University of Patras
Department of
Mechanical Engineering and Aeronautics

Diploma Thesis
Academic Year
2023-2024

Patras, Greece

CONTENTS

INTRODUCTION

The Diploma Thesis (DT) is an important component of a student's education. Its purpose is to give the student the opportunity to work in a scientific manner, utilizing both the general and specialized knowledge acquired during their studies in the Department of Mechanical Engineering and Aeronautical.

The aim of DT is to offer the student the chance to delve into a subject of particular interest to them, which will introduce them to the corresponding field of application and research, and may even serve as the first step towards a related professional and research career.

It carries thirty-six (36) ECTS credits and fifty-five (55) teaching units, and its successful completion, presentation, and grading are essential prerequisites for graduation. The thesis is registered in the ninth and tenth semesters of study, and its execution lasts at least two semesters.

The student, after consulting with a professor or an E.DI.P. (Special Laboratory Teaching Staff) member they wish to collaborate with, selects the thesis topic, and a three-member committee is appointed to oversee the work. The student then applies to the Department's Secretariat for the approval of the thesis supervisor, the topic, and the three-member committee by the Department Assembly. Upon approval by the Assembly, the student can begin their thesis work.

Regarding the content, the diploma thesis must include the following:

- **Literature Review**: A thorough review aimed not only at citing previous work but also providing a critical and synthetic assessment of the research done to date in the scientific field of the thesis topic.

- **Topic Analysis**: This section should outline the problem being addressed, describe the methodology used for solving it, and include details of the experimental and/or analytical, numerical techniques applied, as well as the experimental and/or computational tools used.

- **Results**: The outcomes of the research, the conclusions drawn, and suggestions for future work.

Thesis presentations are held three (3) times a year after the exam periods in June, September, and February, during scheduled open sessions of the Department, on dates and with a program determined by the respective directors. During the presentations, the results of the theses are displayed in A3-sized poster form.

The goal of this booklet is to showcase the results of the theses completed in the Department over recent years.

Below are the abstracts of each thesis.

DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS (FEBRUARY 2024)

NUMERICAL STUDY ON IMPROVING AERODYNAMIC PERFORMANCE USING NATURE INSPIRED RIBLET SURFACES

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ABSTRACT

Innovative technologies that lead to reduction in aircraft drag to reduce fuel burn thus CO_2 emissions is of continued interest to aviation sector. Bio-inspired studies have led to the creation of micro-textured surfaces known as Riblets, inspired by the skin of sharks. These surfaces influence the surface drag properties by altering the flow within the boundary layer. This research investigates the effect of different riblet geometries over a flat plate through numerical modeling. The aim is to quantify the effect of skin friction on this riblet surfaces compared to flat surfaces and study the impact of geometric parameters on drag and flow behavior. The results indicates that the riblets move vortices away from the wall, thus weakening turbulence flow characteristics in the near-wall region. The models were tested under the flight conditions of the Greek Civil Unmanned Aircraft RX-1, HCUAV and a maximum drag reduction of ≈8% was achieved, demonstrating the significant potential of riblets in reducing drag, enhancing surface performance, and minimizing power loss.

Keywords

Ribltes, Skin Friction, Sharkskin, Drag Reduction, Numerical Modeling, Unmanned Aerial Vechile

STRUCTURAL DESIGN OF A COMMERICAL AIRCRAFT WING WITH DISTRIBUTED PROPULSION

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ABSTRACT

The rapidly developing technological world has created growing aviation demands regarding aircraft performance, operation and crucially; environmental impact. The urge to achieve aviation sustainability has led the industry to focus on implementing alternative configurations, such as Distributed Propulsion systems coupled with sustainable power sources. In this Thesis, a Distributed Electric Propulsion configuration powered by a liquid Hydrogen Fuel-Cell system is implemented on a small, commercial Light Sport Aircraft, specifically the Zodiac CH 650 B produced by Zenith Aircraft Company. The purpose is to perform a structural analysis on the Zenith Zodiac CH 650 B modified wing using both analytical and finite element methods and also compare it to the original configuration. The analytical method relies on strength of materials and aerodynamic theory while the finite element method also requires designing and modeling the wing structure in CATIA and ANSYS respectively. Aircraft performance improvements are also evaluated, as Short Take Off Landing capabilities, noise reduction, efficiency increase and (near) zero emissions are required characteristics of future aviation.

Keywords

Commercial Aircraft, Wing Structural Analysis, Distributed Electric Propulsion, Sustainable Aviation, Liquid Hydrogen Fuel-Cell

EXPERIMENTAL CHARACTERIZATION OF THE MECHANICHAL PROPERTIES OF GRAPHENE - REINFORCED COMPOSITES

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ABSTRACT

The primary objective of this thesis is to undertake a comprehensive investigation and experimental characterization of intricate nano-reinforced materials, with a specific focus on graphene-based components, namely graphene nanoparticles and carbon nanotubes. Within the scope of this research, an extensive examination of the properties and potential applications of nanocomposite materials was conducted based on the available bibliography. Subsequent to this, mechanical experiments were executed, including static tensile tests at 0˚ and 90˚, three-point bending tests, and interlaminar shear strength (ILSS) tests, with the intent of ascertaining the mechanical properties of both the reference specimen and the specimen reinforced with nanostructures. Moreover, moisture absorption experiments were undertaken to assess the suitability of the material for specific applications (under distinct environmental conditions). The experimental methodologies and setups employed, along with property calculations and resultant diagrams, are comprehensively presented. Specifically, in consideration of the integration of nano-reinforced materials in aerospace applications utilizing an epoxy matrix, the attainment of commendable mechanical properties, alongside favorable electrical-thermal properties, is imperative. Consequently, the examination focuses on Epoxy Resin R244/H33 & Zoltek Px 35 tow 50k, reinforced with 2,5% graphene nanoparticles (GNPs) and 3,5% carbon nanotubes (CNTs), with a subsequent comparison to the baseline material, Epoxy Resin R244/H33 & Zoltek Px 35 tow 50k. The overarching objective of hybrid reinforcement, and the chosen reinforcement percentages, is to establish significant electrical-thermal properties capable of counteracting the dielectric behavior of the matrix, while avoiding substantial degradation of the mechanical properties. The synergistic interplay between the reinforcements is crucial for achieving optimal dispersion in the matrix and the formation of a conductive network, given that the formation of aggregates is identified as a principal factor leading to mechanical property degradation. In the pursuit of both electrical and thermal conductivity, elevated reinforcement percentages were employed, resulting in the decrease of several mechanical properties for the reinforced materials. Notably, reduced elasticity was observed in bending and flexural tests for the reinforced material, accompanied by an elevated percentage of moisture absorption compared to the initial material. The maximum bending force for the hybrid reinforced material exhibited a reduction of 26%, 15% in static tensile tests at 0˚, and 7,4% in static tensile tests at 90˚. Conversely, an increase of 9% in the elastic modulus was noted for materials reinforced with film on the upper surface, along with a 3,5% increase in the maximum force in static ILSS tests for the reinforced material. Furthermore, an increase of 3,5% in maximum stress and deformation was observed in compression experiments for the reinforced material.

Keywords

Composite materials, Graphene, GNP nanoparticles, CNT nanoparticles, Mechanical experiments, Moisture absorption experiment, Epoxy resin

STUDY OF COMPINED ENERGY HARVESTING AND VIBRATION CONTROL IN A SIMPLIFIED AIRFRAME USING PIEZOELECTRIC TUNED MASS DAMPER

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ABSTRACT

The development of vibration control methods is crucial in flexible structures operating under vibration loads, such as an airframe structure subject to unsteady aerodynamic loads or engine induced vibroacoustic loads. In this direction, the contribution of recently developed piezoelectric tuned mass dampers (PTMDs) could be important. PTMDs consist of a piezoelectric device, an auxiliary mass, and an external electrical shunt circuit. By exploiting the piezoelectric effect, they can absorb kinetic energy of the host structure and convert it into useful electrical energy, which can be subsequently manipulated in the electric circuit to control vibrations. In this project, the capability of the PTMD to provide combined harvesting of the converted electric energy with simultaneous control of the host structure oscillations is first investigated. Then, the effect of the electrical circuit parameters of a semi-active piezoelectric tuned damper on the suppression of developing oscillations at critical points of a simplified aircraft fuselage structure, is evaluated. The modeling of the structure of interest is initially performed using the finite element methods, while the reduced order dynamic equilibrium equations are derived using the eigenmode superposition method, coupled with the electromechanical anti-vibration device and the electrical circuit. Subsequently, the complete modeling of the problem is carried out in a programming environment and the optimal parameters are calculated using a genetic optimization algorithm. Application cases on a reduced-scale airframe structure prototype, demonstrate a strong effect of inductance on the structure of interest, bringing about strong electromechanical coupling, while the addition of combined resistance and inductance coupling provide high control of oscillations and a sufficient amount of electrical energy to be harvested. Combined energy harvesting under conditions of optimal vibration control becomes possible, and also the used anti-vibration device seems to satisfy both intended goals for broadband excitations.

Keywords

Piezoelectricity, tuned mass dampers, vibration control, damping, energy harvesting, optimization

SOLVOLYSIS OF 3D WOVEN CFRPs IN SUPERCRITICAL CONDITIONS: MECHANICAL PROPERTIES OF RECYCLED FIBERS AND COMPARISON WITH PYROLYSIS DATA

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ABSTRACT

The needs of industry have led to the development of lighter and at the same time more durable materials. This has led to the use of new materials, and more specifically composites, characterized by a high strength-to-weight ratio. However, the ever-increasing use of composites in industry in recent decades has led to the need to develop efficient recycling processes. The conventional methods of landfilling and incineration of these materials will be phased out in a few years and replaced by recycling methodologies. Therefore, various methods of recycling composite materials have been developed, the most well-known being mechanical, thermal, and chemical recycling.

This thesis focuses on chemical recycling, which is an efficient and environmentally friendly method. More specifically, the efficiency of solvolysis with water as a solvent (hydrolysis) under supercritical conditions was studied. The composite material recycled was a 3D woven. It is a composite material with a complex architecture, for the recycling of which there is insufficient data in the literature. The results obtained from chemical recycling were compared with pyrolysis results on the same material.

More specifically, experiments were carried out on five specimens in a hightemperature and pressure reactor. Reaction times chosen for the first three experiments were 20, 40, and 60 minutes at 380 degrees Celsius, and for the last two 60 and 75 minutes at 390 degrees Celsius. At the end of the recycling process, the fibers were immersed in an acetone bath for twenty minutes and then placed in an oven at 40 degrees Celsius for 24 hours to remove humidity. To assess the effectiveness of the recycling, the resin decomposition rate in terms of mass was first calculated. This rate in 4 of the 5 experiments was calculated from 90.7 to 93.3%. This was followed by morphological characterization of the fibers by scanning electron microscope

(SEM). In the SEM images, the fibers appear clean and there were no detectable signs of damage to their geometry (diameter). Single fiber tensile tests were then carried out in accordance with ASTM C 1557-14. The tensile strength of the recycled fibers, at the optimum experimental conditions of 380 °C and 60 minutes, was degraded by 11 %. In the same experiment, an increase in the elastic modulus of 23.3% was measured. The comparison with the pyrolysis results showed that solvolysis was more efficient in terms of the mechanical properties of the recycled fibers.

Keywords

Composite materials, Recycling, Solvolysis, Carbon fibers, Mechanical properties.

FABRICATION OF FIBROUS THERMOPLASTIC POLYURETHANE STRUCTURES USING MELT ELECTRO-WRITING FOR STRAIN SENSING APPLICATIONS

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ABSTRACT

In the current investigation, a fibrous and electrically conductive membrane has been developed, having an aim to fabricate functional strain-sensors. Initially, the theoretical background that is related to fabrication of such structures has been thoroughly investigated. Afterwards, the thermoplastic polyurethane (TPU) was selected as a polymer matrix while single-walled carbon nanotubes (SWCNTs) were utilized to create an electrically conductive and flexible strain-sensor. In order to be able to fabricate these structures the Melt Electro-writing (MEW) process technique was utilized, which is an innovative method for fabrication of fibrous polymeric structures by applying high voltage, while in parallel uses the 3D printing logic. The first trial for the fabrication of the strain-sensor comprises an attempt to print the sensor directly by the incorporation of the conductive elements (SWCNTs) into the TPU melt. After fabrication, it was found that the mechanical properties of the final structure were significantly degraded and it was proved not to be electrically conductive. Micro-tensile tests were conducted to identify the mechanical properties.

The second and successful trial to fabricate strain-sensor comprises a metatreatment of the pure TPU structure arose from MEW process. The meta-treatment process involves the immersion of the fabricated TPU structure into a suspension containing deionized water and SWCNTs at the amount of 0.3 %w/w by using ultrasonics (dip-coating process). The dip-coating process had an aim the available SWCNTs to be adhered at the outer surfaces of the printed TPU fibres in order to create a conductive network. Then, the nanomodified structure was left to dry by using a conventional oven to remove the remaining water. During the micro-tensile experiments, the mechanical properties were measured together the electrical resistance ones. Based on experimental results, it was shown that the electrical resistance values were gradually increased during the tensile test. The electrical resistance value of the fabricated strain-sensor was recorded by using electrodes suitably adapted at the ends of the outer surfaces of the sensor which are further connected with a multimeter. Finally, the mechanical properties of the fabricated TPU structures were subjected to heating in order to dry and the annealing process to be occurred (i.e.; enhancement of the mechanical performance). Finally, the morphology of the fibres was studied by using optical and scanning electron (SEM) microscopies.

