tank, regulator, accumulator, solenoid and driver, are the main parts of this phase.
In the next phase, the final design, drawings of the thruster and solenoid are prepared and software or user interfaces are built. The outputs of this phase are suitable and also complete for manufacturing the system.
In this paper, the above phases will be explained, and results of the test procedure of the sophisticated cold gas thruster will be presented and analyzed precisely.

Key Words: Tri-axial satellite simulator (simulator 1001), cold gas thruster, numerical simulation, nozzle.

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Abstract

In this study, the flight of a robot with elastic arms is simulated. It is assumed that the robot flies in plane and has three rigid degrees of freedom. Flying robots are considered to have a central body with two rotors connected to it, and two beams that are elastic in bending and inextensible in length. The mass of each connecting arm is divided between the corresponding rotor and the central body. Each arm adds two elastic degrees of freedom to the problem. Equations of elastic deformations for each side are derived by considering each rotor and its connecting arm as a clamped beam at the root under a transverse load, with bending moment acting on its tip. Constraint forces and moments from both sides are applied to the central body and then equations of in plane motion of the flying robot are derived. Also, three equations are added to find the pitch angle, flight path and position of the robot, with respect to an inertial frame. Some case studies are added to show the differences between a rigid and an elastic simulation of a flying robot. Since the differential equations are second order and non-linear, a numeric method is used to solve them for specified rotors thrusts. Effects of different structural parameters, like damping coefficient, length to diameter ratio, and installation angle of connecting arms, on elastic deformations and the flight path of the flying robot, are investigated. It is shown that as the length to diameter ratio of the connecting arm increases, frequency of vibration decreases and its amplitude increases. Lowering the installation angle will increase both the amplitude and frequency of vibrations. More importantly, it can be seen that an elastic robot climbs harmonically and that deformations of the connecting arms may change the flight path. Although increasing the damping coefficient of the arms will lower the amplitude of harmonic motion, it is shown that higher damping values may result in higher deviations from the assumed flight path.

Key Words: Flying robot, flight simulation, elastic arms, vibration.

DESIGN AND DEVELOPMENT OF A COLD GAS THRUSTER SYSTEM FOR USE IN A TRI-AXIAL SATELLITE SIMULATOR

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Abstract

The main purpose of this article is to describe the design and development process of a cold gas thruster subsystem used in a tri-axial satellite simulator (Simulator 1001) as an actuator. Simulator 1001 emulates the rotational motion of a satellite in orbit and acts as a test-bed for satellite attitude determination and control subsystem design and development. Among these projects, the simulator platform (spherical air-bearing) and several subsystems (cold gas micro-thrusters, onboard processor, attitude sensor, balancing mechanism, high-pressure composite tanks, efficient regulator and etc) has been designed and manufactured (or provided) by our technical team in the Space Research Laboratory of KNT.

By considering the limitations and requirements of the main project, design and manufacture of a simulator 1001 system design procedure of a cold gas thruster subsystem was established. Systems engineering design procedures encompass the tools and methodology necessary to move conceptualization to system implementation, with emphasis on the system as a whole, and user needs. It has four main phases: conceptual design, preliminary design, detailed design and final design.

In the conceptual phase, by reviewing the available samples of cold gas thrusters and using gas dynamics theories, the main coordinates of a cold gas thruster subsystem, including: quantity, tank pressure, regulator pressure, nozzle diameter, expansion ratio and etc., are estimated. In the next phase, the preliminary design, numerical simulation and analysis of gas flow using Fluent software is performed, and the final specifications of the prototype thruster model are exported.

Manufacturing the prototype model and the thrust-stand-test are performed in a detailed design phase. Also, evaluating the thrust level of the protype model and finalization of other component specifications, such as

assumed time history of the second DOF of the mechanism has to be satisfied. This can be performed by mass re-distribution of the links. This highly nonlinear optimization problem can be solved numerically. Recently, evolutionary algorithms have become increasingly popular for solving nonlinear problems in various fields, especially on mechanism design; Particle Swarm Optimization (PSO), Differential Evolution, Genetic Algorithms and the Ant Colony Optimization Technique are among the most popular. Here, we present an algorithm based on PSO to solve, simultaneously, these highly nonlinear optimization problems with some constraints. This dual optimization problem is solved for planar four-bar linkage using a continuous contact model, based on the assumption that the pin is always in contact with the socket. Finally, an example is included to demonstrate the efficiency of the algorithm. The results clearly show that the linear and angular accelerations of the links for the optimal design are very smooth and bounded.

