A REVIEW OF RESEARCH APPROACHES TO CONTAMINANT TRANSPORT IN SATURATED DEFORMABLE CLAY UNDER COUPLED HYDRO-CHEMICO-MECHANICAL PROCESSES

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Abstract

One way to manage municipal solid waste and control leachate leaking into the surrounding environment is to bury them inside an isolated compacted clay liner. Despite the low hydraulic conductivity of clay, there is a possibility of fluid flow or chemical species transport. Phenomena that lead to fluid flow are Darcian flow and chemico-osmosis flow which are respectively caused by hydraulic and concentration gradients. On the one hand, membrane behavior of clayey soils causes chemico-osmosis flow. On the other hand, diffusion and advection cause chemical solute to transport. Due to the importance of the subject, this article provides a comprehensive review of the coupled effects of these phenomena with different research approaches. After categorizing analytical approaches into three groups of experimental, theoretical, and numerical and discussing them in detail, the coupled governing differential equations are presented. These equations describe the hydro-chemico-mechanical processes that influence solute transport in landfills. More importantly, key assumptions and findings of selected research with implications for design of contaminant barriers are criticized and discussed. Eventually, a proposal is put forward for future research in this area based on the current shortcomings and research challenges.

Key Words: Contaminants transport, hydraulic conductivity, chemico-osmosis, diffusion, membrane efficiency, coupled flow, landfill.

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Abstract

Generally, there are different challenges in traditional approaches to aircraft design, resulting in a decrease in the efficiency of the design process. For instance, decisions made at the conceptual design phase are based on limited knowledge about design, while these decisions can significantly decrease the design freedom in further design steps. In addition, the decision in the conceptual design phase constituted as high as 80% of the life-cycle costs. Furthermore, in the conceptual design phase, because of their critical issues in achieving performance requirements, more attention has been given to aerodynamics and propulsion disciplines, while other disciplines are evaluated only later throughout the design process. However, in the last decades, new requirements such as environment-friendliness, considering global warming, reducing energy consumption, reusing, recycling, and remanufacturing have been added to aircraft design criteria. These changes in design requirements have led to the development of different kinds of Functional Requirements (FRs) and disciplines and, consequently, increased coupling and iterative cycles. These issues have increased the complexity of the aircraft conceptual design process compared to the past. Consequently, in the last decades, many researchers and designers have tried to address these challenges. In this regard, various design methodologies such as multidisciplinary design optimization and knowledge-based engineering were developed. These approaches could support the evolutionary improvement of current product designs or the study of the novel complex product or could reduce the coupling between various FRs and Design Parameters (DPs). In this research, designers tried to use the Axiomatic Design (AD) approach to identify and reduce coupling between different FRs, resulting in less repetitive activities and design iteration in the design process. The authors also developed an algorithm based on the AD method to improve the conceptual aircraft design. The results obtained in this study indicate the high efficiency of this method in reducing the coupling between the FRs defined for the aircraft as well as in reducing repetitive activities, thus optimizing the time and the cost of the aircraft design process.

Key Words: Aircraft conceptual design, axiomatic design,coupling, iterative cycles in design process.

INVESTIGATING THE EFFICIENCY OF PIEZOELECTRIC WIND ENERGY HARVESTING IN LEAF-STALK STRUCTURES

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Abstract

In this paper, piezoelectric wind energy harvesting with leaf stalk structures is classified and the performance of each structure with different configurations is investigated. In this research, the main purpose is comparing these harvesters in terms of their structures and determining the best configuration for each environment. In other researches, energy harvesting systems have also been investigated based on the type of fluid-structure interaction or type of piezoelectric materials; however, this study investigated leaf-stalk structures in which wind energy has been the main source of energy harvesting. Although the electrical power harvested from wind energy by piezoelectric materials is by no means comparable to the power of wind turbines, these harvesters are very low-cost, small, silent, and clean and used as a replacement for batteries that become chemical waste after use. In large numbers, they can be used for low-power consumption in commercial, sports or leisure centers. By examining the design parameters that improve the performance of leaf-stalk structure, it is found that in addition to load resistance and wind speed range, leaf and stalk geometry, their configuration, and distance between two systems and the presence or absence of veins affect the frequency of the flutter and consequently the performance of the energy harvesting system. In general, among different geometric shapes, triangle leaves have had the best performance. On the other hand, if the support base is jointed, it also has a positive effect on the performance of the system. Leaves with veins produce more output power than leaves without veins. Among the leaves with veins, the Pinant leaves will increase the efficiency of the system. Due to the wind speed constraints, the dimensions, and costs, one cannot determine the best system, but the best one can be identified for the specific conditions.