Keywords

Composites, Melt Electro-writing process, SWCTs, Strain-sensors, Mechanical properties

SIMULATION OF THE DISASSEMBLY PROCESS OF COMPOSITE STRUCTURES USING THE LASER SHOCK WAVE METHOD

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ABSTRACT

New aircraft engine blades are made of 3D braided composites and incorporate a protective metal layer on the leading edge. The end of life cycle of these structures involves complex disassembly and recycling processes. In this paper, laser impact method is investigated as an environmentally friendly disassembly method. In this context, the simulation of the process in curved geometries is considered and the disassembly method is applied to a part of the geometry of an aircraft engine blade. The modeling of the structures was carried out using the finite element package LS-DYNA. Specifically, the simulation of the 3D mesh composite was performed using a progressive failure model with Hashin-type failure criteria, which incorporates coefficients for the influence of strain rate. The titanium layer utilizes the Johnson-Cook plastic behavior model in conjunction with the Grüneisen constitutive equation while the connection simulation uses cohesive zone elements for the simulation of the connection.

The simulation methodology consists of two parts. First, a curved plate is compared with a flat plate, both loaded with a symmetrical laser pulse, in order to monitor differences in wave propagation and the damage produced at the interface. A section of an engine blade geometry is then used, to which an iterative double laser pulse process is applied, in order to investigate the use of the method in a real structure.

Keywords

Laser shock, debonding, finite element analysis, 3D woven composite, cohesive zone modelling, progressive damage modelling

DESIGN, ANALYSIS AND OPTIMIZATION OF A COMPOSITE HYDROGEN STORAGE TANK FOR AUTOMOTIVE APPLICATIONS

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ABSTRACT

Hydrogen vehicles have the potential to contribute considerably to the decarbonization of our future mobility. These vehicles employ fuel cells to convert stored hydrogen, combined with atmospheric oxygen, into electricity that drives the vehicle. To ensure an acceptable range, hydrogen must be stored under high pressure, leading to the utilization of Composite Pressure Vessels (CPVs) in modern vehicles.

The pivotal role of pressure vessels in automotive industry is achieving an optimal and safe range for Fuel Cell Electric Vehicles (FCEVs), so this thesis presents a comprehensive exploration of every aspect of hydrogen utilization in vehicles. Initiating with a theoretical background, the research emphasizes on both analytical and experimental study conducted on a Prototype CPV, aiming to predict the CPV's performance through the analytical study and then validate its accuracy comparing it with the experimental outputs.

For the design and the analysis of the virtual model, NX Siemens software is used. The initial stages involve the documentation of the geometrically complex pressure vessel, followed by the development of the detailed 3D model of the CPV. The design of a CPV includes various integrated parameters such as the progressive failure and burst pressure, which are calculated in the analysis. A stepby-step approach of formulating the analytical model is presented, and in parallel, a progressive damage model is established to facilitate the prediction of damage propagation and calculate the First Ply Failure and Analytical Burst Pressure (ABP), which represents the analytical ultimate burst of the CPV. As for the experimental study, a burst pressure test is implemented to obtain data on the Experimental Burst Pressure (EBP), burst location, and deformation of CPV. Experimental results are compared with analytical results to validate the model's accuracy in predicting CPV burst.

The successful predictive capability of the analytical model signifies a milestone in composite pressure vessels' maturity. The development of an analytical model that can accurately predict the CPV's performance can revolutionize industries, reducing time, costs and enabling faster manufacturing of CPVs, particularly in automotive industry where Type V CPVs are still relatively new technology.

Keywords

Composite Pressure Vessel (CPV), Analytical Burst Pressure (ABP), Progressive Damage Model, Hydraulic Burst Pressure Test, Experimental Burst Pressure (EBP)

DESIGN, ANALYSIS AND NUMERICAL TESTING OF THE STRUCTURE OF A 3D NANO-SATELLITE MANUFACTURES USING FDM

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ABSTRACT

This thesis presents a comprehensive study on a hybrid CubeSat structure that incorporates additive manufacturing techniques for its main framework and utilizes Aluminum 6061 for the rails through traditional manufacturing methods. This innovative approach exceeds the minimum acceptable resonance frequency thresholds for satellite missions while achieving a mass reduction of 50% compared to traditional microsatellite structures of similar size. The investigation reveals a robust structure, as demonstrated by the derived safety factor from semi-static simulations. Further analysis of stress and displacement under random vibration loads indicates that the structural integrity remains uncompromised. The primary structural components made from Polyether Ether Ketone (PEEK) material, weighing 109 grams, and highlight the effectiveness of high-performance thermoplastics in maintaining rigidity and reducing overall mass.

Keywords

CubeSat, Fused Deposition Modeling (FDM), Polymers, Structural design, Finite Element Analysis (FEA)

NUMERICAL PREDICTION OF RESIDUAL STRENGTH AND FATIQUE DELAMINATION QUANTIFICATION USING C-SCAN IMAGES OF THERMOPLASTIC COUPONS

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ABSTRACT

Thermoplastic materials are widely used in various engineering applications such as in the aerospace and automotive industries due to their excellent mechanical properties and their low specific weight. Therefore, it becomes necessary to develop numerical models capable of predicting their mechanical behavior and strength to successfully evaluate their performance. This thesis focuses on the numerical prediction of the residual strength of a carbon fiber reinforced thermoplastic polymer and the quantification of fatigue damage through non-destructive testing techniques, in specific ultrasonic C-Scan.

The numerical analysis was performed using the finite element computational package LS-DYNA. A quasi-isotropic plate with dimensions of 150 $mm * 25\ mm * 2.24\ mm$ and a [-45/0/45/90]$_{2S}$ lamination was modeled. A fatigue model was developed based on the use of cohesive elements to extract the damage geometry which was exclusively delamination. The simulation was performed for 20, 40, 60, 80, 100 and 120 thousand cycles of loading. This was followed by numerical static tensile simulation to estimate the residual fatigue strength of the fatigue models reclaiming the progressive damage growth model using Hashin-type criteria.

In addition to numerical analyses, 2 coefficients capable of quantifying the damage from fatigue experiments are proposed. In one case, MATLAB is used, and the C-Scan images are processed through the provided color scale. This coefficient is compared to the coefficient developed from the fatigue model by calculating the damage area through the deleted nodes.

From the numerical results, Force-Displacement and Su-N (Strength-Cycle Loading) diagrams were extracted from which satisfying agreement between the prediction of residual strength and the failure mechanisms that lead the material to failure is observed. The fatigue damage coefficient of the C-Scan images was able to predict the damage rate per loading cycles however the results are differed significantly from the corresponding numerical coefficient. Eventually, the correlation of damage rate with the remaining strength of the specimens was satisfied, however further research on the quantification of fatigue damage is suggested to be considered a reliable inspection tool.

Keywords

Thermoplastic composite materials, Finite element, LS-DYNA, Delamination, Fatigue damage quantification, Non-destructive ultrasonic C-Scan

ACTIVELY LEARNING OPTIMUM PARAMETERS FOR 3D PRINTING OF NEW AND SUSTAINABLE MATERIALS

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ABSTRACT

The ability of machine learning algorithms to offer answers to challenging issues has shown significant promise. The prospect of machine learning has evolved quite a distance, as seen by some of the applications of every day, such as speech recognition, email spam filtering, automatic translation etc. Without artificial intelligence (AI) and machine learning (ML), it could take many more years to explore and utilize novel materials to their fullest potential. As it takes a long time and a lot of effort to explore and create new materials for three-imensional (3D) printing technologies, for effective component fabrication, each newly created 3D printing material requires specific print parameters to be learnt, and less-than optimal settings can lead to flaws or fabrication failure. To solve this, firstly a series of experiments are created, single line print. Secondly, using computer vision algorithm the width of the line is extracted as part of feature extraction. The outcome is fed in a self-taught algorithm which autonomously modulates print parameters, resulting in matching of printing settings to target requirements.

Keywords

Machine Learning, 3D Printing, Bayesian Optimization, Hyperparameter Optimum, Sustainable Material

MODELING OF THE FRACTURE PROCESS OF THE ARTERY WITH ATHEROMATIC PLAQUE DURING ANGIOPLASTY OPERATION USING FINITE ELEMENTS MODEL ANALYSIS

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ABSTRACT

The reduction of the inner diameter of the artery due to the creation of atheromatic plaque on the artery lumen, known as artery stenosis, disrupts the blood flow, leading to medical complications, which can be fatal. The angioplasty procedure aims to reopen the artery and uses a stent to keep it open. To improve the efficiency of the operation, different stents were developed, either by changing their material or by adding a drug coating on them. In this study an effort is made to find the point of failure of the artery during the expansion phase of the angioplasty using the in silico Finite Elements Analysis method.

The first step towards that goal was the creation of the model parts in the Abaqus/SolidWorks environments. Starting with the stent geometry, a literature-based design was chosen, with the balloon and the two artery layers having a hollow cylinder shape. Additionally, three plaque designs were created to simulate the different artery stenosis percentages. Following the creation of each model part, their respective materials and Finite Element meshes were added. Afterwards, the different parts were put together to form four models with different artery stenosis. To complete these models, the interactions between parts, the boundary conditions, and the external load were added.

After tracking the types of failure observed in the simulations, the displacement at the points of failure were found for all the models. Afterwards, based on the displacements mentioned before, the balloon pressure at each point of failure was calculated. This calculation was important because the balloon pressure is widely used by physicians during the angioplasty procedure. The results show that no plaque failure occurs during the procedure and that artery failure always precedes stent failure. Furthermore, an inverse relation was noticed between the artery stenosis and the pressure at the artery failure point. Finally, some areas for further research are mentioned, such as the creation of more realistic models and the focus on the artery fatigue.

Keywords

Angioplasty, Stent, Finite Element, Artery Failure

DIVISION OF DESIGN AND MANUFACTURING (FEBRUARY 2024)

FATIGUE LIFETIME PREDICTION OF STRUCTURAL STEELS USING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE TECHNIQUES

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ABSTRACT

Fatigue of materials stands as a prevalent cause of mechanical structure failures, which often occur suddenly, unpredictably, and catastrophically. Accurately predicting the fatigue lifespan of materials is crucial, especially given the potential for fatigue failure to occur within a short design life. While conventional techniques relying on the S-N curve models are widely used in industry, there is a contemporary shift towards employing Artificial Intelligence and Machine Learning techniques to enhance the precision of fatigue lifetime predictions. In this diploma thesis, a dataset containing experimental data from various structural steels is used. Following preprocessing and feature selection, four techniques are applied: Polynomial Regression, Support Vector Regression (SVR), XGB Regression and Artificial Neural Network (ANN), aiming to identify the most effective algorithm. The implementation of these methodologies for fatigue lifetime prediction yields substantial outcomes. All models exhibit satisfactory performance, with XGB Regression demonstrating superior effectiveness. Furthermore, Polynomial Regression provides highly satisfactory results, almost identical to the Artificial Neural Network. Notably, it requires significantly less computational power, making it a practical alternative in cases of restricted computational resources or limited implementation time. Overall, the proposed methodology effectively leverages material preprocessing details, mechanical properties and experimental conditions to provide accurate predictions of the remaining fatigue lifespan of structural steels.

Keywords

Fatigue, Lifetime Prediction, Machine Learning, Artificial Intelligence, Regression

MODELING AND DYNAMIC CONTROL OF IRRIGATION CANALS

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ABSTRACT

Efficient management of irrigation canal networks plays a crucial role in the optimization of water allocation and the enhancement of agricultural productivity. The manual administration of irrigation canal systems is a challenging task, often resulting in suboptimal performance. Consequently, a significant amount of water is wasted, maintenance expenses escalate, and farmers are constrained by inflexible irrigation schedules. The automation of irrigation canals is crucial for reducing water losses attributed to human errors and holds significant implications for the global economy and agriculture. This thesis seeks to develop a control algorithm for irrigation canals within a simulated environment. The methodology of controlling the downstream water depths of irrigation canals is extensively analyzed. By utilizing a combination of well established literature and specialized simulation tools, the underlying physics of open channel flow are explored. The choice of simplified models for control purposes is investigated by employing the tools of linear dynamical systems theory. A centralized MPC controller is developed to handle water depth setpoint changes and gravity offtake disturbances. Finally, the proposed controller is tested on a simulated version of the Corning Canal in California, USA, which serves as Test Case 2 according to the benchmarks set by ASCE for developing canal control algorithms. The results of the benchmark are discussed and the performance of the proposed controller is evaluated.

Keywords

Automatic Control, Irrigation Canals, Open Channel Flow Simulation, Canal ControlOriented Models, System Linearization, Model Predictive Control, Control of Spatially Distributed Systems, Optimal Control

RANDOM VIBRATION RESPONSE BASED ROBUST STRUCTURAL HEALTH MONITORING ON A COMPOSITE WING-SHAPED STRUCTURE VIA MULTIPLE MODEL METHODS

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ABSTRACT

Composite materials are being increasingly integrated into industrial applications, particularly within aerostructures, due to their outstanding mechanical properties and light weight. The issue of early damage diagnosis is important for them as damage growth may lead to unpredictable consequences. In this context, random vibration based SHM has gained considerable importance as it may operate under normal structural operation and naturally provided excitation. Yet, a main problem that has, thus far, inhibited wide adoption is its sensitivity to Environmental and Operating Conditions (EOCs). This study aims at systematically addressing this problem for a lightweight wing-shaped composite structure subject to three types of early damage scenarios: Delamination, interface debonding, and through-the-thickness indentation. The study is based on a Finite Element based simulation model under random force excitation, with the operating temperature varying within the [-10,+20]°C range. This variation affects both the material elastic properties and damping, thus rendering early damage detection challenging. Delamination and through-the-thickness indentation are modeled via layer stiffness degradation, while interface debonding is modeled by adding extra zero-stiffness and low-height layers. The considered damages are of two distinct severities: 'Low' affecting a small area (0.8% of the structure), and 'High' affecting a larger area (1.6% of the structure). Three robust data-based SHM methods, all utilizing single-train-response signals, are employed. They are all founded upon the Multiple Model (MM) concept and include the Power Spectral Density (MM-PSD method), the AutoRegressive parameter vector (MM-AR method), and a Principal Component Analysis transformed and reduced version (MM-PCA-AR method). The study is comprehensive, based on hundreds of

Monte Carlo simulations under numerous temperatures. Various aspects of the methods are systematically examined, such as the number of Training Experiments and SHM performance under operating temperatures different from those used in the training. Damage detection is found to be quite good even for ‘Low-level’ damage scenarios, reaching a very high (96.1%) True Positive Rate for a low (5%) False Positive Rate for the MM-AR and MM-PCA-AR methods. The performance for damage characterization is also very good, reaching an overall accuracy of 86.8% for the MM-AR method.