Key Words: Linkage design, dynamic optimization, Lagrange's equation, clearance.

GYROSCOPIC STABILITY ANALYSIS OF A ROLLING ROBOT

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Abstract

The rotational stability of a spherical shaped system equipped with internal rotors, and constrained to roll on floors, is investigated in multiple cases. The spinning masses produce the momentum, which, in turn, actuates robot motion through the slip-free contact constraint. Understanding this coupling between dynamics and kinematics is crucial in exploring novel mechanical locomotive designs. Possible applications of the aforementioned system may consist of their use as sentinels in large industrial domains and the exploration of unsecured areas when equipped with cameras and multiple sensors. Because such a system exhibits symmetry, or invariance under certain actions, the equations describing the system motion will conserve some physical properties that are quantified by constant values for the integrals of motion.

These constants of motion permit determination of conditions of parametric stability of rolling, spinning, or precession motions, leading to a bifurcation analysis investigation.

As shown, internal spinning disks can be employed as active stabilizers by appropriate feedbacks, dynamically transforming the inertia distribution of the whole system into a stable one. The controllability acquired by implementing at least two rotors is sufficient to permit motion planning in the joint space, conducting the system to track predetermined paths, even on inclined surfaces. This research focused on a locomotion technique that uses dynamically coupled actuation that is different from other direct means of locomotion, profiting by the interplay between dynamics conservation laws and kinematics constraints. Actually, studying the dynamics of nonholonomic systems finds applications in modern technologies, from plane landing gears to satellite applications. The present study reveals that standard approaches for the systematic stability analysis of nonholonomic systems have not yet been fully developed. Although considerable efforts have been made to this end, the realm can still be considered unexplored in comparison to its holonomic homologue. It is also undeniable that inquiries regarding a conventional solution to the stability question would have been much more challenging without considering the physical aspect underlying the problem.

Key Words: Nonholonomic rolling systems, gyroscopic stability, motion planning control, autonomous locomotion.

FLIGHT SIMULATION OF A ROBOT WITH ELASTIC ARMS IN PLANE

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WALKING STABILITY ON A SLOPE FOR A PLANAR 3-LINK BIPED ROBOT VIA ORBITAL STABILIZATION UPON A ZERO DYNAMIC MANIFOLD

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Abstract
Over the last decade, the zero dynamic concept in controlling under-actuated systems is an emerging viewpoint in the study of the generation and stabilization of the walking gait for biped robots. The main feature of this method relies on planning and tracking the reference paths, considered virtual constraints on biped configuration, during their motion. The virtual constraints do not arise from a physical connection between the two variables but rather from the actions of a feedback controller. These virtual constraints are defined as a set of outputs, equal in number to the inputs. Then, by designing a feedback controller that asymptotically drives the outputs to zero, the evolution of the joints of the robot would be synchronized in order to emerge as a walking gait. The virtual constraints are formulated in terms of some functions of a passive coordinate variable of biped configuration that is a strictly monotonic variable during completion of a one step course. It is important to note that this is not a classical trajectory tracking scheme, because the desired evolution of outputs is enslaved to a variety of biped configurations and not time. In this paper, at first, the hybrid dynamic model, which includes motion deferential equations describing the continuous biped evolution during the swing phase, is derived, together with a discrete map for jumping state variables at the impact event. Then, a coherent framework for generation and stabilization of the walking gait on a slope for a planar three link biped robot with pointed feet will be outlined. This method is based on orbital stabilization of the hybrid zero dynamic via Poincare return map analysis. Indeed, the dimension of the zero dynamics is considerably less than the dimension of the model itself; the task to be achieved by the robot is implicitly encoded into a lower-dimensional system. The successfulness of the method is verified by simulation results.

Key Words: Planar biped robot, hybrid zero dynamic, orbital stabilization, impact event map.