Key Words: Energy harvesters, wind energy, piezoelectric materials, fluid-structure interaction, leaf-stalk.

low Earth orbiting satellites. This parameter is greatly dependent on the Earth's local terrain and climatic conditions such as instantaneous cloud coverage. To address the problem of albedo factor uncertainty, it is estimated simultaneously with the attitude and orbit of the satellite. NASA's CERES project provides satellite-based observations of the Earth's radiation budget and clouds over almost 18 years. In this paper, CERES data tables for the Earth's thermal flux and albedo factor have been used to produce more realistic measurement data. The nonlinear filter of Unscented Kalman Filter (UKF) is also exploited for the state estimation. Lack of sun radiation during the satellite's eclipse intervals results in the loss of orbit and attitude observability. The performance and viability of the proposed COAE algorithm are verified by Monte Carlo simulations. Moreover, a sensitivity analysis is conducted within a wide range of semi major axes, eccentricities, and inclinations. The results demonstrate the high sensitivity of the algorithm to the orbit altitude and the sun rays direction.

Key Words: Orbit estimation, attitude estimation, parameter estimation, satellite surface temperature, albedo factor.

NUMERICAL INVESTIGATION OF THE PREMIXED V-FLAME STABILIZATION AND BLOWOUT

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Abstract

Global warming and high fossil fuel consumption increase the application of the low-Nox burner with lean-premixed combustion. However, this type of combustion is more susceptible to thermoacoustic instabilities. Then, a fundamental understanding of the lean-premixed combustion is essential. The aim of this work is the numerical study of a premixed propane-air V-flame stabilized on the designed flame holder with focus on the stability and blowout analysis using ANSYS Fluent. Different turbulent models in cold flow simulation are investigated and for steady flame with lower computational cost and for transient flame dynamics are selected. The combustion models including FR/ED, EDC with 2-step mechanism and EDC with CHEMKIN reduced kinetics with 28 species and 114 reactions are used for simulation. The lean and rich limits for V-flame are predicted and the combustion stability range is determined as using SAS turbulent model and EDC reduced mechanism. The numerical stability limit covers the experimental range. The experimental tests have higher turbulent intensity than numerical model, leading to the difference in the blowout threshold. The flame dynamics on the blowout limit is investigated by instantaneous temperature field and radicals. The NOx emission varies with the mean flame temperature and is higher in the lean combustion than the rich cases. The reason of this phenomenon is incomplete mixing of the fuel and air, leading to the anchoring of the flame on the one side of the flame holder more than the other side and the hot regions formation which results in higher amount of NOx. As the equivalence ratio decreases, the flame fragments are separated locally due to the high strain rate formed with turbulence-flame interaction and transferred downstream with flow velocity. The V-flame surface was enhanced due to the vortex interaction with flame front. With a further reduction in the fuel amount, the heat release by the V-shaped flame area is not sufficient to sustain the burning of the rest of the flame anchoring on the bluff body. Then, the mean temperature immediately reduces lower than ignition temperature, while the radicals are less than the stable combustion, leading to the global flame extinction.

Key Words: Premixed combustion, V-flame, combustion models, turbulence models.

APPLICATION OF AXIOMATIC DESIGN APPROACH TO REDUCE COUPLING AND REPETITION IN THE UCAV CONCEPTUAL DESIGN PROCESS

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IN A COMPOUND OPEN-CHANNEL USING PIV

