an optimal control system in the viewpoint of the ISE performance criterion. These rules have been obtained by iteratively using the steepest descent (gradient descent) optimization algorithm with the constraint of optimizing the step size in each iteration. The proposed rules for tuning of the free parameters of implementable fractional order PI controllers yield in a control system whose performance is better than the control system with an optimal PI controller. This point has been successfully confirmed by some numerical and experimental examples.

Key Words: Control system, implementable fractional order PI controller, optimal tuning, ISE performance index.

STRESSES IN AISI 1045 STEEL TURNING SHAFTS USING ARTIFICIAL NEURAL NETWORK

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Abstract

These days materials can be machined and finished with newly developed tools, eliminating the need for other finishing operations such as grinding or polishing, even for dies and molds. In such cases, it is necessary to satisfy given standards of geometrical accuracy and surface roughness. In addition, the reliability or operating life of the machined products must be ensured because the residual tensile stress accelerates the progress of fatigue cracks and the fatigue life of the product is reduced. Thus, it is necessary to know the residual stress, which is induced. For example, to machine aerospace parts, in which thinness and accuracy are required, distortion and residual stress are very important issues. In fact, the machined surface layer deforms three dimensionally through the chip forming process by the effect of the corner of the tool in common turning or milling. Many industries need to produce parts with specific geometry and dimensions. Therefore, the machining process used to finish the production after processes such as casting and forging. In this process, the various operations carried out which lead to the creation of residual stresses in parts. These stresses can significantly affect the performance of parts. In this study, the effect of cutting speed and feed on residual stresses in AISI 1045 steel machining shafts was investigated. To determine the residual stress profiles, the X-ray diffraction method and electropolishing technique were used. Also, the machining process simulation and the effect of cutting speed and feed variation were performed using the DEFORM software. The results of the simulations were validated with the experimental tests. Then, the artificial neural network was applied to estimate the residual stresses using the data were obtained from the finite element analysis. At all feed, residual stress was increased by adding cutting speed. With appending feed up to 22 mm/rev, the stress was increased but from this amount onwards then there is not a significant increment, this is more evident at the higher cutting speeds.

Key Words: Residual stress, machining, finite element method, artificial neural network.

OPTIMAL TUNING OF IMPLEMENTABLE FRACTIONAL ORDER PI CONTROLLERS BASED ON ISE PERFORMANCE INDEX

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Abstract

Benefiting from the great potential of the mathematical tool of fractional calculus, fractional order proportional integral (PI) controllers have been proposed as the next generations of popular PI controllers. On the other hand, the integral performance indices such as the integral square error (ISE), integral absolute error (IAE), integral time square error (ITSE), and integral time absolute error (ITAE) are commonly used in the design and evaluation of the performance of practical control systems. Considering these points, the present paper deals with the optimal tuning of the free parameters of fractional order PI controllers, to be used in control of first order plus dead time (FOPDT) processes in a unity negative control structure, on the basis of ISE performance index. Using the approach of "tuning based on the implementable form of the controller" instead of the approach of "tuning based on the ideal form of the controller" causes that no incompatibility is seen between the ideal behavior of the controller and the behavior of the implementable controller. Also, to avoid approximation error in the calculation of ISE based cost functions, algebraic relations have been used for analytically finding the values of ISE in the under study time delay control system. In fact, the main contribution of the paper is to propose simple tuning rules for implementable fractional order PI controllers with the aim of achieving

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Abstract

Water crisis is occurred due to a series of challenges and problems and often caused by improper water resources management. Management of river water quality along its quantity is one of the key factors in water resources management. Unfortunately, in spite of numerous standards and regulations, there are still some violations which happen in terms of discharge of pollutants and effluents in rivers and surface water resources. There are several physical mechanisms that influence the discharged contaminants in its movement to downstream, namely advection and dispersion. Among control measures for rivers water quality management, pollution source identification is an effective way for identifying the pollutant parties beside the river. In this paper using the inverse solution of the pollution transport equation in rivers, for one-dimensional case under non-uniform flow regime, a procedure for pollution source identification is proposed. The main underlying theory is based on the Quasi-Reversibility method which solves the advection-dispersion equation by negative time steps. The method converts the ill-posed problem to a well-posed one, by adding the stabilizing term to the advection-dispersion equation. The importance of the stabilizing term is determined by its coefficient in a way that minimum required stability is satisfied. The method was verified by some test cases, which implies that the application of the Quasi-Reversibility method in pollution source identification in rivers can be effectively achieved.