KINEMATIC AND DYNAMIC OPTIMIZATION OF A PLANAR FOUR-BAR LINKAGE WITH JOINT CLEARANCE

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Abstract
Geometrical perfection is usually assumed in the synthesis of linkages; i.e. they are treated without clearance at the joints. But, in practice, clearance in the joints is inevitable due to tolerances and defects arising from design and manufacturing or wearing after a certain working period. Moreover, it provides allowance for the connecting links to move relative to each other. On the other hand, joint clearances affect the performance of linkages tremendously. Here, we design a planar four-bar linkage to follow the desired trajectory, in the presence of clearance at the joint between the crank and the coupler. Firstly, the kinematical synthesis is performed. It is noteworthy that in the presence of clearance at a joint, the linkage gains an additional, uncontrollable, degree of freedom (DOF). Therefore, one has to solve the optimization problem only if this unwanted mobility can be controlled. At this step, a time history of the second DOF is assumed to be known. Thus, the optimization problem can be solved. At the second step, the

Abstract
Available low-velocity impact analyses have mainly been presented for isotropic or laminated composite (especially those with transversely isotropic material properties) structures. In the mentioned models, only the stiffness of the impacted region is considered and the influence of the stiffness of the underneath layers on the impact responses is discarded. It is evident that the stiffness of the substrate layers may considerably affect the contact stiffness of the contact region. In some other papers, the nonlinear Hertz-type contact law has been replaced by a linear one.

In the present paper, in addition to overcoming the mentioned shortcomings, it is intended to extend the previous research to functionally graded plates, whose material properties vary in the transverse direction according to a power law. The apparent contact stiffness is determined through calculation of the volume mean of the material properties and by employing Turner's procedure. Among other superiorities, the solution is presented in a semi-analytical form. The governing equations of the plate are derived based on the classical plate theory, and the analytical solution is of a Navier-type. The proposed solution is adopted, according to the boundary condition of simply supported edges.

Therefore, the plate is modeled as a continuous rather than discrete system. The resulted nonlinear time-dependent equations are solved using the Runge-Kutta numerical time integration method.

In the present research, effects of various parameters of the indenter (radius, mass, velocity) and the functionally graded plate (power law exponent or the so-called volume fraction index and thickness of the plate) on the low-velocity responses (indentation, contact force, and lateral deflection) are investigated in the elastic region, employing non-linear Hertz's contact law. Since the present results are extracted based on an analytical method, modeling, linearization, and common numerical errors are prevented. Results of the present research are verified by results reported by other researchers for special cases.

Key Words: Impact, functionally graded material, semi-analytical solution.

STUDY OF KINEMATIC HARDENING EFFECTS ON AUTOFRETTAGE OF THICK-WALLED CYLINDERS

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Abstract
Autofrettage is an effective method for increasing the load capacity of thick-walled cylinders. Since the behavior of materials in loading and unloading steps is different, it is necessary to provide a suitable constitutive model to accurately predict the behavior of the material and estimate the induced residual stresses. In this study, the Chaboche material model was used to numerically investigate the autofrettage process.

The six constants of this model were determined using the cyclic behavior of material, based on the von Mises yield criteria for Al7075-T6 aluminum. The results were compared with the results obtained from the elastic perfectly plastic model for the material. Experimental tests were done in order to determine the accuracy of the results of each model in prediction of the residual stress distributions. The central hole drilling (CHD) method was used for determination of the residual stresses along the thickness direction. Several specimens were made with different aspect ratios (ratio of outer to inner radii of cylinder), and subjected to various internal pressures to obtain the desired values for autofrettage ratios (ratio of the plastic portion to total thickness of cylinder).

Two aspect ratios; 1.4 and 1.5, and three values; 30%, 45% and 60%, were considered for the autofrettage ratio. Then, stresses were measured in the outer region of the cylinder wall. The results show that the elastic perfectly plastic model predicts the residual stresses greater than experimental values, while the Chaboche model predicts smaller amounts.

However, the results predicted by the Chaboche model are closer to the experimental data, more than the elastic perfectly plastic model. For both material models, the plastic region increases with increasing autofrettage pressure. The residual stress values increase by increasing the aspect ratio, and also, the autofrettage ratio. So, maximum residual stress will be obtained when all of the wall thickness becomes plastic (100% autofrettage ratio).

Key Words: Autofrettage, Chaboche model, residual stress, central hole drilling, thick-walled cylinder.

two plastic hinges and collapse with three plastic hinges, each of which caused structural collapse, based on geometrical specifications. Variation of the pressure collapse of the structure has been depicted versus different cylinder-part or cone-part lengths, graphically. The changing of the collapse mechanism occurs in a particular cylinder-part or cone-part length, such that the collapse pressures approach asymptotic values (pressure collapse of completely cylindrical or conical shells).