Keywords

Robust SHM, vibration based SHM, composite structures, multiple models, temperature uncertainty

SIMULATION AND DEVELOPMENT OF A SOFT PNEUMATIC ROBOTIC FINGER WITH VARIABLE STIFFNESS

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ABSTRACT

In this thesis, a soft pneumatic robotic finger, that has the ability to change its stiffness is going to be simulated and later developed. This process begins with an extensive literature review, that leads to a methodical design process. A proposal for the soft finger emerges and a detailed design process ensues, where every dimension is defined along with choosing the materials and fabrication methods for the creation of a prototype. Using these details, the simulation is performed in finite element method software, that yields promising results. Based on these findings, the soft pneumatic finger is considered a successful design. The prototype is created in two stages, first as a test soft finger with limited functionality and later as the designed soft finger. The fabrication takes place using soft silicone poured in 3D-printed molds. The fabricated soft finger is put through a series of experiments to test the range of motion, the stiffening abilities, and the sensing capabilities of an integrated sensor in the fingertip. These results are later compared to the simulation results and conclusions are drawn on the accuracy of the simulated models. Future work could include the creation of a gripper using the proposed soft finger and more importantly the development of software control for the finger.

Keywords

Soft robots, Pneumatic finger, Granular jamming, Variable stiffness, Simulation

DESIGN OF A MAGNETORHEOLOGICAL FLUID CLUTCH

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ABSTRACT

Clutches are the machine elements which connect the engine of a system with the rest of the system. During the engagement, the driving disc or discs transfer the power of the engine to the driven disc through the torque. A Magnetorheological Fluid Clutch utilizes magnetorheological fluid to achieve the engagement and the torque transfer. Magnetorheological fluids are liquids in which ferromagnetic particles are immersed. When the fluids are placed within a magnetic field the particles form chains in the direction of the field, drastically changing the properties of the fluid. The biggest change has to do with the yield stress. These fluids flow after a certain yield stress has been exceeded, thus increasing the shear stress they exert. The flow model for these smart fluids is Bingham's model. A MRF clutch creates an external magnetic field in order to stimulate the MRF. In this diploma thesis, a magnetorheological clutch in various geometric configurations and input currents has been investigated. Initially the magnetic problem was solved using ANSYS Magnetostatic software. Then after the magnetic field was known, it was used to find the yield stress. Finally fluid flow problem was solved using ANSYS Fluent. The shear stress of the MRF used to calculate the torque the clutch can transfer. Then the Torque Current curves are made for every configuration. Moreover, Torque Radius curves were made in order to determine the best configuration. Finally, it was calculated the power consumption for each configuration. In conclusion, the MRF clutches can controllably transfer large amount of torque.

Keywords

Magnetorheological Fluid Clutch, Yield Stress, Transferred Torque, Bingham Model, Magnetorheological Fluid

DAMAGE DIAGNOSIS IN FLOATING WIND TURBINES BASED ON ADVANCED AL & ML METHODS AND MEASUREMENTS OF VIBRATION SIGNALS UNDER VARYING OPERATING CONDITIONS

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ABSTRACT

The escalating development of offshore wind turbines requires stringent strategies for monitoring and maintenance to ensure their successful and uninterrupted operation. Structural Health Monitoring (SHM) of floating wind turbines, including damage detection processes, constitutes a complex and multidimensional problem due to their positioning in dynamic marine environments with varying operating conditions, which often obscure or ''mask'' the influence of emerging faults, further complicating the process. To achieve this goal, robust machine learning methods are invoked, focusing on their ability to overcome these challenges and address the specific problem, while simultaneously presenting an attractive approach due to their low cost and automation for remote monitoring, compared to alternative methods that require on-site inspection by experienced personnel.

In a similar context, this study focuses on damage detection in the mooring system (chain) of the semisubmersible floating offshore wind turbine 5MW CSC Floating Offshore Wind Turbine (FOWT) using vibration signals, under varying operating conditions of wind speed and wave height, while also emphasizing the number of sensors and training experiments. The methods employed are based on advanced neural networks (NN) as well as statistical time series (STS) methods. Specifically, two separate NN architectures employing Long Short-Term Memory (LSTM) neurons are used: a supervised classification model using the SOFTMAX activation function for damage detection, referred to as S-LSTMSOFTMAX, and a semi-supervised regression model utilizing the root mean square error (RMSE) for the same purpose, denoted as SS-LSTM-RMSE. Similarly, the STS methods are based on the multiple models (MM) concept to represent the healthy dynamics of the FOWT, under various operating conditions using vector or scalar AutoRegressive (AR) models, applied in both unsupervised and semiupervised frameworks, denoted as U-MM-(V)AR and SS-MM-(V)AR, respectively. The hyperparameters of the NN based methods as well as the SS-MM-(V)AR method are selected during the training phase using the Bayesian optimization algorithm minimizing classification accuracy, while standard system identification criteria are used to determine the model order for the U-MM-(V)AR method.

Vibration signals are obtained from numerous Monte Carlo simulations using the model of the semisubmersible floating wind turbine 5MW-CSC via the SIMA workbench. The simulations encompass different wind speed excitations ranging from 7m/s to 12m/s and corresponding wave heights, while nine different damage scenarios are applied via stiffness reduction from 10% to 50%, along the FOWT's catenary line. The damage detection results reveal the remarkable performance of the MM based methods, especially U- M-(V)AR achieving a 100% True Positive Rate (TPR) for a 0% False Positive Rate (FPR) using only 9 signals for training from a single sensor. The SS-LSTM-RMSE method achieves the same performance using only one additional accelerometer and 26 signals for training, while the S- STMSOFTMAX method requires 216 signals for the same performance using two sensors. It is also noteworthy that the NN based methods are characterized by longer training times and increased computational cost, as well as greater sensitivity to hyperparameters, which jeopardizes the performance and reproducibility of the models.

Keywords

Structural health monitoring, vibration signals, statistical time series methods, neural networks, long short-term memory neurons, floating wind turbines, mooring line

DESIGN HYDROGEN FUEL CELL FOR AUTOMOTIVE APPLICATIONS

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ABSTRACT

Worldwide, the environmental disaster as well as the climate crisis are all escalating at a rapid pace leading both scientists and ordinary citizens to wonder if there is another, more sustainable and at the same time efficient alternative. With the above as motivation, this diploma thesis suggests that such solution exists and is offered through green hydrogen. Thus, by presenting that the use of renewable energy sources is not a remedy for all evils, it is underlined that necessary connecting link to make R.E.S. manageable and efficient is the production of green pure hydrogen, through them. Hydrogen is already used by various industrial branches due to the extremely rare properties it offers, with the scientific community classifying it will be as one of the main energy carriers in the future. Fuel cells (FCs) are among the key technologies that Europe will need to rely on in order to comply with the latest environmental targets inspired by decarbonisation and the circular economy. Fuel cell technology has come to the fore with the promise of cleaner, pollution-free, and more efficient energy. Assessing the advantages of using FCs for energy production compared to internal combustion engines and electrification (battery arrays) is capable and necessary to make the scientific and investment community rely towards the gradual weaning off of fossil fuels and the combination of R.E.S. to produce green hydrogen for use. In this paper, extensive reports are made on the historical path of hydrogen fuel cells, while presenting the theory of operation behind a proton exchange polymer membrane hydrogen fuel cell (P.E.M.F.C.). In addition, the technological issue investigated in this work is the differences that different types of channel geometries bring to the operation of a P.E.M. fuel cell. Thus, using software like CATIA V5 and Ansys 2023_R2, geometries of three different types were created and numerous simulations were took into consideration in order to render the appropriate qualification and to present the results for comparison in order to draw reliable conclusions.

Keywords

Green Hydrogen, Fuel Cell, Hydrogen Fuel Cell, Hydrogenokine, Ansys Simulation

A METHOD FOR DETERMINING THE LEVEL OF ASSISTANCE PROVIDED BY EXOSKELETONS IN INDUSTRIAL APPLICATIONS

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ABSTRACT

The subject of this diploma thesis is the proposal of a method to determine the level of assistance (LoA for short) an exoskeleton provides to its user in industrial applications. In the first chapter, the thesis describes the current state of art regarding common occupational injuries in industrial environments, the exoskeleton as a solution to that problem, as well as the implementation of machine learning models in exoskeleton applications. In the second chapter, the proposed approach is described, in which the LoA is estimated based on the anthropometric characteristics of the user, utilizing machine learning models. An experiment process follows, which leads to data collection regarding the effect of task characteristics on the LoA, while the third part of the approach describes the proposal of the method, which takes into account both the anthropometric characteristics of the user and the characteristics of the task they will need to carry out. The implementation of the approach is depicted in detail in the third chapter, which is the estimation of the LoA based on anthropometric data, the experiment procedure and the proposed combined method of estimating the LoA. Finally, the thesis discusses the results of the research process, while it documents the conclusions drawn at the end of it, as well as suggestions for further scientific work.

Keywords

Exoskeletons, level of assistance, user-acceptance study

SIMULATION, FABRICATION AND PROGRAMMING OF A LOW-COST QUADRUPED ROBOT

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ABSTRACT

In the last decade, there have been major advancements in the area of quadruped robots and the Open-Source community has contributed tremendously towards this direction. Inspired by the groundbreaking work of Maurice Rahme on Github, this thesis presents a low-cost opensource quadruped robot development, the OpenQuadruped/SpotMiniMini. SpotMiniMini features a fully 3D printed frame, 12 brushless servo motors that drive four 3-DOF legs. Its unique leg design allows for the lower leg actuator, commonly located at the knee joint, to be positioned at the level of the hip joint by transferring motion through a 3D printed pulley and a driving belt. The robot's onboard computer is a Raspeberry Pi 4B that runs as its operating system an Ubuntu 20.04 LTS headless server. The quadruped's software is built inside a ROS Noetic environment. This framework establishes a communication infrastructure that integrates the RPi with a Teensy 4.0 microcontroller for the low-level control of the robot's servos. The latter is possible through serial UART communication protocol. Moreover, the robot has an IMU gyroscope sensor that provides data for orientation sensing and can receive joystick commands from a wireless gamepad connected to the RPi. A lithium battery powers a PCB that distributes it to all the hardware components of the robot. Finally, the Quadruped uses a D^2-Randomized Gait Modulation method with Bezier Curves for foot trajectories generation.

Keywords

Open-Source, Low-cost, Robot, Quadruped, ROS

ON THE COMPLEXITY QUANTIFICATION OF INDUSTRY 4.0 MANUFACTURING SYSTEM USING THE INFORMATION THEORY AND SHANNON'S ENTROPY

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ABSTRACT

The quantification of complexity in manufacturing systems has been a challenge since the integration of Information Technologies (IT) in industry. Over the last decades, the transition from the traditional manufacturing system to the manufacturing paradigm of Industry 4.0, with the integration of the Internet of Things (IoT), Big Data and emerging technologies along with the concept of mass customization, has led to the development of Cyber Physical Systems (CPS) and Product Service Systems (PSS). Due to the multidimensionality of the modern manufacturing systems, complexity is constantly increasing, having become even more challenging to measure. At the same time, the quantification of complexity and the performance evaluation of a company's manufacturing system lifecycle are very important for competitiveness, cost effectiveness and business performance. Using the Information Theory and Shannon's entropy is a way to quantify complexity of Industry 4.0 paradigm and approach the optimum communication between the different departments that comprise the manufacturing system. Hence, this thesis examines and analyses existing methodologies for the quantification of complexity and seeks to provide effective criteria for validating complexity formulae, in terms of performance and adequacy.

Keywords

Information Theory, Shannon's Entropy, Manufacturing System, Complexity, Industry 4.0, Product Service System.