Key Words: Inverse model, quasi-reversibility method, advection-dispersion equation, pollution source identification.

EXPERIMENTAL INVESTIGATION OF AEROELASTIC DEFORMATIONS OF A FLAPPING WING WITH IMAGE PROCESSING TECHNIQUE

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Abstract

In recent decades, flapping-wing micro aerial vehicles (FWMAVs) have shown an increased interest for flight at low Reynolds numbers. Major components of a flapping wing system are flapping mechanism and flexible wings. The degree of wing flexibility represents an important role in the production of required unsteady aerodynamic forces of flight. In the present work, a simple four-bar crank-rocker mechanism transforms the rotational motion of a small electric motor to a harmonic flapping motion. The flapping frequency is controlled directly by altering the input voltage. A flexible membrane half-elliptical planform wing with a span of 100 cm, a mass of 10 grams and an aspect ratio of 6 is developed. Furthermore, a test bed is built to investigate the aeroelastic features of a flapping wing vehicle. To extract important kinematic parameters such as relative deflection, angular velocity and acceleration, a high-speed camera facility and image processing techniques are used. Results show the total normal force has two component, the inertial force which is a function of the wing mass distribution and the flapping kinematics, and the aerodynamic force caused by the flapping motion and wing deformation. These inertial and aerodynamic forces bend and twist the wings during the flapping motion, resulting in passive shape variation that may affect many aspects of flight performance. Maximum deflection happens mostly in the zero angle position of the wing when the wing is parallel to the horizon, in this condition combination of dynamic forces are maximum as well. In addition, by using this facility, verification of aeroelastic simulations become possible.

Key Words: Flapping wing, flexible membrane wing, aeroelastic deformation, image processing.

PREDICTION OF CUTTING SPEED AND FEED EFFECTS ON RESIDUAL

and plane stress fracture toughness was investigated experimentally, by R curve method for initial aluminum, copper, magnesium and Al/Cu/Mg composite. Results showed that the value of plane stress fracture toughness depends on both strength and ductility. Also, fracture toughness of produced layered composite reached 32.1, which increased 3.24, 2.18 and 2.73 times, respectively, compared to the initial samples of aluminum, copper and magnesium. In addition to investigations of the plane stress fracture toughness, mechanical properties, fracturgraphi and microstructure investigated through uniaxial tensile test, microhardness measurement, and scanning electron microscope (SEM) and optic microscope (OM). Results of carried out tests, showed the value of ultimate tensile strength (UTS) and microhardness for Al/Cu/Mg layered composite compared to initial Al 1050, pure Cu and Mg AZ31B increased but the elongation decreased sharply, that the main cause of these increase and decrease are applied high strain and cold working. Value of ultimate tensile strength for Al/Cu/Mg layered composite received 220.3 MPa that compared to initial Al 1050 and pure Cu and Mg AZ31B, 144%, 23% and 29% enhanced, respectively. Also microhardness calculated for each layers of composite individually and for initial Al 1050, pure Cu and Mg AZ31B increased 136%, 84% and 41%, respectively. Results of SEM demonstrated that ductile fracture mechanism govern for Al and Cu layers but fracture surface of Mg layer is absolutely brittle fracture.

Key Words: Multi-Layered Al/Cu/Mg composite, cold roll bonding, fracture toughness, mechanical properties and microstructure.

STUDY THE EFFECT OF TRANSVERSAL BIASING STRESS ON MAGNETO-MECHANICAL BEHAVIOR OF MAGNETIC SHAPE MEMORY ALLOY SINGLE CRYSTAL

