Abstracts of Papers in English

INTEGRATED ROBUST GUIDANCE AND CONTROL OF VTVL REUSABLE LAUNCH VEHICLE AT PRE-LANDING PHASE USING SLIDING MODE CONTROL

B. Asadi
babak.asham@gmail.com
M. Fathi(corresponding author)
fathi@sharif.edu
Dept. of Aerospace Engineering
Sharif University of Technology
DOI:10.24200/J40.2022.58323.1608

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 3-13, Original Article

- Received 29 December 2021; received in revised form 21 September 2022; accepted 16 October 2022.

Abstract

In this article, guidance and control of the reusable launch vehicle at pre-landing phase have been studied. A plenty of vertical take-off and vertical landing (VTVL) reusable launch vehicle have been gradually developed to access the space allowing for reducing the flight operation costs and realizing reusability such as Falcon 9. The goal of this article is increasing the accuracy and safety of the guidance and control system of the launch vehicle in order to successfully land on the ground station. Integrated guidance and control, being a novel method in guidance and control, is used to guide the launch vehicle in the re-entry phase and landing phase on the ground. The returning object studied is a Falcon 9 rocket for which we find the 6 DOF model. This vehicle has a vertical landing phase and implementing an integrated guidance and control system is a novel approach in this area. The controller used in this article is based on sliding-mode. This controller has an acceptable performance against the uncertainties and indefinite values of the system parameters. GPOPS software is used to create the initial flight path of the launch vehicle. This software calculates the optimal landing path with respect to dynamic constraints, control constraints and a cost function. Genetic algorithm is used to find the constant parameters for guidance and control. In this work, a fast terminal sliding mode control is proposed for a VTVL reusable launch in the present of distur-

bance and uncertainties. Compared with the previous works, the proposed controller has satisfactory performances and achieves smaller steady-state error under the consideration of multiple simulation results.
Results show that integrated guidance and control needs less bulk standard deviation than common guidance and control due to simultaneous solving of guidance and control equations. This causes the defined constraints not to surpass the acceptable values anywhere in the path.

Key Words: Integrated guidance and control, sliding mode controller, gpops software, genetic algorithm, launch vehicle, reusable.

PREDICTION OF THE HIT PROBABILITY UNDER VARIOUS NOISE FACTORS TO IMPROVE THE GUIDANCE LAW OF AN AUTONOMOUS UNDERWATER VEHICLE

M.S. Zamani(corresponding author)
zamani@yazd.ac.ir
Dept. of Mathematical Sciences
Yazd University
S. Sadeqian Bafqi
sajadsadeqian@email.kntu.ac.ir
Dept. of Aerospace Engineering
K.N.Toosi University of Technology
DOI:10.24200/J40.2022.60494.1643

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 15-25, Original Article

- Received 24 January 2022; received in revised form 21 May 2022; accepted 18 June 2022.

Abstract
Submarine robots or autonomous underwater vehicles (AUVs) are one of the most important tools for identifying, monitoring and inspecting the marine environment and the oceans. In addition, it is used for applications such as tracking surface targets. In the process of tracking a target by an autonomous underwater vehicle, designing the most efficient guidance law is of particular importance. In order to evaluate the efficiency of the tracking process, various criteria such as ease of implementation, less need for target data and the probability of hitting the target must be considered. Among these factors and other effective factors in evaluating tracking performance, hit probability is the most important and telling variable. in complex situations, the most common way for calculating this parameter is the Monte Carlo method. This method is based on performing multiple simulations of the AUV and target motion for various uncertainties in the problem. The ratio of the number of times that the tracking process is successful provides an estimate of the hit probability. However, in order to achieve good accuracy, it is necessary to select a sufficiently large number of repetitions in the Monte Carlo method and therefore the computational cost of calculating the hit probability will be high. In this paper, first, using machine learning methods and in particular the gradient boosting method, a model for predicting the hit probability is presented with the appropriate accuracy. Then, using this model and by geometric calculations, the tracking parameters in the preset phase are determined in such a way that maximizes the hit probability. The efficiency of this method will be demonstrated through the simulation of different scenarios. In the end, by considering the randomness along the path, the AUV and target dynamic system is modeled as a stochastic process using the Ornstein-Olenbeck process. Then, the Monte Carlo simulation is described and similarly, previous works can be repeated.