REMAINING USEFUL LIFE ESTIMATION (RULE) FOR ROLLING BEARINGS VIA RANDOM VIBRATION SIGNALS AND A FUNCTIONAL MODEL BASED METHOD

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ABSTRACT

In the present thesis, a study on the estimation of the remaining useful life of a bearing on a shaft via vibration signals and a statistical time series method based on Functionally Pooled (FP) models has been conducted. The double -row bearing, designated "Rexnord ZA-2115," has been subjected to a radial load of 27 (kN) under normal operating conditions over a period of 7 days, from February 12 to February 19, 2004. The employed data have been based on acquired signals from an accelerometer mounted on the bearing housing, which recorded at a sampling frequency of Fs = 20 kHz. A total of 984 signals have been available and divided into 4 batches corresponding to 4 simulated experiments/artificial life cycles, each consisting of 246 signals and corresponding to different total operating hours. This division of signals aims at investigating the potential for estimating the remaining life across different total operating time ranges of the bearing, particularly in cases where it approaches the end of its useful life more rapidly. The objectives of this thesis are the proper formulation of a method based on FP models for the effective and comprehensive modeling of the bearing's dynamics throughout its lifetime and, through this, the accurate estimation of the remaining useful life for all different life cycles, using a minimal amount of data for the method's training. Specifically, the methodology followed was based on Functionally Pooled Autoregressive (FP-AR) models of order na = 91 with a functional basis of dimension p = 6, which successfully represented the bearing's dynamics as confirmed by model residual checks and spectral comparisons. The estimation of the bearing's remaining life commences when the system enters a degraded state, detected through a statistical test based on the acceleration spectrum. The detection of degradation is achieved timely, specifically before half of the total life span, and the estimation of remaining life through the method based on Functionally Pooled models is excellent, deviating by only 0.5% from the actual remaining lifetime, using just 82 signals for its training. The superiority of the proposed method over existing literature is confirmed through comparisons with the Wiener degradation model based on frequency and time domain features, which fail to adequately describe the bearing's dynamics throughout its operation time. The Wiener model's best performance shows a 1.1% deviation from the actual remaining lifetime, which is surpassed by the excellent 0.5% achieved by the proposed method. Finally, the results of this work confirm the applicability of the proposed method for prognostics in bearings, thereby supporting the direction of predictive maintenance, which implies fewer undesirable operational interruptions and, consequently, red uced costs.

Keywords

Remaining Useful Life Estimation, Vibration Signals, Functionally Pooled Models, Statistical Degradation Models, Predictive Maintenance

DAMAGE DETECTION IN A POPULATION OF SIMILAR COMPOSITE BEAMS USING STOCHASTIC METHODS

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ABSTRACT

The present work aims at damage diagnosis including the detection, location and size characterization, in a population of nominally identical beams made of composite materials through advanced vibration based stochastic methods. For this purpose, the characteristics of each beam (geometry, materials), which typically represents a part of an aircraft structure, are simulated using a finite element model in ANSYS software. The manufacturing uncertainty due to the use of composite materials is geometrically simulated by varying the beam thickness (±20% range of variation from the nominal thickness), while the operating conditions during flight are simulated by turbulence-like excitation, including the effects of excitation arising from rotating components. The examined damages of through-the-thickness cracks with a width of 1 mm are geometrically (material removal) implemented in two different positions, and for each location, three different sizes are considered (0.6%, 2%, 3.3% of length). These specific damage sizes result in small variations in the healthy dynamic characteristics, which are significantly overlapped when examined under the manufacturing uncertainty present in the dynamic characteristics of the examined population, posing a challenge for their robust diagnosis in this work. Additionally, the excitation conditions are considered non-measurable, leading to the exclusive use of response signals for estimating the Transmittance Function, which is used as a characteristic quantity in diagnosis to eliminate the effects of the excitation. Specifically, the estimation and dynamic identification are carried out with nonparametric (Welch) and parametric models (ARX-OLS, IV). The full or reduced, via Principal Component Analysis (PCA), model parameter vectors are used in diagnosis within a Multiple Models framework, which ensures robustness to manufacturing uncertainty. The evaluation and comparison of the two estimators regarding diagnosis are performed through 114 Monte Carlo simulations and several rotations of the training set to ensure the statistical reliability of the findings. Finally, the detection results are presented using ROC curves, demonstrating excellent performance for both estimators (100% correct detection rate for all damages at 0% false alarms rate). The results of location and size classification are presented using Confusion Matrices, which are judged very well in terms of accuracy, for both location (82.9% for ARXOLS, 82.5% for IV) and size (72.6% for ARX-OLS, 73.8% for IV) classification of the damages.

Keywords

Population-based damage diagnosis, composite structures, vibration signals, Transmittance Function, Statistical Time Series Methods, detection, location and size classification

THEORETICAL INVESTIGATION AND MODELLING OF ADDITIVE MANUFACTURING PROCESS USING SURROGATE MODELS

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ABSTRACT

The advent of Industry 4.0 has introduced a transformative era in manufacturing, characterized by the pervasive integration of digitalization and automation. This paradigm shift has fundamentally reshaped the landscape of product creation. Key technological advancements, such as machine learning, data analytics, robotics, and additive manufacturing (AM), offer substantial enhancements to industrial processes by reducing the dependence on human labor, decisionmaking, and avoiding the occurrence of human errors. Specifically in the AM sector, a critical tool is the concept of Surrogate Models (SMs). These SMs serve as simplified approximations of original models and have found widespread application across various facets of AM, including process optimization, material selection, print defect prediction, temperature forecasting and monitoring, among others. Av advantage of employing SMs lies in their ability to reduce the computational burden associated with running simulations or experiments for each iteration of design or parameter adjustment. This cost-effective approach is instrumental in enhancing both the effectiveness and efficiency of manufacturing processes. As the sophistication and quality of 3Dprinted products continue to advance, the role of SMs becomes increasingly pivotal. In this context, the objective of the current Diploma Thesis is to introduce the innovative concept of a Spatiotemporal Surrogate Model (ST-SM) applied to a specific manufacturing process—the Laser Powder Bed Fusion (LPBF) process. The aim is to approximate the temperature at different spatial points (nodes) over time within the material part, utilizing a Finite Element Analysis (FEA) model and compare Finite Element Method (FEM) and SM output. The initial step involves the creation of a simplified FEA model, mimicking a small portion of the material being directly heated by the laser during the LPBF process. Subsequently, the simulation of the LPBF process is conducted to calculate the temperature profile at the selected nodes. Following this simulation, the ST-SM is meticulously constructed and validated. This ST-SM has the potential to enhance manufacturing by enabling the monitoring of nodes’ temperature profiles. Except for predicting the nodes’ temperatures, the ST-SM is also used for process control and defect detection within the part. Manufacturers can directly intervene in process parameters, such as adjusting laser power or ambient temperature, with precise insights provided by the ST-SM. Subsequently, manufacturers could gain control over material's mechanical properties. This control translates to enhanced functionality and dependability of the final product, underlining the importance of this innovative approach in the ever-evolving landscape of advanced manufacturing processes.

Keywords

Industry 4.0, Additive Manufacturing, Spatiotemporal Surrogate Model, LPBF, Finite Element Analysis

DIVISION OF ENERGY, AERONAUTICS AND ENVIRONMENT (FEBRUARY 2024)

COMPUTATIONAL INVESTIGATION OF THE EFFECT OF CORUGATED INSERTS ON THE FLOW AND THERMAL FIELD OF A PIPE OF RECTANGULAR CROSS-SECTION AND CONSTANT WALL TEMPERATURE, FOR THREE DIFFERENT MORPHOLOGIES, IN TURBULENT FLOW

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ABSTRACT

In the present research, the effect of wavy additions on the flow and thermal field of a pipeline, which has a rectangular cross-section and a constant temperature on the walls, is studied. Specifically, this effect is investigated for three different morphologies of the wavy surfaces and for Reynolds numbers 5000, 10000, 15000 and 20000. The aim of the study is to enhance the heat transmission along the pipeline. The computational investigation is based on Computational Fluid Dynamics (CFD) and is carried out using Ansys Fluent software.

First, a theoretical introduction to the concepts related to the research is carried out. In particular, reference is made to fluid properties and flow characteristics. In addition, duct flow is described, emphasizing turbulent flow, roughness, pressure losses, friction coefficient, and secondary flows. Next, an analysis is made on the characteristics of the disturbance and the disturbance models are presented. Afterwards, an analysis is performed on forced convection and heat transfer enhancement with wavy surfaces. Also, regarding the theoretical model, an introduction to computational fluid dynamics is conducted and the modelling process in Fluent is described. Then, the geometry of the problem models is defined and designed, and the computational meshes are constructed. Immediately after, the k – ε Realizable disturbance model is chosen to solve the problem. Next, the water inlet temperature of 300 K and the wall temperature of 353 K are set.

Then the simulations of the three models and the simple pipeline are carried out, through the Ansys Fluent software. Results concerning mean temperature, heat transfer function, friction coefficient and Nusselt number are conducted and listed. Finally, the conclusions of the present research are presented, according to which model one, which has the largest wavy surfaces, enhances heat transmission more.

Keywords

Corrugated surfaces, Turbulent flows, Heat transfer enhancements, Computational fluid dynamics simulation, k-e turbulence model

COMPUTATIONAL INVESTIGATION OF THE FLOW AND MIXING FIELD CHARACTERICSTICS DOWNSTREAM ANOVEL CONFIGURATION, SUITABLE FOR THE AERODYNAMIC STABILIZATION OF STRATIFIED GASEOUS FLAMES

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ABSTRACT

The present thesis studies an experimental prototype installation with the use of a computational program in order to discover the characteristics of the air fuel mixture and the flow field created in the installation. The prototype was designed and created in the laboratory of Technical Thermodynamics and Applications of Statistical Engineering of the University of Patras. The installation and the working conditions were digitally simulated with the use of the program Ansys Fluent. In the beginning of this thesis a theoretical background of the phenomenon of combustion is given. It is followed by a presentation of the solving program and the basic models and equations that were used. Then the data from the installation of aerodynamic stabilization of layered flames of air-fuel mixture are presented (mixture air-ropane). After the parameters and the correct initial conditions are set up, the solving equations are chosen the program starts to solve the equations that describe the phenomenon using time steps and iterations. The goal is to reach a stable solution that converges. In total six runs of the program were executed for two different fuel supply values 400 liters/hour and 500 liters/hour and three lengths of fuel injection 245, 270, 290 mm. Lastly the results of the stabilized flow are presented and commented. Those contain the airfuel ratio (Φ), the velocity profiles in x and y axis, the kinetic energy of the working fluid and the dispersion of turbulence in the flow field.

Keywords

Computational analysis, air-fuel ratio Φ, air-propane mixture, flow field

HEAT TRANSFER AND AIR CIRCULATION IN A REFRIGERATOR

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ABSTRACT

The domestic refrigerator is an electric appliance that operates continuously. So, energy consumption reduction is critical in order to achieve the desirable economy. In the effort to protect the environment the energy consumption of appliances should also meet certain standards which are different in every country. The domestic refrigerator should preserve the quality of stored products with the minimum amount of energy consumption. In order to keep the energy consumption as low as possible the compressor runtime should be decreased. The compressor switches to an off state when the temperature inside the refrigerator reaches a certain value. It is critical to predict the temperature field inside the refrigerator. In this study CFD simulation was conducted for a simplified model of a forced convection domestic refrigerator. The software Ansys Fluent v 23.2 student version is used for the simulation of our cases.

In order to find out the most efficient setup for the fan flow rate and evaporator location inside the refrigerator four cases with the same initial conditions are studied. In the first case the evaporator is located at the back vertical wall of the refrigerator and the fan has a flow rate of 72 m^3/h. In the second case a fan with a flow rate of 94 m^3/h is used. In the third case with the same fan the evaporator is separated into two parts, one horizontal with 0.2 m length and one vertical with 0.4m length. In the fourth case the length of the horizontal part is increased at 0.4m and the length of the vertical part of the evaporator is reduced at 0.2 m. The average temperature of the air inside the refrigerator and the temperature of the stored products are compared for all the four cases.

Keywords

Forced convection, domestic refrigerator, CFD analysis, heat transfer, air circulation.

EXPERIMENTAL INVESTIGATION OF THE NON-REACTING TURBALENT FLOW FIELD DOWNSTREAM A CONFIGURATION SUITABLE FOR THE AERODYNAMIC STABILIZATION OF STRATIFIED GASEOUS FLAMES

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ABSTRACT

In this student research project the experimental setup and measurement methodologies for the study of the isothermal flow field downstream of a high velocity ratio coaxial flow configuration, using Particle Imaging Velocimetry (PIV) are presented. This particular aerodynamic stabilization facility, of stratified flames, was developed at the Laboratory of Thermodynamics and Statistical Applications, University of Patras. Initially, the PIV methodology is presented and a brief history of its more general uses in science is given. Then, a brief presentation of combustion theory is provided. Moreover, the turbulent flow characteristics and the turbulent energy scales together with the basic theory of coaxial flows with or without recirculation are discussed. In addition, the experimental setup used and the means by which the results of the experiment were obtained are presented. Finally, the methodology and analysis of the uncertainties associated with the specific velocity field measurement methodology is also provided. Lastly, the results of the experiment related to the velocity profiles, turbulence intensity and the uncertainty of the PIV method are derived.

Keywords

Isothermal flow field, recirculation, PIV, coaxial flow, turbulence

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING VENTS WITH GRILLES OF DIFFERENT CONFIGURATIONS

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ABSTRACT

In this thesis, the aim is to study the air flow through grilles in a room of specific dimensions, in order to calculate and evaluate their characteristic variables. These are related to the velocity distribution, rise,throw, drop, spread and the pressure drop of the air beam. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (V_c = 10 m/s). The region of interest is where a person feels comfortable in room conditions, which in this study was defined as the one with air velocity of 0.5 m/s. The turbulence model used to predict the region is the Realizable k-ε. Among other things, the turbulence models, discretization methods and algorithms for solving the equations are presented. Grilles of different types of design and use were tested and compared. The grilles to be studied were designed in SOLIDWORKS, while the computational investigation and visualization of the results were performed with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was performed by a colleague, which is not included in this study.

Keywords

Grilles, Air beam, Comfort, Finite elements, Computational fluid dynamics

ANALYTICAL SOLUTION FOR SQUARE CAVITY FLOW

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ABSTRACT

Solving the equations via analytical methods is a difficult endeavor, due to the complexity of the nonlinear partial differential equations of the system. In this thesis, a method for the analytical solution of the Navier - Stokes equations is presented, adapting techniques used in numerical methods. In particular, the Implicit Potential (IPOT) method is applied for the coupling between velocity and pressure. The main feature of this method is that it provides an explicit expression for the pressure, which is obtained through an iterative procedure. The main objective of this Thesis is to express the solution as a Fourier series expansion and calculate the involved sums with the desired accuracy. First, the algorithm for solving the equations using the method is presented in detail and applied to the lid driven square cavity flow problem. Then, the final equations are implemented computationally to obtain results, and appropriate plots of the velocity components are generated, in order to compare the data obtained from different programming languages, as well as with the results obtained from the numerical computational solution of the problem. Finally, a convergence study of the velocities is carried out and cases are examined to achieve faster convergence.