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Abstract

Magnetic shape memory alloys (MSMAs) are a new class of smart materials which are good candidates for energy harvester, actuator and sensor systems due to their special properties such as high reversible strain, high fatigue life and fast time response. In order to use these materials in mentioned systems, a returning mechanism is always needed to return the specimen to the initial situation. Common method in energy harvesters is applying a bias magnetic field, but in this paper, the function of returning mechanism is improved by applying a bias stress which works together with the bias field. For this purpose, the influence of exerting a compressive stress along the bias field direction on a single crystal of a magnetic shape memory alloy is addressed. This compressive stress can be caused by a pre-strain or a spring-based system. To achieve this aim, general equations of problem in 2-dimentional loading situation is derived by using existing thermodynamic-based models, and in simulation section, the effect of the biasing compressive stress on magneto-mechanical characteristics of material is investigated by altering this stress in different situations. After applying this stress, it is illustrated that the returning mechanism shows a better performance in the sense that the amount of magnetization variation of material, which influences output voltage, increases. It is also demonstrated that completely removing the bias field is impossible and the best function is in 0.24 tesla of magnetic field with 0.3 MPa compressive stress.

Key Words: Magnetic shape memory alloys, energy harvesting, bias field, returning mechanism.

INVERSE SOLUTION OF THE ADVECTION-DISPERSION EQUATION IN RIVERS FOR POLLUTION SOURCE IDENTIFICATION

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Abstract

This paper deals with experimental and numerical studies of fracture behavior of Al. 5083-H321 alloy, under uniaxial and biaxial tensile loadings. In order to experimentally investigate biaxial fracture behavior, cruciform specimens were prepared using electrochemical method, based on Lionel proposed model. The specimens were gridded by electrochemical etching method. A dependent biaxial tension mechanism was also designed and fabricated with relatively high precision machining methods. Installing the mechanism on an INSTRON-1343uniaxial machine, the experimental biaxial tests were performed at ambient temperature and strain rate of 0.0003 sec^{-1}. Different aspects of the facture behavior, which may be of more interest to study, include initiation and development of fracture pattern, fracture path on the specimen section, and the force diagram for each of the arms. ABAQUS commercial software was utilized to simulate the biaxial tension test. Damage model was incorporated into the FE simulations to enable the FE model to capture the fracture occurrence in the cruciform specimen. Displacement loading with different ratios was applied to the specimen arms in the FE model to study the effect of loading ratio on the fracture of the material. Experimental and numerical results for location of crack initiation, path of crack growth and also the arms force diagram were compared and a good correlation was observed between. The experimental results reveal that the fracture grows along the corner-to-corner diagonal line, in the test section zone of the specimen. Simulation results show that minimal strains occur in the test section zone, near the arms. Experimentally measuring the fracture stress is one of the great challenges, and hence, numerical simulation would be very useful in this regard. Maximum of stress gradient in the simulation results is observed along the corner-to-corner direction, in the test section zone. Based on the simulation results, some fracture biaxial points were obtained in the first quarter of the biaxial stress plane subspace. These fracture stress point can be used to determine the material fracture loci in the first quarter of the biaxial stress plane subspace.

Key Words: Cruciform specimen, Al. alloy 5083-H321, biaxial loading, forming limit stress diagram fracture (FLSD).

EXPERIMENTAL EVALUATION OF FRACTURE TOUGHNESS FOR MULTI-LAYERED AL/CU/MG COMPOSITE PRODUCED BY COLD ROLL BONDING PROCESS

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Abstract

In recent years, multi layered composite have been attention of many researchers and different industries. Cold roll bonding (CRB) is one of the method for produce layered composite that compared to other composite manufacturing methods are more economically and have the ability to produce layered composite with different material. In the present study, Al/Cu/Mg layered composite was produced through CRB method at room temperature, without lubricant and via using laboratory rolling machine by applying 60% reduction in thickness

and depth and the flyer plate is moved rapidly to collide with the base plate to generate bonding. The energy required to move the flyer plate, is produced by plasma pressure created by laser impact on the surface of the flyer plate. The main advantage of this connection is its capability to attach two dissimilar metals in order to enhance physical, chemical, or mechanical properties on one side of a cheaper metal.
Same as other welding methods, it is very important to forecast and optimize the weld quality obtained by this process. Hence, finite element method using ABAQUS software, was employed to simulate the laser welding or cladding process in this research and verified by experimental data. Impact speed, serration angle and depth are the main affecting parameters on weld quality. Therefore, multi-objective particle swarm optimization (MOPSO) algorithm for a certain thickness of the flyer plate was utilized to maximize the welded area of two plates and minimize the cost of machining the base plate for making serration using the data generated by finite element analysis, linked to MATLAB for optimization of these objectives. The optimization results indicate an increase in joined area at the connection point as well as reduced number of grooves which leads to decrease in manufacturing cost.