Key Words: Hit probability, gradient boosting method, monte carlo method, underwater autonomous vehicle, guidance law, machine learning.

NUMERICALLY AND EXPERIMENTALLY INVESTIGATION OF THE EFFECT OF ANISOTROPY AND STRESS TRIAXIALITY ON THE FRACTURE STRAIN

P. Abedinimanesh
parmida.abedini@ut.ac.ir
F. Hazinia
faraz.hazinia1367@ut.ac.ir
M. Ganjiani (corresponding author)
ganjiani@ut.ac.ir
Dept. of Mechanical Engineering
University of Tehran
DOI:10.24200/J40.2022.60374.1640

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 27-34, Original Article

- Received 15 March 2022; received in revised form 9 July 2022; accepted 14 August 2022.

Abstract
The aim of this article is to investigate numerically and experimentally the effect of stress triaxiality and

anisotropy on the fracture strain for metals. As the aluminum has always been one of the most widely used metals in the industry. This metal has unique properties such as lightness and high resistance to corrosion, hence, 1100 aluminum alloy is used in this article. This metal is malleable and also has high workability so it is suitable for applications including shaping. To achieve the properties of the sheet, it is first necessary that all samples were made according to the ASTM-E8 standard and the specimens were designed to achieve some different stress triaxiality. This samples includes the standard-, notched- and shear-specimens. All samples are loaded in tension state. In order to investigate the anisotropy, the specimens are prepared in rolling direction, 45 and 90 degrees to rolling direction for each samples. The uniaxial tensile test was performed on the specimens until the onset of failure. For measuring the fracture strain experimentally, a new method with lower costs than others have been proposed. For standard and notched specimens, the strain measuring is based on the difference between cross-section areas for shear-specimen, the changes in the notched radius has been proposed for strain measuring criterion. Also, in order to calculate the stress triaxiality in the fracture zone, all experiment tests are simulated in Abaqus. The equivalent plastic strain and stress triaxiality of the elements in fracture zone are reported. The average value of these elements are compared to the corresponding experimental data. At the end comparing the results obtained from experimental and simulations shows that the failure strain is calculated with great accuracy. For more explanation, the maximum error is found to be 12.8% for notched-specimen. Furthermore, the non-linear effect of stress triaxiality on the fracture strain are well shown.

Key Words: Fracture strain, stress triaxiality, anisotropy, aluminum 1100.

EFFECT OF VIBRATION AMPLITUDE AND TEMPERATURE ON THE SHAPE AND SIZE OF ALUMINUM POWDER PRODUCED BY ULTRASONIC ATOMIZER PROCESS

M.M. Mojtahedi
mehdi.mojtahedi92@gmail.com
H. Soleimanimehr(corresponding author)
soleimanimehr@srbiau.ac.ir
Dept. of Mechanical Engineering
Science and Research Branch
Islamic Azad University

M. Moazami-Goudarzi
moazami@srbiau.ac.ir
Dept. of Materials Engineering
Science and Research Branch
Islamic Azad University
DOI:10.24200/J40.2022.60374.1640

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 35-45, Original Article

- Received 21 May 2022; received in revised form 3 August 2022; accepted 15 August 2022.