Keywords

Navier – Stokes equations, Analytical Solution, 2-dimensional flow, Lid driven square cavity, Convergence

PROCEDURE FOR LAUNCHING AND INTRODUCING A SPACECRAFT INTO ORBIT

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ABSTRACT

The process of designing spacecraft launch procedures is of utmost importance to ensure the success and safety of space missions. This meticulous planning and development plays a key role in orchestrating the complex sequence of events that lead to a successful launch. This Diploma thesis presents the theoretical background of the entire process of determining the parameters of a launch, the factors that influence it and the calculations that take place in this regard. The presented design and calculation procedures are also used in a series of case studies.

Keywords

Spacecraft Launch, Launch Window, Launch Timing, Launch Field

EXPERIMENTAL INVESTIGATION OF THE FORMATION AND DEVELOPMENT CHARACTERISTICS OF A FIRE WHIRL ON A POOL FIRE

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ABSTRACT

Fire whirls are a rare but potentially destructive type of fire; actually, they are buoyant flames that swirl, under appropriate flow conditions. They can occur artificially on a small scale in a laboratory for study, or naturally in large fires in forest or urban environments. The creation of fire whirls requires the existence of an organized source of angular momentum, which imparts high angular velocity to the air entering the flame's plume. In fire whirls, is observed that the flame length is much longer than in a typical flame. The fire through the eddies after its lift can be carried quite far from the place where it was created, so new outbreaks can occur, and the spread of the phenomenon is rapid and unpredictable. In addition, fire whirls are found to have a higher rate of heat release from their core and a higher rate of combustion. In order to understand the phenomenon, many studies are being carried out, several of which have led to excellent findings on its behavior and conditions of development.

In this paper we investigate experimentally whether a fire whirl is developed in a pool fire and its behavior under various flow conditions, while in cases where it is developed, we measure the height of the flame. We first extensively discuss the theoretical background of pool fires and the fire whirls and report important studies of the phenomenon and their conclusions. We then present the experimental setup in which we varied the flow conditions and created pool flames by burning propane, in order to find the formation conditions of fire whirls. The quotation and commentary of the experimental results follow the analysis of the experimental procedure. The imposition of specific flow conditions is achieved by controlling three key parameters of our experiment, these are: the rotation speed of the experimental setup frame, the fuel flow rate, and the burner diameter. Changing the frame rotation speed, i.e., the angular momentum introduced into the flame plume, causes a change in the flow circulation. Changing the burner diameter and fuel flow rate leads to a change in flame loading. Diagrams

showing our experimental measurements help us draw conclusions about the connection between the height of the fire whirl and these parameters.

Keywords

Fire whirl, pool fires, flow circulation, flame load, angular momentum

DIFFRACTED FIELD AROUND AN ABSORBING RIGHT-ANGLED WEDGE

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ABSTRACT

The present diploma thesis focuses on the study of the acoustic diffracted field generated around a right-angled absorbing wedge, due to plane wave propagation. Within the framework of the study, an existing approximate solution describing the diffracted field around a reflective wedge is modified in order to generalize it for the case of an absorbing wedge. Chapter 2 summarizes the fundamental mathematical concepts for the description of the problem. First, Helmholtz's equation is formulated in cylindrical coordinate system. Afterwards, a contour integral representation of the solution is obtained. Thereafter, boundary conditions describing reflective, soft, and absorbing wedges are analyzed, and the analytical solution of the problem for the first two types of boundary conditions is also presented. In Chapter 3, literature data regarding sound-absorbing materials and the macroscopic physical properties governing them are presented, while in Chapter 4 acoustic parameters, such as acoustic impedance, are described. In Chapter 5, empirical models for predicting the acoustic properties of porous sound-absorbing materials through their macroscopic properties are described, which will be used later in the thesis. In addition, Chapter 6, discusses the acoustic properties of melamine foam. In Chapter 7, the new approximate solution regarding the diffracted field around a right- angled absorbing wedge is developed. The proposed solution is based on an existing solution for rigid surfaces, which is modified to be applicable for absorptive wedges by multiplying the terms of the solution by appropriate reflection coefficients. These coefficients depend on the acoustic conductivity of the wedge material and on angles of incidence on the wedge surface, which depend on the relative angular positions of the source and receiver and are different for different combinations of source-receiver angular positions. The results of the proposed solution are compared with the exact Hewett-Morris solution, as well as with two approximate solutions described in Chapter 8. In Chapter 9 the results between the new approximate solution and the existing ones are compared for different acoustic impedance cases. In particular, a dependence of the error on the ratio of the frequency to the material's flow resistivity and on the acoustic distance was observed. Then, in Chapter 10, the processing times of the methods are gathered and commented on, from which the speed of the new solution is distinguished. n Chapter 11, the extension of the new approximate solution is proposed for the case of spherical wave propagation and random internal wedge angle ($2\Omega<180^o$). In particular, the extension of the approximate solution is implemented by modifying the coefficients by which the solution terms are multiplied. In this section, comparisons with experimental data and with the Nord2000 approximate solution are implemented. The proposed solution compares well with both the approximate Nord2000 solution and the experimental data. The new solution is distinguished for its underlying speed. It has the ability to describe plane as well as spherical waves, different wedge angles and is valid for any source-receiver configuration. Finally, it is valid for receiver positions close to the shadow boundary.

Keywords

Acoustic diffracted field, absorbing wedge, plane wave propagation, reflection coefficients, approximate solution.

EXPERIMENTAL INVESTIGATION OF THE REACTING FIELD IN A PRIMARY STABILIZATION ZONE UNDER THE IMPACT OF A SWIRL-INDUCED RECIRCULATION

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ABSTRACT

In recent years, the need to reduce exhaust emissions, one of the primary factors of the greenhouse effect, has become apparent. One of the most important problems we face is the continuous increase in energy needs worldwide, which pushes the use of electric or renewable energy sources, hybrid systems or innovative combustion technologies with low emission production. The present power generation systems are using solid fuel. In such systems a reduction in pollutants can be achieved by replacing solid fuels with natural gas. One of the key questions that arises is whether these systems can function properly. Based on this question, a burner was developed which aims to improve the efficiency and stability of combustion. In particular, this work investigates the interaction of an axisymmetric, stabilized, on a solid body, primary combustion zone, which operates under conditions of a stratified mixture, with a secondary cam, coaxial, swirling ring-shaped air stream. The burner consists of two cavities which are formed by three concentric and axially symmetrical discs. The centers of the discs are connected along their axis with a tube, from which gas is injected into the first cavity through an annular notch to the second disk. The second cavity helps to enhance the mixing of the fuel/air mixture and supplies the area of flame stabilization, which is located on the other side of the stabilizing disc. The area of flame stabilization is surrounded by a coaxial turbulent flow and a confluent external ring-shaped stream of air. This configuration leads to the creation of two successive recirculation zones, which interact aerodynamically with each other. One initial recirculation zone above the flame stabilizing disc and a second Central Toroidal Recirculation Zone [CTRZ] which is located above the first. This is caused by the introduction of turbulence and is responsible for the further mixing of the main products of combustion. The novelty of this device is in the location of the turbulence intake, located in the area of the exhaust gases, and not in the area of the anchoring of the flame, which is the usual one. The experimental investigation of this system is divided into three sections, in the study of the isothermal field, the mixing field and the reactive field. This study began from the simplest cases, and gradually proceeded to the introduction of turbulence and then the external air regulating current. Also, the study of the reactive field was done for two cases, lean and rich mixture.

Keywords

Turbulent natural gas flames, swirl burner, recirculation, CH* and OH*, chemiluminescence

COMPUTATIONAL INVESTIGATION OF THE EFFECT OF A VORTEX GENERGATOR OF LONGITUDINAL FLAT BLADE TYPE, ON THE FLOW AND THE THERMAL FLOWFIELD OF A PIPE OF RECTANGULAR CROSS-SECTION AND CONSTANT WALL TEMPERATURE, FOR DIFFERENT ASPECT RATIO OF THE PIPE'S CROSS SECTION AND THE WIDTH OF THE BLADE, IN TURBULENT FLOW

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ABSTRACT

Vortex generators are proposed as an effective technique for enhancing heat transfer. In this study, the effect of a longitudinal-type vortex generator on the flow and thermal field of a rectangular duct is examined. The analysis was conducted for six different cases with various dimensions of the duct's cross-section and the ramp width, including aspect ratios of the crosssectional dimensions (height/width) of 3/2, 2/2, 1/2, and aspect ratios of the ramp width to duct width of 0.1 and 0.05.

Initially, fundamental theoretical knowledge in fluid mechanics and heat transfer necessary for the reader's understanding is presented. Additionally, an introduction to computational fluid dynamics through ANSYS FLUENT is provided, in which the computational simulations are conducted.

In the main part of the work, the geometry under investigation is constructed, with the ramp forming a 30° angle with the duct, and the discretization is applied. The optimal number of computational elements required is investigated. The k-ε Realizable turbulence model is selected for the solution, and boundary conditions are defined.

Subsequently, the simulation is performed, and the work is completed when the convergence criteria are met. Regarding the results, it is observed that when the ramp is sufficiently thin relative to the duct width (aspect ratio of 0.05), the best results are achieved with an 7% increase in the Nu number with minor friction losses (a 5% increase in losses).

Keywords

Vortex Generators, Heat Transfer Enhancement, Turbulent flows, CFD simulations

EARTH TO AIR HEAT EXCHANGERS: CONTRIBUTION OF THE SYSTEM TO THE COOLING LOAD REDUCTION IN THE BUILT ENVIRONMENT

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ABSTRACT

At a time when the population is growing and life expectancy is increasing, energy needs are multiplying exponentially. Combined with harmful exhaust emissions and rapid climate change, this is an unprecedented energy crisis, which is being addressed by energy-saving measures in many sectors. Energy-efficient buildings play an important role in this effort, as innovative designs and new technologies significantly reduce the energy consumed for heating and air conditioning of indoor spaces. Buildings are the places where people spend most of their lives, and are therefore responsible for at least a large part of the energy consumed worldwide. In the context of energy planning, the use of ground for heating and cooling buildings plays an important role. Whether by direct or indirect methods, such as underground buildings and earth-to-air heat exchangers (EAHE) respectively, the heat capacity and physical properties of ground ensure a comfortable climate for the occupants and a less costly energy system compared to conventional heating/cooling (air-conditioning) methods. In this outline, the use of ground for cooling buildings will be described in detail, in particular by the methods of underground buildings and EAHE. Further, various models that have been developed to calculate and predict the performance of EAHEs and to examine their effectiveness will be analyzed and assessed in several climatic types.

Keywords

Energy Conscious Design of Buildings, Ground Cooling, Earth-sheltered buildings, Underground Buildings, Earth-to-Air Heat Exchanger

MODELING OF A PEM FUEL CELL IN OPENFOAM

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ABSTRACT

The aim of this diploma thesis is the simulation of the fluid mechanics in the Membrane Electrode Assembly (MEA) of a hydrogen proton exchange membrane fuel cell, using the opensource software, OpenFoam. The present study breaks down the installation of the MEA in discrete solid and fluid components, and examines the fluid dynamics and thermal effects in a simplified model of the MEA, which includes the bipolar plates, the gas flow channels and the gas diffusion layers. The discretization method and numerical analysis of the model are achieved through the standard libraries and solvers of the open-source, C++ based, CFD toolbox, OpenFoam. Due to the symmetric shape of the configuration, we can use a half of the geometry in question, in order to reduce the total computational cost while allowing for a denser mesh in areas with large gradients. This thesis describes the process of creating the OpenFoam case, starting with the geometry and mesh generation, proceeding to the mathematical and computational modeling and lastly presenting the results of the simulation.

Keywords

Proton exchange membrane fuel cell, hydrogen, computational fluid dynamics (CFD), thermal analysis, OpenFoam

STUDY OF THE ACOUSTIC FIELD IN THE ANCIET THEATER OF EPIDAURUS

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ABSTRACT

In the present thesis, the acoustic field in the ancient theatre of Epidaurus is investigated in the frequency domain, where a cross section simplified as right-angled steps is considered. The sound field at a listener consists of geometrical acoustics contributions and of the diffraction field. The geometrical acoustics contributions include the direct signal from source to receiver as well as the reflections from the source to the orchestra and/or to the back of the seats before they reach the receiver. The diffraction field is created as sound from the source reaches the edges of the steps and then the receiver. One existing semi-empirical and three approximate analytical solutions are employed for the examination of the diffracted field. Through the comparison of the proposed solutions, the computational advantage of the semi-empirical solution is observed, which is orders of magnitude faster than the approximate solutions. The diffraction field's behavior was investigated, particularly the contribution to a receiver from the upper and lower steps. For the height of the standing actor it is observed that the strongest contribution always comes from the second upper step, while the origin of the weakest contribution can be found in both upper and lower diffractions. Additionally, the impact of proximity to shadow boundaries is investigated, while the use of a recently presented parameter is extended from the time domain to the frequency domain as a means of predicting diffraction signals based solely on geometric characteristics. Furthermore, the effect of absorbing surfaces and the impact of geometrical characteristics such as the source height, the inclination of the theater, as well as the difference in angle between the lower and upper koilon were examined. Finally, a comparison of the results of the acoustic field with existing experimental data is conducted, which reveals their good agreement.