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Abstract

A compound open channel is composed of the main channel and flood plain. In experiments with compound open channel conducted to ensure that the flow is uniform and fully developed, it is necessary to study the distribution of discharge in the main channel and flood plains. The purpose of the present study is to investigate the effects of channel inlet condition on flow uniformity by considering distribution of discharge in channels with length to flood plain width ratio lower than 35 (needed for fully developed flow condition) by analyzing the flow field and turbulence parameters. For this purpose, particle image velocimetry method has been used in a rectangular compound open channel. To provide correct measurement of secondary velocities, using a non-intrusive method such as particle image velocimetry is completely essential. The results of this study show that in short compound channels with the same screen installed in the main channel and flood plain, there is significant mass transfer from the flood plain to the main channel until the end of the channel length. It was found that in this case, a considerable downfall occurs for the maximum velocity position in the main channel. However, with a supplementary screen installed in the flood plain, in addition to the typical screen, expected conditions are established similar to the fully developed compound channels. In this condition, the time-averaged streamwise velocities vary considerably in the flood plain along the spanwise direction. On the other hand, in short compound channels with the same screen installed in main channel and flood plain, the streamwise velocities do not change significantly along the flood plain width duo to the imperfect interaction of main channel and flood plain. These observations express that to provide correct distribution of discharge, a supplementary screen should be installed in the flood plain of the compound channel.

Key Words: Compound channel, entrance effect, mass transfer, flow pattern, particle image velocimetry.

SIMULTANEOUS ORBIT, ATTITUDE AND ALBEDO PARAMETER ESTIMATION USING SATELLITE SURFACE TEMPERATURE DATA

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Abstract

Development of low-cost small satellites has been at the center of attention in recent years. Concurrent Orbit and Attitude Estimation (COAE) requires fewer sensors onboard and subsequently results in some cost reductions. In this regard, the present paper has focused on addressing the importance of COAE utilizing temperature rate on satellite surfaces. To this end, the thermal model for a low Earth orbiting satellite is introduced first. A three-axis stabilized spacecraft is assumed equipped with small measurement plates that are isolated from each other and from the internal heat sources of the satellite. As the Sun and the Earth are the significant sources of radiation for a near Earth space system, the view factor is the key parameter for observability of the orbital elements, while the Sun radiation is responsible for the attitude observability. The Earth albedo factor is a major uncertain parameter required for the thermal analysis of

in solar desalination can be divided into three different sectors: indoor reflectors, external reflectors, and a combination of indoor and outdoor reflectors. Internal or external reflectors concentrate solar radiation on the basin and can increase the desalination performance. On the other hand, time-consuming and expensive solar manufacturing processes still lead researchers to use computational fluid dynamics. Therefore, the present study was done to simulate a double slope solar still with an external rotating reflector, in which sun radiation is concentrated on the basin water, resulting in an increase in productivity. Thus, equations of continuity, momentum, energy, and concentration conservation were solved using Comsol Multiphysics software by assuming the fluid as single-phase humid air, laminar natural convection, and steady-state condition 2D geometry. The simulation was done for two primary angles, and the results were compared with the experimental data available for 20th November 2017 in Dezful weather conditions (longitude and latitude 48.36 and 32.42) located in southwestern Iran. It was shown that there was good agreement between the results. Moreover, it was shown that by changing the external reflector's primary angle, the temperature of water and glass increased by about 7% and 4%, respectively. In addition, the Nusselt number decreased by 5%, which caused an increase in the productivity rate by about 32%.

Key Words: Solar still, performance, rotating external reflectors, simulation.

EVALUATION AND MANAGEMENT OF WORKERS' MUSCULOSKELETAL INJURY RISKS DURING HANDLING/INSTALLATION OF THE DRIVER CAR SEAT IN IRAN-KHODRO INDUSTRIAL GROUP

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Abstract

Low back and musculoskeletal injuries are prevalent and costly especially among workers performing manual material handling (MMH) activities. To manage risk of injury, first, one needs to quantify spine loads during the MMH activity under consideration and then, design effective prevention programs. Installing driver car seat in Iran-Khodro industrial group is a physically heavy and cyclic MMH activity that generates large loads on the worker's spine and therefore needs to be assessed and redesigned. This study uses various quantitative and qualitative lifting analysis tools to assess this activity and subsequently provide affordable engineering interventions to reduce risk of injury. Spinal loads including L4-L5 disc compressive loads and L5-S1 shear loads were evaluated using various quantitative (musculoskeletal biomechanical) tools/models (3DSSPP, Anybody, and predictive equations). As the job had a cyclic nature (22 seats per hour and 8 hours per day), various qualitative tools were also employed to assess the risk of injury (RULA, REBA, NIOSH, WISHA, MAC, V3, and MatTra). Motion analysis was performed on the worker in the workstation to determine body posture during this MMH task. Worker's posture, weight of the seat (16 kg), and position of the seat with respect to body were the most important inputs in the foregoing assessment tools. Results of the biomechanical analyses indicated that the task caused L4-L5 compressive and shear loads beyond the recommended safe limits (3400 N for disc compression and 1000 N for shear loads). Further qualitative analysis using the foregoing qualitative tools confirmed the high risk of injury during this MMH activity. The main reason for such high risk injuries to the spine was found to be the large trunk flexion of the worker when installing the seat inside the car. To manage the risk of injury, it is recommended that this MMH activity be eliminated using manipulators. As the workspace did not allow for the installation of such manipulators, the worker's working height was lowered so to reduce trunk flexion angle. Reassessment of the job after this intervention indicated that spinal loads remained below recommended safe limits and risk of injury considerably reduced.