Abstract

Ultrasonic waves have been used in research and industrial fields for many years, and the use of these waves in some of these fields is very old. And it seems that its scope of application is increasing day by day. One of the fields in which this technology is used is the production of metal powders. In the process of producing metal powder from their melt, the melt must be turned into very fine droplets under the influence of an energetic flow, which will turn into metal powder particles after cooling. In the ultrasonic atomization method, the energy intended to create melt droplets is supplied by ultrasonic waves and transferred to the desired metal melt. In this article, the effect of the vibration range on the shape and size of the aluminum powder produced by the ultrasonic atomization process with a vibration frequency of 20KHz has been investigated. The effect of factors such as melt temperature and ultrasonic wave amplitude on particle size and particle shape was investigated. It was also investigated at what level each of the factors affect the expected characteristics of the research. By examining the obtained results, it was observed that with the increase of the temperature of the melt, the viscosity of the melt decreases, and as a result, the atomization of the melt becomes easier, and also the surface tension force is reduced, and it becomes easier to separate the melt drop from the melt film created on the atomizer. And it was also observed that with the increase in the size of the vibration range, the produced metal powder has a smaller average size in terms of size and a narrower size distribution range. The average particle diameter of the powder produced by this method in this experiment was $82.43\mu m$, the maximum particle diameter was $92.16\mu m$ and the minimum - particle diameter was$71.33\mu m$.

Key Words: Ultrasonic, atomization, aluminum powder, vibration amplitude, frequency.

DYNAMIC BEHAVIOR ANALYSIS OF PIEZOELECTRIC FLOW MICRO

SENSORS AND CORRESPONDING LINEAR WORKING DOMAIN

M. Akbari
akbari.m@fasau.ac.ir
A. Karimzadeh (corresponding author)
a-karimzadeh@fasau.ac.ir
School of Mechanical Engineering
Fasa University
DOI:10.24200/J40.2022.60635.1646

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 47-53, Original Article

- Received 3 July 2022; received in revised form 31 August 2022; accepted 20 September 2022.

Abstract

In the present study the dynamic behavior of a piezoelectric flow micro sensor based on vortex-induced vibrations (VIV) is investigated. This sensor is made by a cantilever beam, piezoelectric layer and a cylinder at free end which is used to measure the fluid velocity. The proposed VIV sensors have nonlinear dynamic behavior for different flow velocities therefore in designing VIV micro sensors obtaining linear operational working range is an important parameter. In this paper the dynamic behavior of micro flow sensors based on the modified couple stress theory (MCST) is investigated and linear operational working span is derived. The coupled governing equations of silicon based and piezoelectric layer cantilever beam, gauss electric and Van der pol equation are derived. Utilizing the derived equations the dynamic behavior of the micro sensor on the basis of parameters such as damping coefficient, cantilever beam length, material length scale parameter and tip cylinder mass is analyzed. The operational work range of the micro sensor, the acceptable linear behavior domain and error of linear behavior assumption of the device is investigated. According to the results the maximum linearization error is 3.5%. In addition to that reduction in cantilever beam length and tip cylinder mass increase the operational working range of the micro sensor. Analyzing the effect of damping coefficient on the dynamic behavior of micro flow sensor show that increasing the damping coefficient decreases the beam deflection and output voltage, but has no effect on the operational working span of the system and in order to obtain precise output from this sensor the damping coefficient must be reduced. Findings indicate that parameters which make the device behave stiffer such as reduction in beam length or tip cylinder mass or considering non-classical stresses gives a wider acceptable voltage range at higher flow velocities for the micro sensor.

Key Words: Micro sensor, flow sensor, piezoelectric cantilever beam, modified couple stress theory.

EXPERIMENTAL INVESTIGATION AND ANALYSIS OF COMBUSTION PROPERTIES AND CHEMICAL-PHYSICAL PROPERTIES OF NANO-FUEL USING HYBRID NANOSTRUCTURE ADDITIVES

S.A.H. Zamzamian(corresponding author)
azamzamian@merc.ac.ir
S. Rezazade Mofradnia
srezazadeh69@gmail.com
M.R. Pazouki
pazoukim.reza@gmail.com
M. Pazouki
m.pazouki@merc.ac.ir
Solar Energy Group, Materials and Energy Research Center(MERC)
DOI:10.24200/J40.2022.58323.1608

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 55-67, Original Article

- Received 5 July 2022; received in revised form 30 July 2022; accepted 14 August 2022.