Keywords

Diffraction, Acoustics, Ancient Greek Theatre, Frequency Domain, Source Strength

DIVISION OF MANAGEMENT AND ORGANIZATION (FEBRUARY 2024)

STUDYING THE BURNOUT EFFECT ON THE ENGINEERS' QUALITY OF LIFE

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ABSTRACT

The quality of life is very important for humans and in recent years there has been a systematic effort to improve it. A reasonable question that arises is whether and how much it is affected, among others, by burnout, which is a phenomenon that seems to intensify year by year. With the term quality of life we refer to the mental, physical and social well-being of the individual, while with the term burnout we are talking about a state of physical, mental and spiritual fatigue due to the chronic work stress experienced by each employee.

In the context of this work, an attempt is made to assess the level of quality of life and burnout of the engineers who work in Attica. Also, the effect of some basic demographic characteristics (such as gender, age, educational level, work field and job title) on the level of quality of life and burnout of engineers is studied. Moreover, engineers are grouped based on the level of burnout and their quality of life and an attempt is made to predict their quality of life from demographic factors and the dimensions of burnout.

Regarding the levels of quality of life and burnout, we observe that Engineers have medium levels of quality of life, medium levels of emotional exhaustion, low levels of depersonalization and medium levels of personal achievement.

Regarding the grouping of the participants based on their level of burnout and quality of life, we notice that three groups are created, the 1st group includes people with high level of burnout and low level of quality of life, the 2nd group includes people with medium level of burnout and quality of life, while in the 3rd group are people with lowlevel of burnout and high level of quality of life.

Finally, regarding the contribution of burnout levels to the prediction of quality-of-life dimensions, we observe that physical and mental health are negatively affected by emotional exhaustion and depersonalization and positively by personal achievements.

Social relationships are negatively affected by depersonalization and positively by personal achievement, while environmental health is negatively affected by emotional exhaustion and positively by personal achievement.

Keywords

Quality of life, burnout, motivation, demographic characteristics, survey via questionnaires

THE USE OF THE LEAN SIX SIGMA METHODOLOGY IN TELECOMMUNICATION EQUIPMENT INSTALLATION SERVICES

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ABSTRACT

In today's competitive environment, flexibility and adaptation to the circumstances are essential elements for the viability of a business. It is therefore necessary to standardize and improve processes in order to gain a competitive advantage. The aim of this Diploma Thesis is to analyze and present the optimization of the processes of a Technical Department of a Telecommunications Company, by adopting the methodology Six Sigma (6σ). The study will be done through simulation in the Extendsim environment. First of all, an approach to Business Process Management will be made and then we will analyze the Lean Six Sigma method by describing the two sub-methods that constitute it and their combination. Lean thinking helps to reduce the unnecessary processes, while enhancing the efficiency of the rest. Six Sigma method helps businesses to increase their credibility through the reduction of problems with emphasis on quality. Then, the modeling processes are described by recording the steps of the simulation and the benefits that it offers. The study concerns the improvement of processes in telecommunications equipment installation services through the Six Sigma logic. At first, time results are extracted for some initial data and then, by applying the method Six Sigma a comparison is made with the new ones through several simulations. Finally, some basic conclusions are drawn from the use of the method related to the benefits from reducing time and increasing reliability for a business.

Keywords

Processes, Lean, Six Sigma, Lean Six Sigma, Modelling, Simulation, Efficiency, Quality, Time, Standard Deviation

METHODOLOGY FOR THE STRATEGIC LOCATION OF ELECTRIC VEHICLE CHARGING STATIONS

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ABSTRACT

The fast pace of recent events in the technology of electric driving, the manufacturing of electric vehicles that drives the attention of most automobile manufacturers and the global political scene, that sees older regulations being called back and newer restrictions taking effect for the evolution and establishment of green energy and EVs, has brought the need for organizing , planning and programming and strategic decision making for the preparation of infrastructure capable of supplying the needs of every electric vehicle owner. For the first few months of 2024, Europe's sales of EVs has increased by 15%, in comparison to the same number of the previous year. It is a fact that the benefits of electric driving and EVs, can only take place as long as there is a capable infrastructure (both of charging stations and the electric grid) to cover the demands. This generates the problem of planning and integrating the network of electric vehicle public charging station hubs. The strategic placement of EVCHs (Electric Vehicle Charging Stations), is the subject of this paper. Using the tools of operational research for planning a model and the computing environment of ExtendSim for the simulation and optimization of the model, this paper is going to analyze various methods of optimizing the placement of electric vehicle charging stations in a given route and by comparing the results of the process and analyzing the outcomes, will then generate the conclusions for the decision making. Every step of planning the stochastic model in the computational environment of ExtendSim is documented and explained.

Keywords

Electric Vehicles, ExtendSim, simulation, optimization, strategic placement

TECHNO-ECONOMIC ASSESSMENT OF INTERVENTIONS TO REDUCE CARBON INTENSITY IN CONTAINER SHIPS

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ABSTRACT

The area of interest of the paper is sustainable shipping,with emphasis on the design and evaluation of interventions to reduce carbon dioxide emissions. Initially, sustainable shipping is analyzed (objectives, benefits, obstacles) and the regulatory framework of the industry is examined with emphasis on the two new environmental assessment indicators CII and EEXI. Then, through secondary research, interventions aimed at reducing carbon intensity are presented and evaluated, based on five main axes of intervention (technological measures, operational measures, green fuels, alternative energy sources, regulatory framework), while the implementation of the relevant interventions is presented through twenty cases from the Greek and international reality.

In light of the above, ten green intervention alternatives on a container ship are evaluated. Each alternative is assessed against three criteria: the CII and EEXI environmental indicators and its economic viability. The overall assessment is based on weighting factors for three different approaches: an environmental, an economical and an 'intermediate' approach. The thesis presents useful conclusions on the design and evaluation of green interventions on existing ships to comply with the new regulations.

Keywords

Sustainable shipping, green shipping, green ships, reduction of emissions, carbon intensity reduction, greenhouse gases, maritime technology, marine technology, container ships, CII, EEX

ANALYSIS & DESIGN OF AN OPEN INNOVATION PLATFORM

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ABSTRACT

In this thesis we studied in detail issues of Collaborative Decision Making in Open Innovation environments, with the ultimate goal of creating a proposed decision management model. The above two methods play a decisive role in the improvement and effectiveness of an organization's decisions. Initially, in the context of open innovation, ideas are created in an environment open to incoming knowledge, but also ready for its wide dissemination externally. The knowledge material that is created externally and freely is valuable, using the method of collaborative decision-making we have created an easy way for it to enter internally and be used effectively. A catalytic role in this process is played by the proper management and assimilation of knowledge, this method is called the absorptiveness of an organization. Focusing on the concept of collaborative decision-making through an open innovation environment, we proposed a model to enable citizens to participate in public issues that directly concern them. This platform has been inspired by all the information we have collected and having taken into account all the necessary features and conditions we need. Decisions here are made within a framework where transparency, internal consistency and logical correctness prevail. After studying this thesis, we have important information in our hands, which can be the basis for creating sophisticated online Open Innovation models based on Collaborative Decision Making.

Keywords

Open Innovation, Absorptivity, System, Cooperative Decision Making, Support System

PRESENTATION, ANALYSIS AND EVALUATION OF THE USE OF ELECTRONIC BANKING SERVICES IN GREECE

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ABSTRACT

The pervasive integration of e-banking into the daily lives of individuals has resulted in a substantial transformation, largely supplanting traditional banking practices. The ability to execute transactions seamlessly at any time and from any location stands out as a pivotal competitive advantage over conventional brick-and-mortar banking services. This thesis presents the different types and the advantages and disadvantages of e-banking as well as the core assessment criteria. It focuses on the landscape of the electronic banking industry in Greece, realizing a PESTEL analysis and using the Porter's five forces framework. Thesis' basic aim is to dissect and assess customer satisfaction in relation to the services offered through a comprehensive approach, utilizing both the implementation and analysis of empirical data.

A structured online questionnaire was distributed to 216 adult participants, comprising 149 women and 67 men, all active users of e-banking services. The findings of the research reveal a prevailing level of moderate to high satisfaction among customers engaging with e-banking services. The evaluation of customer satisfaction pinpointed specific attributes that ranked highest in significance. Notably, the information aspect of e-banking applications emerged as the most influential factor, followed by considerations such as security and trust in the banking organization, the navigational experience, the visual aesthetics of applications, and the spectrum of services provided. Customer service, while still a crucial component, fell slightly lower in the hierarchy of satisfaction indicators. Contrary to expectations, age and education levels were found to be non-discriminatory factors in determining customer satisfaction. However, the study identified a significant discrepancy in satisfaction levels based on the monthly income of participants, with those possessing higher incomes exhibiting a lower level of satisfaction. This observation underscores the need for a nuanced understanding of customer satisfaction dynamics within the context of e-banking services, particularly concerning income demographics.

Keywords

E-Banking, Customer Satisfaction, PESTEL Analysis, Porter five forces analysis, Questionnaire

VALORISATION OF WOODY BIOMASS: FEASIBILITY STUDY FOR A WOOD CHIPS PRODUCTIONPLANT

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ABSTRACT

This thesis focuses on the perspective of woody biomass, emphasizing the investigation of the establishment of a woodchips production plant. Firstly, the principles of bioeconomy and the context of its development in Greece are reported, while a historical review of the use of biomass is presented and the main categories of biofuels are described.

From solid biofuels, the cases of pellets, briquettes and woodchips are presented in detail (characteristics, uses, quality standards, combustion equipment, production process), and then a comparison is made between them regarding certain properties (size, calorific value, density, packaging).

The feasibility study for the establishment of a woodchips production plant is structured in the following nine axis: market analysis (products, customers, competitors, suppliers, distribution), location of the plant, raw materials supply, mechanical equipment, organizational structure, human resources, business strategy, investment execution planning and business cost analysis. The essay concludes with an evaluation of the investment regarding two different scenarios, which differ in terms of the purchase price of raw materials, as well as with the formulation of useful conclusions about the factors affecting the viability of the plant.

Keywords

bioeconomy, biofuels, biomass, pellet, briquettes, woodchips, chipping, residual biomass, wood recycling

DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS (JUNE 2024)

NUMERICAL SIMULATION OF A THERMOPLASTIC COMPOSITE STIFFENED PANEL CONTAINING CRACK ARREST FEATURES

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ABSTRACT

In this thesis, the effectiveness of crack arrest features was tested on test subjects consisting of skin-cohesive elements-stringer. In order to find the best layout, the test parameters considered were the diameter of the mechanism and its distance from the crack initiation point. The plates used were made of composite materials consisting of a thermoplastic Low-elt PAEK matrix reinforced with carbon fibers modeled as co-consolidated plates with zero thickness cohesive elements. The methods used were the Induction Low Shear Friction Spot Riveting and the Refill Friction Stir Spot Welding.

In the first method, a rotating rivet and the plates were heated while it was inserted until the desirable depth was reached. The second method melts the plates locally using friction and then the melted material is used to refill the hole created.

The results showed a significant increase in the strength of the test subjects when loaded in tension under the optimal parameters. In some cases, the mechanisms worsened the strength under compression loading while all of them showed increased results in tension.

The second part of the thesis tested another layout under compression with an initial crack at the middle of the stringer. The results in this case also showed increased strength after the optimal mechanisms were created.

Because of the limited data and tests conducted, the verification of the effectiveness of the mechanisms is not feasible. The results however push towards further studying of these mechanisms and the use of composite materials in more applications due to their flexibility and high ratio of strength to weight.

Keywords

Polyaryletherketone, stringer, crack arrest feature, ILSFSR, RFSSW

MECHANICHAL AND THERMAL ANALYSIS OF AIRCRAFT CRYOGENIC TANK SUPPORTING STRUCTURES

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ABSTRACT

This diploma thesis entitled "Mechanical and thermal analysis of aircraft cryogenic tank supporting structures" aims to design of a double-walled, capsule-shaped cryogenic liquid hydrogen fuel tank to be placed inside the fuselage of a medium range aircraft. The design includes structural and thermal analysis of the tank, with the section of appropriate insulation, construction materials and internal supporting structure in between its two walls. The design pecifications shall be based on the total weight of the structure, the heat flux that enters the tank and the developing stresses and strains in the tank. Additionally, a computational analysis and comparison is carried out on three models of different internal support modes, and then the cryogenic liquid hydrogen tank with pretension cable supports is designed. After the first results of analysis are obtained, the design model of the tank is formulated in terms of geometry, structure and construction materials. By comparing the two simulations, the benefits and drawbacks of each tank model are identified. At the same time, alternative internal supports and insulation modes of the cryogenic tank are recommended to reduce the strength requirements and thermal intrusions respectively.

Keywords

Cryogenic tank, Internal support, Insulation, Liquid hydrogen, Mechanical analysis, Heat flow

MODELING OF A PIEZOELECTRIC DEVICE WITH AN EXTERNAL COMBINED IMPEDANCE CIRCUIT FOR A SEMI-ACTIVE TUNED MASS DAMPER

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ABSTRACT

This work analyzes the procedure followed to create simulation models of the APA- 1500L piezoelectric actuator, from Cedrat Technologies. Advances in the field of electronic systems, as well as the need to reduce energy consumption, bring to the fore efforts to recover energy from many possible sources. The structural vibrations of dynamic systems could stand as a source with a large scope for energy harvesting. Through a piezoelectric device, it is possible to achieve vibration damping in systems combined with energy recovery, which can be exploited in the operation of secondary systems.