Key Words: Low back pain, risk of injury, qualitative/quantitative risk assessment analysis, biomechanical models, Iran-Khodro.

EXPLORING IMPACTS OF INLET CONDITION ON FLOW STRUCTURE

Key Words: Dynamic modes decomposition, thermal diffusion, reduced order model, dynamical system.

RECOGNIZING ACCEPTANCE LEVEL IN FACIAL EXPRESSIONS BY NEURAL NETWORK

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Abstract

Today, robots play an important role in the daily lives of people with disabilities and even ordinary people, so that in almost all areas of treatment and assistance, education and rehabilitation, games and entertainment, we see the presence of all kinds of social robots. Because working in the above areas requires a strong spirit and performing a specific action with constant quality many times, robots can take the place of humans well and do their job without fatigue and boredom and with a constant quality. However, one of the disadvantages that may exist in human-robot interactions is the lack of emotional mutual understanding, which means that usually the robot has no emotional understanding of human moods and sometimes this is the reason why the quality of interactions decreases. Perhaps, the perception of people's satisfaction can be considered as a major parameter in our interactions between humans and robots, meaning that creating a proper interaction always increases the level of satisfaction in humans and on the other hand, people express dissatisfaction. They can express their unwillingness to continue an interaction. Hence, this paper attemts to use a canonical neural network model to find people's level of acceptance when facing a predetermined scenario. Unlike numerous and valuable studies that use deep neural network to diagnose facial expressions and the raw image of the person as the input of the network, in this paper, the histogram vector of directional slopes of face as a characteristic vector describing the level of acceptance and a small neural network model is used as classifier. The obtained model, in addition to the high power of satisfaction, has the ability to generalize and recognize unlearnt negative emotions. Small size and low processing cost are two very important elements in the efficiency of separate systems, which are considered as two basic constraints in the model. Sometimes, other parameters are ignored to achieve these two important ones.

Key Words: Acceptance level, expressions, neural network, facial expression.

SIMULATION OF A DOUBLE SLOPE SOLAR STILL WITH ROTATING EXTERNAL REFLECTOR

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Abstract

In recent years, for some reasons such as population growth, environmental pollution, industrialization, and urbanization, drinking water has been challenging to access. Therefore, solar still is considered one of the promising available technologies to produce drinking water because of its advantages such as abundance, cleanliness, and economics. However, their productivity is relatively low, and present designs need to improve and develop. To achieve high desalination performance, researchers have made many efforts to build different designs of solar desalination and found that desalination made with reflectors would be a good idea. Reflectors

Abstracts of Papers in English

REDUCED ORDER MODEL OF CONDUCTION HEAT TRANSFER IN A SOLID PLATE BASED ON DYNAMIC MODE DECOMPOSITION

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Abstract

Simulation and numerical analysis of physical phenomena, especially for the unsteady problems due to the dependency of the numerical algorithms on the computer hardware and the large number of computational nodes, are the most important problems. For these reasons, the number of computations and computational costs increase. The order reduction method is the one that has been widely used in recent years to reduce computational time. In this way, by reducing the constraints of the system without changing the inherent features of the problem, the computational efficiency will dramatically increase. In this study, using the basic concepts of dynamical systems, the thermal diffusion problem is investigated using the dynamic modes decomposition method. Then, a reduced order model is established for the related governing equation of this phenomenon. Accordingly, based on the projection of the governing equation in the vector space of modes, by using dynamic modes, a reduced order model is obtained with respect to the properties of dynamic modes. The obtained model to simulate the time evolution and parametric variations can be properly replaced with the original equation and predict the behavior of the system with very good accuracy. A comparison between the results of the present reduced order models and the simulations of the exact solution shows high computation accuracy.