Abstract

Nanostructured additives have been widely used in various industries especially power industry in order to decrease both specific fuel consumption (fuel consumption per unit of electricity production, SFC) and pollutants emission. The most important fuel properties are fuel density, kinematic viscosity, flash point, cetane number, and calorific value. Calorific value of a fuel is the thermal energy released per unit quantity of fuel when the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture. It measures the energy content in a fuel. The calorific value of a fuel can be measured in a bomb calorimeter. The most frequently used fuel additives for diesel engines are oxygenated additives, antioxidants, cold flow improvers, lubricity improvers, cetane improvers, metal-based additives, and nanomaterials. In recent years, various nanomaterials, acting as diesel engine fuel additives, gained substantial attention. According to investigation results obtained so far, these additives look to be extremely promising. This follows from the wide range of options they offer in influencing practically all important engine characteristics by affecting many processes from fuel combustion to exhaust treatment. In this study, hybrid nanoparticles were dispersed in mazut and diesel fuels as hybrid nanofuels and the physico-chemical properties of manufactured nanofuels were evaluated. Dispersion of the nanoparticles were carried out in two stages. They were weighed and mixed to surfactants and added to fuel. Then the mixture was

dispersed by using an ultrasonic device.The results indicated that the rate of calorific values of mazut-based nanofuels and diesel-based nanofuels were improved to 13.41% and 14.02%, respectively, in proportion to pure mazut and pure diesel fuels. Therefore, metal oxide nanoparticles and multi-walled carbon nanotubes had a remarkable impact on combustion properties of fuels. The final price of nanofuel was up to 20-30% more than pure fuels which can be reduced when nanofules are produced in large scale. It can be concluded that the optimized samples of mazut-based and diesel-based nanofuels had all properties of an ideal fuel for using in a combustion process and could be considered as suitable alternatives to pure mazut and pure diesel fuels.

Key Words: Nanofuel, nanodisel, hybrid nanostructure, nanomazut, combustion.

INVESTIGATION OF THE LOCAL HEATING EFFECT ON THE AERODYNAMIC FORCES OVER A CYLINDER AT REYNOLDS 1000

M.M. Falahi
mo.falahi@mail.sbu.ac.ir
N. Nabatian(corresponding author)
n_nabatian@sbu.ac.ir
Faculty of Mechanical and Energy Engineering
Shahid Besheshti University
DOI:10.24200/J40.2022.60657.1647

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 69-77, Original Article

- Received 9 July 2022; received in revised form 10 September 2022; accepted 20 September 2022.

Abstract

The interaction of the thermal and velocity boundary layers of 2D cylinder at Re=1000 is modeled in ANSYS Fluent. Heating elements different positions as well as various temperature effects on the flow characteristics are investigated. Temperature variation of the cylinder surface changes the fluid properties including density, viscosity, specific heat and conductivity. Their dependencies are modeled in the form of polynomials as the function of temperature. The velocity inlet boundary condition of 0.6 m/s, the pressure outlet with 0 Pa and no-slip condition for cylinder wall are set. The lateral boundaries are freestream walls while the sidewalls are symmetric. The pressure-velocity coupling is modeled with Coupled method and $k-\omega$ is used for turbulence modelling. The surrounding temperature is 25° . The comparison of the heating element application on the windward and leeward sides of the cylinder show that its usage on the leeward side is more efficient on the flow control and reduces the aerodynamic forces significantly. By increasing the fluid viscosity due to the temperature enhancement, the Reynolds number decreases while the surface friction increases. With surface friction enhancement under leeward side heating, vorticity strength is reduced and the vortices lengths are elongated downstream. Consequently, free shear layers interaction and vortex shedding are delayed forming a relatively symmetric velocity pattern and pressure distribution. The symmetry of the pressure distribution reduces the oscillation amplitude of the aerodynamic forces that leads to the flow control. Increasing the cylinder surface temperature on the leeward side rises the intensity aerodynamic forces variation. The results indicate that the location, size, and temperature of the heating elements influence the separation points of flow and the aerodynamic forces acting on the body. The utilization of the heating element with a temperature of 1000° on the leeward side leads to 87.1% lift force and 25.9% drag force reduction; while using them on the lateral sides, despite delaying the separation points of the flow, leads to flow instability. The size of vortices is decreased resulting in the higher shedding frequency. The cause of this phenomenon is related to the changes in the characteristics of flow and vortices that alter the velocity and pressure fields.