The goal is to model a piezoelectric device that is used in a semi-active vibration suppression system. The system has shown significant potential in reducing vibrations from multiple structural modes in the low-frequency range using a small auxiliary mass. The initial analytical models are going to be compared to complex 3D models, which improve the predictions of the analytical ones. The scope of work is the detailed design of the device in 2D and 3D space, to evaluate the possible meshing methods in each case, and to integrate the electromechanical properties of the piezoelectric arrays to the device.

2D models are created using Abaqus and MATLAB software suites. Models using truss and frame elements are compared in static and dynamic simulations, using one or more elements. During the multi-element tests, meshing convergence is achieved, thus determining the number of elements necessary to have satisfactory results. The 2D models were successful in predicting the behavior of the real device in the frequency spectrum of the first eigenfrequency of the device.

3D models were prepared in Abaqus and needed a thorough study of the device's geometry, and a lot of meshing comparisons before settling for the optimal meshing technique. Results

were improved in comparison to 2D models, predicting a second resonance frequency, as measured in the experimental campaign. For these reasons, the electromechanical integration is explored using these models.

In order to obtain the piezoelectric properties of the material to use as input for the model, experimental measurements are made in the device, and the constitutive equations for the single piezoelectric layer are manipulated to express the equations of motion for multi-layer stacks. For a more realistic simulation, the stack device is modeled as multiple piezoelectric layers, electrically connected in parallel, using appropriate equation constraints.

The results, with some corrective constants used in the piezoelectric properties, are satisfactory, with the device showing behavior very close to the mechanical and electrical experimental measurements. The result is the design and verification of a model for the specialty piezoelectric device, which with some corrections in its geometry is able to be used in models with complex host structures, for predicting the device vibration control capabilities.

Keywords

Energy Harvesting, Vibration Control, Piezoelectric Dampers, Finite Element Modeling, Abaqus, MATLAB, 3D Modeling

AEROLASTIC TAILORING OF HIGH-ASPECT RATIO WINGS VIA TOW-STEERING

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ABSTRACT

Over the past several decades, composite materials have been used progressively more in the aerospace industry due to their superior performance, lightweight design and inherent 'tailorability'. Traditionally, unidirectional composites stacked to form a laminated structure are used for high performance load carrying applications. However, with the introduction of automatic fiber placing machines, it is now possible to manufacture composites with fibers that follow curved paths inside the laminae. This process is known as *tow-steering* and the resulting composites as *variable stiffness composites*.

Tow-steered composites allow for even greater flexibility in the design of structures by taking advantage of the anisotropic behavior of fiber composites to enhance performance with no additional weight penalty compared to conventional composites. However, given the highly coupled nature of aeroelastic problems, it is not obvious nor intuitive to find the optimal fiber patterns, and sophisticated computational methods and optimization algorithms are required.

In this thesis, a structural optimization framework is developed for the aeroelastic benchmark uCRM-13.5 aircraft wing. More specifically, the wing structure is represented by a Finite Element model utilizing beam and shell elements, while a medium fidelity DLM model is incorporated to model the aerodynamics. A series of optimizations are performed to evaluate the benefits of using tow-steered composites over their conventional counterparts. Static strength, buckling and flutter constraints are imposed in all optimization runs.

Initially, a mass optimization is performed on the wing, using conventional composites for the skins, in order to determine the optimum unsteered configuration. Then, tow-steering variables are introduced into the problem, resulting in a 12.5% reduction in structural mass. Subsequently, two single-objective optimizations are performed 3 on the optimum unsteered wing configuration using only the tow-steering design variables. First, the wing is optimized for stength, by maximizing the aggregated value (KS function) of the skin first-ply failure indices. A 47% reduction in the KS function was achieved in the tow-steered wing compared to the optimum unsteered configuration. Next, the wing is optimized for flutter velocity, achieving an increase of 29% in the optimized tow-steered design.

Finally, a multiobjective optimization run is conducted to explore the Pareto front between skin strength (KS function), buckling and flutter velocity in terms of the fiber steering patterns.

Keywords

Aeroelasticity, Optimization, Tow-Steering, Aeroelastic Tailoring, Variable Stiffness Composites, Flutter, u-CRM Wing

CONCEPTUAL DESIGN AND CONSTRUCTION OF A SMALL CANISTER BASED DEPLOYABLE UAV FROM COMPOSITE MATERIALS

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ABSTRACT

The term UAV (Unmanned Aerial Vehicle) covers all vehicles that fly in the air without a human pilot or passenger and are usually guided by remote control. UAVs offer some important advantages over manned aircraft in terms of performing certain specific missions. Some of these beneficial features are their ability to complete tasks quickly, efficiently and at low cost, the elimination of the need for humans to perform dangerous tasks, their revolutionary impact in the field of mapping and surveillance, and many others. In this work, our goal is to design a small UAV made of composite materials, launched from a tubular launcher. This innovative concept offers the possibility of taking off from anywhere, minimizing the take-off time, easy transportation, small occupied volume. The mission of this UAV is to participate in search and rescue operations in mountainous environments.

The first step is the preparation of a detailed study to define the general basic specifications of the aircraft. This study starts with a review of the historical evolution of UAVs, an explanation of the basic terminology, a presentation of the UAV classification categories and a description of the current state of the art in the field. A detailed description of the aircraft configuration options is also given, followed by an analysis of the Concept of Operations. Here, the mission is defined, its difficulties are highlighted and, through a market analysis, appropriate decisions are taken. This initial study concludes with a presentation of the aircraft design methodology.

The design process starts with the definition of the specific technical specifications of the mission and the calculation of the aircraft weight, wing area and engine power. The next step is the design of the wing, which includes the calculation of all its parameters and the definition of its geometry. A similar procedure is followed for the design of the horizontal and vertical tail section that follows. Next, we design the fuselage, taking into account the geometry of the folding sections, we design the control surfaces of the aircraft and we define the "flight envelope" by constructing the V-n diagrams. At this point, we make reference to the construction materials, where we propose specific composites for each part of the aircraft. The aircraft design process concludes with the structural analysis of the wing, followed by the 3D drawings of the aircraft.

With all the information about the aircraft, we continue designing the other parts of the system. These are the wing and tail section folding mechanism, the propulsion system, the UAV launcher and the canister that will carry the UAV. Finally, we present the steps required to reach the final construction of the UAV and we describe the proposed construction method.

Keywords

Conceptual design, Unmanned Aerial Vehicle (UAV), Search and rescue operations, Deployable wing, Composite materials

INVESTIGATION OF THE DYNAMIC PERFORMANCE OF AN AIRCRAFT WIND TAIL EQUIPPED WITH SHAPE MEMORY ALLOY WIRES

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ABSTRACT

The objective of this Diploma thesis is to develop an aerofoil having the ability to change its dynamic characteristics avoiding dangerous aeroelastic dynamic phenomena. Within the framework of the diploma work, the natural frequencies and oscillation characteristics of the new proposed wingtail design will be studied, focusing on their ability to change due to the installation of shape memory alloy wires. The ultimate goal is to propose an innovative design that will allow on the one hand the change of the dynamic characteristics and on the other hand the change of the geometry of the airfoil due to the active geometry.

Initially, this thesis commences by analyzing and elucidating the phenomenon of the shape memory effect, along with the broader mechanisms governing shape memory alloys. Lagoudas constitutive model that describes these effects is presented in order to have a better understanding of how SMA works. The subsequent section involves the design of a winglet structure integrating a specific subsystem of Nitinol wires to impart requisite forces through geometric manipulations. Computational simulations are utilized in this procedure to assess the effectiveness of the ongoing design endeavor, ensuring the operability of the implemented mechanisms. If inconsistencies emerge, these simulations serve as a guide for potential redesign endeavors. Throughout this process, multiple analyses are conducted to optimize the structural behavior and achieve a state where manipulation of the response is achievable through suitable techniques. Additionally, all preceding steps are accompanied by the experimental phase, which constitutes the most critical aspect of this investigation. Within this phase, a prototype is manufactured to demonstrate the demanding functionalities of the concept, aiming to create a morphing structure capable of altering its natural frequencies and geometry in a manner that enhances aerodynamic performance. In the experimental part, the structure is created as close as possible to the design model aiming to minimal discrepancies with the simulations.

Finally, after the completion of these steps, a discussion took place to suggest potential applications. These could ensure safety from external loading conditions and others that, through its morphing nature, preventing the presence of aeroelastic instabilities like flutter.

Keywords

Shape Memory Alloys, Nitinol, Morphing Winglet, Natural frequencies, Design and Simulation

CONCEPTUAL DESIGN, AIRFOIL SELECTION AND AERODYNAMIC ANALYSIS OF TWIN-TURBOPROP AIRCRAFT WING

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ABSTRACT

The design, analysis and enhancement of the aerodynamic characteristics of a full-scale wing, employed on a twin-turboprop commercial aircraft, requires a synthetic, repetitive process, with multiple stages for the development and execution of it. The recurrent rubbing with the fluid mechanics principles of said case, is a prerequisite for a through understanding of the phenomena, which occur in the flow field, around an airplane wing.

The wing's conceptual design starts with the prediction of the total weight of the aircraft -along with that of its individual components- based on given specifications for its flight profile. This prediction, along with the employment of various aviation regulatory criteria, are combined to obtain the correct dimensioning of the wing.

Using data sets, of the specifications of wings used by similar aircraft and defining the maximum lift coefficient needed, it's possible to evaluate certain secondary wing characteristics, such as its Aspect Ratio, Sweep Angle, Taper Ratio or Twist. Finally, then, the appropriate airfoil for use on said wing is chosen.

A preliminary design is conducted for the selected airfoil, to evaluate, confirm and possibly enhance its aerodynamic characteristics. A Mesh Independent Study is conducted, using a simpler -and more widely applicable airfoil- like the symmetrical NACA 0012. Its aerodynamic coefficients are calculated for various angles of attack and different meshes, combining several turbulent models and refining their parameters. The calculated results are then contradistincted with experimental reference data.

Having defined the applicable combination of mesh and turbulence parameters, it's possible to conduct the aerodynamic analysis of the selected airfoil, to determine, via the use of a

repetitive algorithm, the necessary angles of attack, providing the required amount of lift, which balances out the aircraft's weight, during the main flight stage.

The aerodynamic coefficients of the airfoil are then recalculated at the now determined angles of attack, for them to be bettered, using drag reduction arrangements, such as riblets. The effect of riblets on aerodynamic performance is examined only for the main flight phase of the flight profile, when their impact on lowering the overall fuel weight of the aircraft can be felt.

Keywords

Twin-Turboprop Commercial Aircraft, Wing Conceptual Design, Airfoil Aerodynamic Analysis, Turbulent Boundary Layers, Riblets

INVESTIGATION OF A SEMI ACTIVE TUNED MASS DAMPER BASED ON SPECIAL PIEZOELECTRIC STACKS FOR VIBRATION MITIGATION

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ABSTRACT

The control of vibrations is a crucial field of engineering, affecting many structures subjected to external excitations such as earthquakes and wind. Therefore, developing effective vibration control mechanisms is essential. The Research Group of Structural Mechanics and Smart Materials has developed a Semi-Active Tuned Mass Damper utilizing a shunted specialty piezoelectric device. SATMD consists of a piezoelectric transducer connected to an auxiliary mass and an external electrical circuit with combined impedance. The operating principle is based on converting the mechanical energy of the main structure into electrical energy, which flows into the external electrical circuit and is dissipated or absorbed by the combined impedance parameters. This study examinates an improved device, which includes an auxiliary mass connected with two piezoelectric devices in series and two external electrical circuits. The goals of this work are (1) the effect of the combined impedance parameters of the external circuits on the response of critical points of the structure, (2) the addition of the minimum auxiliary mass, and (3) successful multi-modal vibration suppression across a broad frequency range. The modeling of the structure of interest is performed using finite element method and corresponds to a lab-scale simplified airframe mode. The dynamic characteristics of the host structure are similar to those of a small regional aircraft. The oscillators introduced by the SATMD are independent of the dynamic characteristics of the host structure. Moreover, an ad-hoc design of the parameters of the improved version of the SATMD (auxiliary mass, inductance, resistance) was conducted to reduce vibrations simultaneously across a broad frequency range. After that, an optimization of the aforementioned parameters is also performed. Finally, a comparison of the optimal results of the SATMDs with different mechanical connections was carried out, as well as a comparison of the SATMD utilizing one piezoelectric device with that utilizing two piezoelectric devices connected in series. Overall, it was proved that connecting two piezoelectric devices mechanically in series and electrically uncoupled provided excellent results, requiring significantly small auxiliary mass. In this work, was achieved a multi-modal suppression and vibration control of flexible structure using auxiliary mass equal to 0.6% of the mass of the host structure.

Keywords

Semi active tuned mass damper, special piezoelectric stacks, mechanically connection in series, simultaneously vibration mitigation, comparison of results

DESIGN, STRUCTURAL AND THERMAL ANALYSIS OF A 6U NANOSATELLITE

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ABSTRACT

The aim of this thesis is the design of a 6U nanosatellite, which will be subjected to computational structural and thermal analysis to test its structural integrity and examine the thermal behavior of its components. The design and the selection of materials shall be according to CubeSats specifications and the requirements of the CubeSat dispenser. At the same time the selected subsystems shall carry out the assigned mission.

The structural integrity of the CubeSat will be tested through a series of different analyses simulating the launch environment of the spacecraft. Each analysis represents a specific type of structural loading to which the satellite is subjected during launch. These simulations will make it possible to determine the structure's strength and the chances of a successful transfer to space.

The thermal testing will be separated into two analyses, which will examine the extreme thermal situations of the CubeSats space environment. These will be the hot scenario, in which all parameters are defined such that there is maximum heat input to the satellite, and the cold scenario, where the opposite is true. These analyses serve as an indicator whether the satellite subsystems will operate within their operating temperature range when the CubeSat is in orbit.