Key Words: Laser shock welding, cladding, weldability window, multi-objective particle swarm optimization.

NUMERICAL ANALYSIS OF GROWING THE DUCTILE DAMAGE IN STRUCTURES REINFORCED BY SMA USING CONTINUUM DAMAGE MECHANICS APPROACH

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Abstract

In general, materials include micro-cracks and small holes which is created during the manufacturing process. The growth of these micro-cracks leads to degradation of mechanical properties and resulting in deterioration of the materials. Continuum damage mechanics is the new field of failure criteria which survey the behavior and responses of weakened material during the complete process of deterioration of material. This method defines the damage growth with an internal variable and can be used to predict the failure behavior of many materials such as metals, composites, polymers, and so on. Shape memory alloys have unique features, such as, having memorable properties, being super elastic and being energy absorber, which led to new applications in science and engineering research. Super elastic property accompanies with a lot of energy absorption during creating a Hysteresis loop. In this research, we examine mechanical behavior of materials reinforced with smart alloy in the context of environmental damage mechanics. Simulation and experimental results were very close. The considered structure is a notched piece of aluminum which is reinforced by the smart alloy. This material is notched because when the smart alloy reaches to its maximum reversible strain, damage variable reaches to its critical value due to the stress concentration. Accordingly, in this case, the effect of existence of the smart alloy is studied to find how it reduces the growing of the damage. Simulation of the mentioned structure is performed with Finite Element Analysis, where the structure was modeled under longitudinal loading. UMAT code of Lemaiter model, was developed for behavioral properties with damaged aluminum, UMAT code of Brinson model was used for behavioral properties of shape memory alloy. Simulation results suggest that different behavioral aluminum with aluminum reinforced by SMA. Existence of smart alloy on the aluminum substrate reduces the damage evolution and the structure fails in higher loadings. Also, the simulation results showed that reinforcing materials such as aluminum with shape memory alloys, up to the failure, are suitable choices for cyclic loading.

Key Words: Continuum damage mechanics, lemaitre model, shape memory alloys, brinson model, UMAT.

DETERMINING OF FORMING LIMIT STRESS DIAGRAM FOR AL5083-H321 ALLOY BY CRUCIFORM SPECIMEN

BY THE BUBBLE FORMATION IN VERTICAL COLUMN

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Abstract

Two-phase flow systems analysis data are rear and cause major problems as efficient prediction in operation and control of the system or delay in identifying system parameters behavior.Analysis of the pressure waves through transient conditions can be an effective method to achieve precise results.

In the present article, the bubble formation was studied using computational fluid dynamics (CFD) and the acoustic finite element method (FEM). The simulation conducted to obtain the aerodynamic noises generated by initiation and separation of bubbles in a vertical column. A Transient three-dimensional model is developed based on VOF method for tracking interface of two phases and large eddy simulation (LES) for an accurate calculation of pressure fluctuations. The model is simulated with the aid of the commercial software ANSYS FLUENT based on the finite volume method. To obtain convergence the implicit body force treatment is taken into account PISO algorithm is used to calculate a consistent result between velocity and pressure field. Pressure is discretized with PRESTO scheme. The RANS solution is used to calculate the initial flow field. In this case momentum is discretized with the second order upwind scheme and the geometric reconstruction scheme has been used as the volume fraction discretization scheme.

Due to the importance of interface tracking in sound sources recognition and the problems which occur during adding LES model in the simulation, different interface reconstruction methods has been compared. High Resolution Interface Capturing scheme (HRIC) is selected as the best method.

The Fofwcs Williams and Hawking (FWH) equation is used as an extension of the classical Lighthill aerodynamic acoustics for predicting far field noises. Sound sources are extracted by taking samples of pressure fluctuations from Wall penetration and virtual plane that is defined parallel to flow. These sources are investigated in the moment of separation and formation of bubble. In this paper are concluded that the largest fluctuation occur during necking of bubbles, while the smallest bubble produced the biggest peak in acoustic fluctuation curves. Besides time analysis, the pressure fluctuation is transferred from time domain to frequency by Fourier transform method and spectral analysis is performed on the data. The spectral analysis are compared to experimental results to better understand the effects of turbulence models, flow rate and methods of taking sample on the acoustic frequency response. The spectra of the filtered acoustic data (at airflow rate of 240 lit/min) shows a peak at about 40 Hz and is shown frequency response increases by the decrement of flow rate in bubbly flow. In this research frequency merge of two bubbles is demonstrated at 800 Hz and frequency response is used to estimate the bubble size.