Key Words: Flow control, heat transfer, thermal boundary layer, velocity boundary layer, aerodynamic forces.

INVESTIGATION AND SIMULATION OF A COOLING CYCLE BASED ON MISOTSENKO CONCEPT

M. Tohidloo
mahdi.tohidloo@mech.sharif.edu
M.A. Bakhtiari
mohammadali.bakhtiari@mech.sharif.edu
M.H. Saidi(corresponding author)
saman@sharif.edu
Dept. of Mechanical Engineering
Sharif University of Technology
DOI:10.24200/J40.2022.60517.1648

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 79-88, Original Article

- Received 11 July 2022; received in revised form 14 September 2022; accepted 16 October 2022.

Abstract

The Maisotsenko cycle is a novel thermodynamic concept which captures the internal energy in an air cooling process by using the latent heat of evaporation of water. This concept is a regenerative indirect evaporative cooling cycle (RIEC) which utilizes a new arrangement of airflow streams to achieve better performance. In the field of air conditioning, this cycle is known as a high efficiency cooling cycle due to the cooling of the air-water vapor flow temperature to its dew point temperature. Most commonly known variant of this concept is a cross-flow cooler which will be examined in this paper.

In the present study, the governing equations of a heat and mass exchanger based on the Maisotsenko cycle has been extracted. This heat and mass exchanger has been analyzed and simulated in the month of July, which is the hottest month of the year, in the climatic conditions of Tehran. Temperature analysis utilizing the finite difference method has shown that the heat and mass exchanger based on the Maisotsenko cycle has superior performance than existing devices in the cooling air process in the field of air conditioning technology. the air temperature in Tehran decreases from 40.2° C to 22.2°C when passing through the device.

The possibility of employing a Maisotsenko cycle air conditioner in different climates of Iran has been investigated in this study. The results revealed that the cooler based on the Maisotsenko cycle performs satisfactorily for more than 85 percent of the population and more than 86 percent of the regions of Iran. Also, according to the acquired data, the air conditioner based on the Maisotsenko cycle operates with an average coefficient of performance of 31 in various regions of Iran. The airflow passing through this heat and mass exchanger is cooled to 90% of it's inlet wet bubble temperature.

Key Words: Maisotsenko cycle, evaporative cooling, simulation, HVAC.

COMPARISON OF EXPERIMENTAL RESULTS BETWEEN USING AUXETIC SHOE, CONVENTIONAL SHOE AND BAREFOOT ON THE KINEMATICS OF VERTEBRAL COLUMN DURING DROP VERTICAL JUMP

M. Rahmani Dehaghani
mostafarahmani94@gmail.com
A. Nourani(corresponding author)
nourani@sharif.edu
N. Arjmand
arjmand@sharif.edu
F. Farrahi Ghehi
fatemehfarahighehi@pardis.sharif.edu
Dept. of Mechanical Engineering
Sharif University of Technology
DOI:10.24200/J40.2022.60791.1650

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 89-98, Original Article

- Received 20 July 2022; received in revised form 15 October 2022; accepted 16 October 2022.