Key Words: Cylindrical-truncated conical shell, static-plastic analysis, internal collapse pressure.

INVESTIGATING MAXIMUM ALLOWED ANGULAR VELOCITY OF A ROTATING HOLLOW FGM CYLINDER, CONSIDERING VARIABLE DENSITY AND YIELD STRESS

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Abstract
Rotating hollow cylinders are involved in many industrial applications. On the other hand, the advantages of functionally graded materials have made them more attractive for application in different areas, such as in aircraft and aerospace industries. Because of this, in recent years, much research has been conducted on them. In this paper, maximum allowed angular velocity of a rotating hollow FGM cylinder is investigated. The analysis is based on the small deformation theory. The cylinder is assumed to be infinitely long. Therefore, the deformation state in the cylinder is in a plane strain state. Young's modulus, density and yield stress are assumed to be power-law functions of the radial coordinate.
The maximum allowed angular velocity has been defined as the angular velocity at which yielding is initiated, based on the Tresca yield criterion. Dimensionless parameters have been introduced, based on the basic geometrical and material parameters of the problem. Then, the governing equation, which is an equilibrium equation in terms of radial displacement, has been solved analytically. The strain components have then been determined, using the obtained radial displacement and strain-displacement equations. Stress components are derived using the generalized Hook's Law. To identify stress component ordering, the radial distribution of dimensionless stress components was plotted. This was done for the special case of equal exponent parameters. The results show that for this special case, when the exponent parameters vary between -2 and 2, hoop stress and radial stress components are, respectively, the largest and the smallest stress components. Then, the effect of parameter variation, especially density and yield stress, on the maximum allowed angular velocity, is investigated.
Results show that the radial variation of density and yield stress may have a considerable effect on stress distribution and yielding initiation, and, consequently, on the maximum allowed angular velocity. To the best of the authors' knowledge, density variation was not taken into consideration in previously published research into this problem.

Key Words: Functionally graded material, rotating hollow cylinder, Tresca yield criterion, maximum allowed angular velocity.

A SEMI-ANALYTICAL SOLUTION FOR LOW-VELOCITY IMPACT ANALYSIS OF FUNCTIONALLY GRADED RECTANGULAR PLATES

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NUMERICAL SIMULATION OF LEWIS FACTOR EFFECT ON CHARACTERISTIC PERFORMANCE OF A COUNTER-FLOW WET COOLING TOWER

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Abstract
The most efficient equipment through which heat rejection processes may be realized is the cooling tower. Cooling towers are used to cool a warm water stream through evaporation of part of the water into an air stream. These zones are modeled and solved numerically using a computer code, and the developed models of these zones are validated against experimental data. The mathematical models of these cooling towers are developed and validated against the experimental data available in the literature. These devices basically consist of three zones, namely; spray zone, fill packing and rain zone. The spray and rain zones are often neglected, even though, in large cooling towers, a significant portion of the total heat that is rejected may occur in these zones. Therefore, the heat and mass transfer contribution of the spray and rain zones in cooling towers is discussed as well. Numerical results fall within the range of experimental measurements, and show a higher accuracy, compared with the results of previous researchers. The effect of Lewis factor on the characteristic performance of a wet cooling tower, such as water loss rates, outlet dry-bulb temperature of air, outlet water temperature and heat rejected rate, under a wide range of weather conditions, for two different dry bulb temperatures of air, 10^0C and 40^0C, is investigated using the Bosnjakovic equation. Air is saturated at a rapid rate for a lower Lewis factor, so, water loss rates get a higher value. The growth of the Lewis factor increases the heat rejected rate and the outlet air dry bulb temperature. Reduction of Lewis factor increases outlet water temperature, because of higher convection heat transfer. The Lewis factor has no effect on characteristic performance for warm and humid inlet air.

Key Words: Wet cooling tower, numerical simulation, Lewis factor effect, characteristics performance, spray and rain zones.