Key Words: Two-phase flow, acoustic waves, lighthill analogy, noise emissions.

OPTIMIZATION OF CLADDING USING LASER SHOCK WELDING BY MULTI-OBJECTIVE PARTICLE SWARM ALGORITHM

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Abstract

Laser shock welding process has recently attracted the attention of many researchers. Similar to explosive and magnetic welding, this process may also be used for impact welding using solid state welding principle. Impact welding is based on the influence of high-velocity collision of two base metals and generation of metallurgical atomic bonding in the solid phase at the contact area at ambient temperature. This process is also used to clad a sheet metal with a thin layer of other metal, named flyer plate. The base metal is serrated with certain angle

Abstract

Recently exploiting the methane in comparison with the hydrogen as a coolant fluid in launch vehicles captured the interest of space propulsion research community. A few of the main advantages are: it is denser and lower-cost, and it has a lower storage cost. Recognition and analyzing the thermal behavior of coolant flow in regenerative cooling paths are of great importance in the optimum design and performance enhancement of air vehicle engines. In the present study, near-critical fluids heat transfer under supercritical pressure and close to pseudo-critical temperature conditions are investigated. Thermal behavior of cryogenic coolant fluids in the regenerative cooling channels is also analyzed. Solving equations and simulations of fluid flow are conducted with a commercial CFD package, which contains applications and utilities for finite volume solvers. This software gives the possibility to use the self-developed object-oriented C++ programming for applying the boundary conditions, the state equation, and transport properties. Furthermore, coolant flows of methane and hydrogen in the transcritical and supercritical regimes inside the three-dimensional cooling channels are studied. Solver validation is performed through simulation of hydrogen in the uniformly heated circular channel. Further, real gas equations of state and transport property relations in transcritical and supercritical regimes have been explored. Also due to the significance of the near-wall phenomena inside coolant channels, the accuracy of Spalart-Allmaras and k-ŏ3c9 family turbulence models are compared with each other and numerical results are validated with experimental data. In the cooling channels with high heat fluxes, heat transfer from the hot wall to the coolant fluid suffers in some areas and thus the wall-temperature increases. One observes that the transcritical regime and heat transfer deterioration regions through the behavior of specific heat at constant pressure, transport property and thermodynamic parameters of coolant fluid could be identified.

Key Words: Transcritical methane, heat transfer deterioration, real gas equation of state, cryogenic fluid.

THE EFFECTS OF OBJECTIVE FUNCTION COMPUTATION METHOD ON DESIGN OPTIMIZATION OF TRANSONIC AIRFOILS USING ENHANCED GENETIC ALGORITHM

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Abstract

One of the fundamental problems in aerodynamic shape optimization with Genetic Algorithm (GA) and numerical flow solution is the computational time required to obtain the optimum airfoil. This is mainly due to the large number of flow solution calls that contributes the majority of the total computational time in an optimization process. In transonic flows the computational cost will further increase due to the existence of shock wave and flow instabilities especially when the fitness function is calculated by solving full Navier Stokes equations. Thus, one simple idea could be using the inviscid flow solution instead of viscous flow one. Thus, the purpose of the present paper is to study the effects of the flow viscosity on the optimum airfoil and investigate the possibility of using inviscid flow solution for objective function calculation instead of expensive viscous solver. The modified PARSEC parameterization method is used for airfoil shape modeling that is able to generate airfoils with divergent trailing edge suitable for viscous flow calculations. The linear and torsional spring analogy are used simultaneously for moving computational grids. The optimization process used an adaptive range Genetic Algorithm for obtaining the optimum geometry in the less number of generations. The fitness function is calculated by solving the compressible flow equations using a cell centered finite volume scheme on unstructured grids. The time integration is also carried out using a dual time implicit approach. A two equations k-e turbulence model is also used for high Reynolds number flow computations. The results show that the optimum geometry at real transonic flow conditions can only be achieved when viscous effects are fully considered in the fitness function computations. They also show that using the viscous flow solution for fitness calculation can increase the objective function by about 70% in comparison with the inviscid optimum airfoil.

