement with other results reported in the literature.

**Key Words:** Two-phase flow, interface tracking algorithm, foam-extend, finite volume method.

## A COMPARATIVE STUDY OF THE AERODYNAMIC PERFORMANCE AND ECONOMIC VIABILITY OF H-SHAPE AND V-SHAPE WIND TURBINES IN THE CLIMATE OF ZAHEDAN CITY

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Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 111-118, Original Article



- Received 23 May 2023; received in revised form 11 July 2023; accepted 13 August 2023.

### Abstract

This research evaluates two types of vertical axis turbines from both an aerodynamic and economic perspective. The turbines used in this study have straight (H-shaped) and angled (V-shaped) blades, with equivalent dimensional characteristics that are suitable for the climatic conditions and average wind speed distribution in Zahedan city. The aerodynamic evaluation of the turbines was conducted using the semi-analytical DMST method. The results indicate that the V-shaped turbine generates significantly less power than the H-shaped turbine due to the reduction of the effective area of the turbine and the torque produced by its rotor. However, during startup, the V-shaped turbine exhibits about seven times less negative power than the H-shaped turbine, which improves the overall startup process. Economically, the cost of energy production per kWh for a V-shaped turbine is approximately 20% lower than that of an H-shaped one. This makes the V-shaped turbine a more suitable option for urban and small-scale applications.

**Key Words:** Vertical axis wind turbine, aerodynamic performance, economic evaluation.

## EXPERIMENTAL DETERMINATION OF CORRECTION FACTORS FROM CHARPY IMPACT TESTING OF API X65 STEEL WITH VARYING SPECIMEN THICKNESS

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**DOI:10.24200/J40.2023.62502.1686**

Sharif Mechanical Engineering Journal
Volume 40, Issue 1, Page 119-127, Research Note



- Received 18 June 2023; received in revised form 3 October 2023; accepted 28 October 2023.

### Abstract

The purpose of this research, in addition to determining the characteristic forces, including the yield force and maximum force, was to calculate the correction factors to predict the onset of failure in the energy transmission pipelines with high toughness under dynamic (impact) loading. To achieve this goal, an instrumented Charpy impact machine, which plots the force-displacement diagram during the impact test, was used. Then, by dividing the area under the force-displacement diagram into two parts, both the initiation energy and crack growth energy in API X65 steel were calculated. The results showed that the total energy provided by the machine dial was in agreement with the total energy calculated from the area under the force-displacement curve. Characteristic forces were also determined from the force-displacement curve as described in the BS 14556 standard. After that, power law expressions with high accuracy were extracted to describe the behavior of the tested steel against variations of the Charpy sample thickness for crack initiation energy, crack propagation energy, and characteristic forces. Additionally, the average correction factor, which is used in prediction models of energy transmission steel pipelines, was found to be 1.26, which is in good agreement with the available results for the current steel in the literature. It was shown that by increasing the thickness, due to the transition from plain stress to plain strain condition, the correction factor changed from 1.26 to 1.3 in 8 to 10 mm thicknesses, while it did not change so much from 4 to 8 mm thicknesses. By examining the characteristic forces and plotting the ratio of the yield force to the maximum force versus thickness variation, it was also found that increasing the thickness leads to decreasing the work hardening of the steel.

**Key Words:** Fracture energy, crack initiation energy, crack propagation energy, instrumented charpy impact machine, API X65.