Abstract

Footwear condition has been found to change kinematics of body especially in high-demanding activities. The present study compared the kinematics of healthy individuals when different footwear conditions were used. Two types of shoes, i.e., auxetic and conventional, were compared with each other and also with barefoot condition during gait and drop vertical jump (DVJ) activities using in vivo experimentation. A number of 11 male individuals were asked to do the experiments. Three trials for each footwear condition were completed for every participant, i.e., total of nine trials for each person. All methods were performed in conformity with relevant procedures and protocols. Their motion and force-plate data as well as electromyographic (EMG) activities of some trunk muscles were recorded during abovementioned actions. Two main stages of first landing (FL) and second landing (SL) were considered in the DVJ activity. Statistical analysis, using ANOVA and Tukey's honestly significant difference, was carried out to investigate effects of footwear conditions on the kinematics. Results showed that biomechanical changes between the the three footwear conditions were insignificant in gait and the SL phase of DVJ. However, significant differences were detected during the FL stage of DVJ; using the auxetic shoes resulted in smaller EMG activities in longissimus and iliocostalis muscles, smaller anterior-posterior distance between the center of pressure of ground reaction force and heel, and also larger maximal hip, knee, and ankle flexion angles ($p_i 0.005$) compared to conventional shoe condition. The differences were even more pronounced when the auxetic shoe was compared with barefoot condition. The results can be used to help guide selecting an appropriate footwear for different activities. Furthermore, the methodology presented in this study can be used to examine the suitability of newly developed shoes especially for athletes for high-demanding actions. Further studies are needed to distinguish the influences of different parameters of shoe sole on the body kinematics.

Key Words: Auxetic shoes, EMG, kinematics, drop vertical jump.

OWL AEROACOUSTICS: ANALYSIS OF A SILENT FLIGHT

M. Mozafari
mstfmozafari18@ut.ac.ir
M. Masdari(corresponding author)
m.masdari@ut.ac.ir
Faculty of New Sciences and Technologies
University of Tehran
DOI:10.24200/J40.2022.60494.1643

Sharif Mechanical Engineering Journal
Volume 39, Issue 1, Page 99-118, Review Article

- Received 13 June 2022; received in revised form 24 July 2022; accepted 31 August 2022.

Abstract

The owl is renowned as nature's stealth bird and possesses distinctive aeroacoustic qualities. When it comes to the silent flight of owls, two primary hypotheses are considered: The self-masking hypothesis and the stealth hypothesis. Consequently, our intention is to present a comprehensive review article on the aeroacoustics of owls. This paper provides a concise overview of research conducted using Open Source Intelligence (OSINT) studies and visualization techniques, delving into how owls achieve silent flight and how their noise reduction mechanisms can be applied in engineering designs. The objective is to examine the distinctive physical characteristics of owls, their foraging behavior, and their ability to maintain silence in the presence of other species. Subsequently, the focus shifts to an analysis of the noise generated during owl flight, with emphasis on the geometric aspects of their wings, which play a crucial role in enabling silent flight. The subsequent sections provide an overview and summary of efforts to model the wing characteristics responsible for silent flight, as well as a description of noise reduction technologies inspired by owl features. In general, there exists a wide range of hypotheses regarding the silent flight and stealth of owls; however, the most compelling and well-supported explanations to date revolve around three key factors: the serrated structure of the wing leading edge, the velvety fibers and fringes along the trailing edge, and the combined effect of trailing edge and leading edge serrations. These factors contribute to a significant reduction in overall sound pressure levels across all angles of attack, stabilize speed fluctuations on the suction surface, and eliminate low and high-frequency sounds. Additionally, owls possess long velvety feathers on their wings, which absorb sound frequencies, and the elongated distal barbules create a multi-layered porous structure that enhances sound absorption.

Key Words: Aeroacoustics, owl flight, aeroacoustics of silent owl flight.