STATIC-PLASTIC ANALYSIS OF CYLINDRICAL-TRUNCATED CONICAL SHELL UNDER INTERNAL PRESSURE

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Abstract
Conical shells are of interests to many engineering branches. These shells are usually used as components for bearing pressure. For instance, in civil engineering applications, structures like; silos, pressure vessels, tanks, cooling towers and chimneys, involve conical shells in their constructions. Large conical tubes have a transition cone between two cylinders of different diameter. Conical reducers are used in oil transfer tubes for connecting two cylinder pipes of different diameter, and in places that do not fit the flange. Thus, these structures could be modeled as conical shells under internal pressure loading. Also, in the field of marine engineering, a body of submarines could be modeled as cylindrical shells with rigid reinforcement rings that are blocked by a truncated cone. In the field of aerospace engineering, a spacecraft cabin can also be considered a conical shell. In two recent applications, the model of conical shells is under external pressure. Therefore, due to the use of these structures, their analysis under pressure loads is essential and must be considered.
In this paper, the plastic behavior of thin-walled cylindrical-truncated conical shells under static internal pressure will be investigated analytically. Towards this aim, the material behavior is assumed rigid-perfectly plastic, and a common rectangular surface has been used as the yielding criterion composed of stress resultants, M_θ and N_φ. According to the present approach, three basic mechanisms have been defined for structural collapse. These include cone-part collapse, collapse with

regions. Therefore, the widely accepted Weibull distribution function is adopted here to model the wind measurement data. Weibull parameters include shape factor, k, and scale factor, c, which are calculated together with standard deviation for each three regions at different heights. Higher values of shape factor, k, leads to sharper peaks, which show less variation in wind speed. The scale factor, c, is a measure for windy regions. The root mean square (RMSE) is used to assess the quality of fitting the Weibull function into the wind measurement data. The average wind speeds are calculated over the months of the years 2008 to 2010. It is observed that average annual wind speed in Khash station is 3.8, 4.32, and 4.57 m/s for the heights of 10, 30, and 40 meters, respectively. In Lootak station, these values are 4.56, 6.28, and 6.54 m/s, respectively. Nosratabad station possesses an annual average wind speed of 4.82 and 5 m/s for heights of 30 and 40 meters, respectively. Average monthly wind power density is also evaluated for the three stations at different heights. In Khash station, this shows an annual average wind power density of 86 W/m2 for a height of 10 meters, 114 W/m2 for a height of 30 meters, and 132 W/m2 for a height of 40 meters. Similarly, it is observed for Nosratabad that the annual averaged wind power density of 125 W/m2 at 30 meters height and 144 W/m2 at 40 meters height can be achieved. These stations are thus categorized as weak sites for in-grid wind power generation and are recommended for off-grid local use for electricity or mechanical power generation. Further study reveals that Lootak station, with an annual average wind power density of 157 W/m2 at 10 meters height, 344 W/m2 at 30 meters height, and 388 W/m2 at 40 meters height, possesses good potential for in-grid electrical power generation. Finally, a wind rose diagram, which indicates wind direction distribution, is plotted for the three stations to obtain the dominant wind direction for installing wind turbines.

Key Words: Wind energy, Wiebull distribution, Sistan and Baluchestan, wind rose, wind turbine.

INVERSE EXPERIMENT DESIGN FOR ESTIMATION OF LOCAL CONVECTIVE HEAT TRANSFER COEFFICIENT IMPINGING SLOT JET

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Abstract
Jet impingement is widely used in industry because of the highly favorable heat transfer rate it provides. Engineering applications include the annealing of metal sheets, drying of textile products, deicing of aircraft wings, and cooling of gas turbine blades and electronic components. There are several techniques used in evaluating the local convective heat transfer coefficient. Mass transfer methods have been widely used since many years ago. The heat-mass transfer analogy, in conjunction with the naphthalene sublimation technique, was used to investigate local and average heat transfer coefficients. Thermo chromic liquid crystals have been applied extensively to heat transfer measurements. Using temperature maps obtained from liquid crystals applied to a constant heat flux surface, Newton's Law of Cooling is used to establish distributions of the convective heat transfer coefficient. However, these methods either require expensive or delicate equipment or have limitations to high temperatures or high levels of turbulence in the f̆b02ow. An alternative method that is also particularly suited for the investigation of jet impingement heat transfer, is the inverse heat conduction(IHC) technique. The temperature on the impingement surface is measured. It is advantageous because it can be carried out with simple, low-cost instrumentation and subsequent numerical procedures. In this technique, temperatures measured at some proper interior locations on the impingement surface are used to estimate a thermal boundary condition. The word "estimation" is used here, as temperature measurements always contain noise. Tikhonov's regularization technique and Beck's function estimation method are among the most well-known approaches in inverse heat transfer. The purpose of this study is to use the solution of a transient, sequential IHC scheme to estimate the distribution of the steady-state and unsteady convective heat transfer coefficient in a pulsating jet in laminar flow and turbulence flow at different frequencies, and present the optimum simulation. The method is required to be considered two-dimensional because of the lateral conduction that occurs between the warmer and cooler areas of the surface of the target plate. The inverse scheme used is tested using simulated measured temperatures containing Gaussian noise.