Key Words: Aerodynamic optimization, viscosity effect, genetic algorithm, transonic flow, grid movement.

ACOUSTIC ANALYSIS OF AERODYNAMIC NOISES CAUSED

produces heat that as heat source for the Stirling engine use Stirling engine work and begin to produce mechanical work. The hybrid system consists of molten carbonate fuel cell and Stirling engine has been recently put more emphasis on it and somehow it can be regarded as clean energy and new. In this paper, MATLAB software was used to optimize the genetic algorithm that yields the highest percentage of hybrid systems is 84.71%. Following the first review of the work and efficiency of irreversible and reversible work and the efficiency of the hybrid system and each of its components described above. And then the molten carbonate fuel cell voltage in a state of irreversible and reversible pay. 87.60% efficiency hybrid system in its irreversible and reversible mode with a maximum working reversible molten carbonate fuel cell is 94.21% and that the returns in terms of temperature between the temperature of 800 K to 1100 K hybrid systems for molten carbonate fuel cell integration mode and a certain uniformity.

Key Words: Optimization, thermodynamic analysis, integration, molten carbonate fuel cells, stirling engines.

IDENTIFICATION OF STATE SPACE DYNAMICS OF A FIXED-WING AERIAL VEHICLE WITH NEURAL NETWORKS USING FLIGHT TEST DATA

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Abstract
Most of the Unmanned Aerial Vehicles (UAVs) fly at low speed and low Reynolds number regimes and may have complex nonlinear dynamics. Hence, using available aerodynamic and propulsion software is not always reliable. On the other hand, dynamic modeling of UAVs by experimental test data is expensive and time consuming. For this reason, dynamics identification is a simple and useful solution. In the current study, the dynamic model of a fixed-wing UAV has been identified using flight test data. The UAV has a canard configuration and is powered by an internal combustion engine with a fixed pitch propeller. Because of longitudinal and lateral dynamic coupling, due to rotary propeller and polyhedral wing, a multi-input multi-output (MIMO) dynamic model in the state space form has been identified. The identification process has been performed by two scenarios. At first, dynamics is identified in a way that it can be used for investigation of stability as well as designing MIMO controllers. This model can also be used in online investigation of instrument degradation and faults. The aim of the next scenario is to identify the dynamic model which can be used in software simulation. The identified dynamic models are also validated with the test data that is logged in a second flight test. The UAV dynamics has also been identified by the SSEST method, which is a MIMO identification technique and estimates the state-space model using time or frequency domain data. The results show that the presented method is simple but effective and fast enough to be used for online identification of aerial vehicles and other mechanical systems. The quality of the system identification by the linear neural networks is appropriate and comparable with other MIMO identification techniques and the proposed model is robust against the noise and uncertainties, which can predict all flight parameters.

Key Words: Linear neural network, multi-input multi-output identification, UAV dynamics, state space identification.

THERMAL BEHAVIOR ANALYSIS OF NEAR-CRITICAL CRYOGENIC FLUIDS IN COOLING CHANNELS

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Abstracts of Papers in English

OPTIMIZATION, THERMODYNAMIC ANALYSIS AND INTEGRATION INCLUDING MOLTEN CARBONATE FUEL CELL HYBRID SYSTEM AND THE STIRLING ENGINE

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Abstract

Due to rising fuel prices and environmental concerns fuel cells as an alternative to conventional power plants will be considered. Among the produced molten carbonate fuel cell MCFC fuel cell as a fuel cell Operating temperature and high power applications where high heat is removed from Be considered. Stirling engine as well as a high efficiency reciprocating engine because the engine operating quietly and economically attention. The hybrid system consists of molten carbonate fuel cell and Stirling engine. Its works that The anode molten carbonate fuel cell, hydrogen reacts with carbonate and electrons and produces water and carbon dioxide That carbon dioxide is transferred to the cathode through a cycle where the air reacts with oxygen and generate carbonate produced at the anode to the cathode, electrons are transported and generate electricity This reaction