Key Words: Impinging slot jet, convective heat transfer coefficient, inverse heat transfer method.

Vukalovich's virial equation of state and related steam properties are suggested.

Key Words: Two-phase flow, state equation, supercooled vapor, nucleation, supersaturation.

INCENSEMENT OF GAS TURBINE POWER IN A COMBINED CYCLE, BASED ON OPTIMIZED DESIGN OF A HEAT RECOVERY STEAM GENERATOR (HRSG)

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Abstract
Dealing with the increasing demand for electricity is one of the most challenging issues in developing countries. Electrical energy is a common kind of energy, and, in this regard, power plants play a key role in its production. Among different kinds of power plant, combined cycle power plants (CCPPs) have gained much attention. They are attractive options in the power generation field due to having higher thermal efficiency than individual steam or gas turbine power plants, and having less negative environmental impact. The most important part of a CCPP is the heat recovery steam generator (HRSG). The heat recovery steam generator (HRSG) is widely used in power plants for energy recovery and efficiency improvement. Therefore, optimization of the heat recovery steam generator (HRSG) is a key element in increasing the efficiency of the combined plants. Also, due to the large number of design parameters of HRSG, performing an optimization study is necessary for finding the optimum design. These parameters include thermodynamic variables, such as pinch and approach points, as well as geometric parameters, such as fins and tube characteristics. In this study, the design parameters of HRSG, such as thermodynamic and geometric parameters, have been optimized as decision parameters with the objective of incensing gas turbine power in the combined cycle plant. The optimization has been carried out using the Genetic Algorithm (GA). In this paper, a comparison between heat exchange rate, required heat exchanger area and the exergetic efficiency of HRSG is carried out for base and optimized cases, in order to consider the effect of optimization on HRSG operation. The results show that the ratio between the power loss of the gas turbine to the nominal power of the gas turbine (i.e. HRSG is not attached to the gas turbine) in the optimized case is 1 percent, which is an improvement over the base case, which is 5 percent.

Key Words: Gas turbine, heat recovery steam generator, gas pressure drop, objective function.

WIND POTENTIAL ASSESSMENT FOR INSTALLING WIND TURBINES IN THE PROVINCE OF SISTAN AND BALUCHESTAN, IRAN

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Abstract
In the present study, wind potentials in three regions; Khash, Lootak, and Nosratabad, are investigated in the province of Sistan and Baluchestan, in Iran. Annual wind measurements, including wind speed and wind direction, were made at three heights of 10, 30, and 40 meters, at 10 minute intervals, by the meteorological organization of Iran. Wind speed distribution is important for evaluating wind potential in certain geological

Abstracts of Papers in English

ANALYTICAL INVESTIGATION OF EFFECT OF STATE EQUATIONS AND THERMO-PHYSICAL PROPERTIES ON A SUPERSONIC TWO-PHASE STEAM FLOW

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Abstract
Water vapor contains liquid droplets at low pressure stages of a steam turbine, and this two-phase flow can be modeled analytically (mathematically) in a one dimensional convergent-divergent nozzle. The main goal of this paper is to investigate the effect of different state equations and thermo-physical properties of water vapor on modeling the performance of a supersonic two-phase flow. In this research, for the first time, the virial equations of state proposed by Vukalovich, and the related steam properties, have been compared with the state equations and the equations of the thermo-physical properties of vapor in ASME steam tables published in 2006. The principal gas-dynamic differential equations of the two-phase flow are solved by the Runge-Kutta technique. In this regard, the proposed nucleation and droplet growth equations, and, also, the equations of state and thermo-physical properties from the two above mentioned references are used. The results have been compared with the experimental data, including the pressure ratio and droplet diameter. According to the results, for inlet stagnation pressures and temperatures less than 1.5 bars and 400 Kelvin, respectively, the equations proposed in the ASME steam tables are more accurate than the other equations. But, for higher inlet pressures and also inlet temperatures up to 600 Kelvin,