Lastly, there will be a review of the simulation results and suggestions about the production of the CubeSat.

Keywords

CubeSat, structure design, simulation model, structural analysis, thermal analysis

WATER/ETHANOL MIXTURE SOLVOLYSIS OF CFRPs UNDER SUBCRITICAL AND SUPERCRITICAL CONDITIONS AND MECHANICAL CHARACTERIZATION OF RECYCLED FIBERS

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ABSTRACT

The industry's demand for lighter and more durable structures has increased the complexity of applications and the materials used. This has led to the adaption of new materials and particularly composite materials. As a consequence, the production of composites has risen sharply, leading to a significant increase in the concentration of waste at the end of their life cycle. European Union legislation and significant taxes on waste and chemical residues aim to prevent landfilling in the near future, thus enhancing the development of efficient recycling processes for composite materials. However, recycling these materials is challenging, mainly due to the difficulty of removing the thermosetting matrix. This thesis focuses on chemical recycling, as this process is an ecological recycling method and yields optimal mechanical properties to the recycled product. It presents an initial evaluation of the solvolysis process for a carbon fiber-reinforced composite material, based on the mechanical properties of the recovered fibers. Chemical recycling experiments were carried out on test specimens using a water/ethanol mixture as a solvent under supercritical and subcritical conditions. In each experiment, the mixture ratio of these two substances was gradually varied to determine the optimal solution ratio. The effectiveness of the recycling procedures was assessed by calculating the resin decomposition efficiency, conducting morphological characterization using SEM, and performing single-fiber tensile tests on the recovered fibers in accordance with ASTM C 1557-14. In addition, the data from these tests were evaluated with statistical tests, such as the two-parameter Weibull distribution. In most experiments, the resin decomposition efficiency, measured in terms of mass, ranged between 63% and 93%. Experiments with rates too low to isolate the fibers were rejected at this stage. Mechanical tests revealed that the recovered fibers retained more than 82% of their initial tensile strength and over 80% of their initial elastic modulus. Understanding the mechanical properties of the recycled carbon fibers allowed for an evaluation of the variation of the experimental data was carried out through the Weibull distribution of the tensile strength statistics. Finally, bar charts classified according to the water/ethanol ratio in the solvent were presented and their impact not only to the environmental footprint, but also to the resin degradation rate, modification rate of the mechanical properties and the scatter of the experimental results were evaluated.

Keywords

Composite Materials, Recycling, Solvolysis, Morphological Classification, Mechanical testing.

EFFECT OF MOISTURE ON THE STRUCTURAL HEALTH MONITORING EVALUATION OF FLAX COMPOSITE LAMINATES USING PIEZOELECTRIC ACTUATOR/SENSOR PAIRS

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ABSTRACT

In this thesis, the effect of moisture on the structural health monitoring evaluation of flax composite laminates was investigated using piezoelectric actuator/sensor pairs. Initially, the motivation of the high demand for sustainable and lightweight materials from industries was presented as well as the main disadvantage of plant fiber materials which is their hydrophilic nature combined with the inherent risk of minor impact damage. In the next chapter, a literature review was made of publications in the scientific fields of water absorption by flax fiber-reinforced plant composites, damage to these materials by low energy impact loading and the use of ultrasonic waves with piezoelectric transducers to monitor structural integrity. To carry out the experiments, plates of non-woven flax fibers, randomly distributed, were prepared with epoxy resin, which was selected due to its hydrophobic nature. Additionally, based on the mechanical properties of the material, the frequencies for the least dispersive fundamental modes were determined. Based on the dispersion characteristics as a function of the frequencies, the selection of the piezoceramic elements that were glued to the tiles in a specific rectangular arrangement in order to propagate waves in various directions resulted. The wave characteristics of the samples were extracted at an pristine stage and then a group of samples were subjected to a low energy impact and then all were immersed in water until saturation. At regular intervals after immersion in water, the weight of the panels was measured using a laboratory scale and wave propagation measurements were performed on them. In this way, the changes in wave propagation characteristics due to moisture uptake in both healthy and damaged specimens were investigated. Additionally, an assessment of the effect of water absorption on the dispersion characteristics of the wave propagation signal was made through directional measurements using the Laser Doppler Vibrometer as sensor.

Finally, the effectiveness of the guided ultrasonic wave method for the detection of low-energy impact damage at the various stages of saturation, i.e. in the presence of an aqueous environment, was studied.

Keywords

Water Absorption, Flax, Wave Propagation, Piezoelectrics, Impact Damage

DIVISION OF DESIGN AND MANUFACTURING (JUNE 2024)

ELASTOHYDRODYNAMIC LUBRICATION IN NON CONJUGATED SURFACES UNDER RAOUGHNESS. APPLICATION IN SPUR GEARS

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ABSTRACT

In machinery applications, lubrication plays a critical role in ensuring reliable operation and extended service life of components. The purpose of this work is to present the mechanisms of lubrication, and primarily that of Elastohydrodynamic (EHD) lubrication, as multi-factorial phenomena, focusing particularly on the influence of roughness of the lubricated surfaces and temperature, factors which have often been neglected in previous studies. Moreover, the importance of detailed tribological study in the design of machine elements is emphasized, in this case the study pertains to spur gears. The study is conducted computationally, by modeling and solving the problem based on the finite difference method.

The work begins with a comprehensive introduction to lubrication principles and the variety of lubricants used in industrial applications. This is followed by an examination of the fundamental mechanisms governing fluid lubrication. Subsequently, EHD lubrication is studied separately, including its characteristics and the parameters that affect it.

For accurate modeling of the multi-factorial nature of EHD lubrication of nonconformal surfaces and for solving the fluid dynamics problem, the Reynold sequation is presented and explained as the fundamental equation governing the problem. The finite difference method is then presented, and the approach to solving the Reynolds equation is explained.

Surface roughness, as a key parameter affecting lubrication, is thoroughly analyzed. Specifically, the characteristic quantities and parameters influencing surface texture are explained, and the importance of correct measurement of the active surface for modeling is emphasized.

With these theoretical tools, the work presents a computational model that solves the problem of one-dimensional EHD lubrication under the influence of roughness.

To highlight the importance of roughness and correct measurement of its profile, a parametric study is conducted with three different roughness measurements, from which valuable conclusions are drawn. Additionally, another parametric study is carried out to demonstrate the importance of the ambient temperature at which the lubricant operates.

Finally, utilizing the conclusions from all of the above, a tribological study of a pair of spur gears is conducted for their critical operating phases.

Keywords

Lubrication Theory, Elastohydrodynamic Lubrication, Roughness, Finite Difference Method (FDM), Fluid Mechanics, Computational Methods, Spur Gears

PREDICTION OF FRICTION IN HYDROGEN INTERNAL COMBUSTION ENGINES USING MACHINE LEARNING MODELS

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ABSTRACT

In modern times, the energy crisis is a major issue that demands immediate action. One factor contributing to this situation is the almost exclusive use of fossil fuels in motoring. In the scope of energy progression, the scientific community's interest is focused on hydrogen because of its combustion properties. The usage of hydrogen in internal combustion engines can help to minimize greenhouse gas emissions by around 50%. In addition, the advancement of machine learning in the field of AI has resulted in the creation of numerous techniques that can predict energy needs and help optimize its use, reducing consumption and costs.

This study focuses on two different Machine Learning methods, Artificial Neural Network and Random Forest. Artificial Neural Networks can adapt and generalize from trained data, making them capable of handling new and unknown situations successfully. Random Forest is a competitive method that combines many decision trees to improve the accuracy of predictions. This reduces the possibility of overfitting and leads to reliable results.

The methods mentioned are used to predict parameters in the frictional first compression spring-cylinder wall friction pair in a hydrogen ICE. Their training is based on the factors of crank angle, gas pressure in the combustion chamber, gas temperature, and gas pressure in the region behind the compression spring, which is due to the escape of some amount of gas from the chamber (blow-by). The predictions of the models relate to the thickness of the lubricating layer and the total friction developed. The purpose of the study is to compare and determine the most appropriate and reliable method for the friction problem.

In conclusion, the use of the most accurate method in the friction problem involving the compression spring and cylinder walls is crucial to obtain results with speed and reliability.

Regarding the ICEs, the behavior of the prevailing method is also examined on other fuels (CNG), thus enhancing the drawing of useful conclusions.

Keywords

Internal Combustion Engines, Hydrogen, Machine Learning, Artificial Neural Network, Random Forest, Blow - by Effect, Tribology

VIBRATION RESPONSE-ONLY DAMAGE DIAGNOSIS IN A POPULATION OF 8-DOF NOMINALLY IDENTICAL LINEAR SYSTEMS UNDER UNCERTAINTY VIA STATISTICAL TIME SERIES METHODS

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ABSTRACT

This thesis aims at the damage detection and characterization (location, magnitude) of inherent damages, of stiffness degradation type, in a population of 8-DOF nominally identical linear systems (mass-spring-damper) based exclusively on vibration response-only signals and Statistical Time Series (STS) methods. The dynamic characteristics of the population are significantly affected by inherent uncertainty, due to the variability in masses, springs, and dampers. The parameters' values are obtained through sampling from a uniform distribution, with boundaries set at ±5% of the nominal values. Furthermore, the deviations of the dynamic characteristics from the healthy state due to the considered damage scenarios (stiffness degradation of 7%, 14% and 24% in two distinct springs) are thus discreet, that they are significantly overlapped when examined in the population domain. These observations yield in employing two robust frameworks towards uncertainty: (i) of the Multiple Models (MM) and (ii) of the Hyperspheres (HS). These two frameworks are applied for the construction of the 'Healthy Subspace', which represents the healthy dynamic characteristics under uncertainty, modelled by the parameters of the Vector AutoRegressive Moving Average (VARMA) models for the first time in this specific problem. The potential improvement of the performance in detection via the usage of the Principal Component Analysis (PCA) method is examined as well. The damage characterization regarding the location and the magnitude is implemented hierarchically based on the MM framework, while the efficiency of the cosine similarity algorithm is also investigated. The results based on hundreds of test cases obtained from 20 healthy and 120 damaged systems are reviewed through the rotations process (20) during the Baseline phase, both for detection and for each of the characterization phases. The performance in damage detection is evaluated using ROC curves (True Positive Rate (TPR) –

False Positive Rate (FPR)), highlighting the superiority of the MM framework (100% TPR mean average for all considered damages for 1% FPR) over the Hyperspheres framework (56.2% TPR mean average for all considered damages for 1% FPR) and over the results of preceding study (Koen, 2024) using AR statistical time series models instead of VARMA (57.2% and 64.8% TPR mean average for all considered damages for 5% FPR for MM-AR and MM-PCA-AR, respectively). Similarly, the efficiency of the employed methods for the hierarchical damage characterization is assessed within the form of Confusion Matrices, indicating once again the superiority of the MM framework (100% average correct detection rate in the 1st and 79.1% in the 2nd stage) compared to the cosine similarity algorithm (56% average correct detection rate in the 1st and 33.4% in the 2nd stage).

Keywords

Structural Health Monitoring, Damage detection/Characterization, 8-Degrees-Of-Freedom system, population uncertainty, statistical time series methods, Vector ARMA

PREDICTION OF DYNAMIC CHARACTERISTICS OF CYLINDRICAL JOURNAL BEARINGS WITH AXIAL GROOVES, USING NEURAL NETWORKS

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ABSTRACT

Journal bearings are one of the most important and widely used machine elements, therefore their analysis becomes necessary. In order to predict the behavior of journal bearing during operation and in cases of external excitations (unbalance) or changes such as increase of viscosity or rotational speed, it is necessary to determine both the static and dynamic characteristics of the bearing. In detail, the dynamic coefficients of damping and stiffness, which are key characteristics of bearing operation, will be determined.

The calculation of the coefficients can be implemented by using artificial intelligence and specifically by applying Artificial (ANNs) or Deep Neural Networks (DNNs), which are computational models whose working principles are based on biological neurons. Just like the human brain, the NN is trained from known input-output samples, evolves and then generalizes the data by giving each time an output to corresponding new input data, in instantaneous time.

In this thesis, the purpose is to determine the dynamic damping and stiffness coefficients and then use them to analyze a rotating shaft vibration. Firstly, samples of input-output data will be generated which are obtained from literature and have been determined by numerical methods for a range of Sommerfeld number and for journal bearings with two and four axial grooves. Afterwards, different network's architectures will be tested for each case, since in the first case the outputs are the damping coefficients and in the second one are the stiffness coefficients, while the inputs are the length-diameter ratio of the bearing and the dimensionless number Sommerfeld. Moreover, after completing the training of neural networks, a comparison is made between the values of the dynamic coefficients which are generated from neural network's output and those which are given by the literature, in order to check the network's reliability.

Lastly, is presenting an analysis of Jeffcott rotor behavior, which is supported on journal bearing and subjected to an external excitation due to unbalance. The vibration responses of the rotor in horizontal and vertical directions are presented, as the rotational speed and the unbalance force are increased, while both types of bearings are compared.

Keywords

Journal Bearing, Dynamic Coefficients, Neural Network (NN), Vibration, Unbalance

DESIGN AND PHYSICAL-BASED SIMULATION ANALYSIS OF NH3 DISTRIBUTION SYSTEMS FOR VESSELS

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ABSTRACT

Because of the global environmental crisis that the planet is experiencing today, there is a global trend to turn to alternative energy sources that do not harm the environment, as humanity has done so far. Following European Union's mandatory limits on harmful emissions in maritime, the transition from conventional to alternative fuels is seen as the most promising route to achieving greenhouse gas reductions. In this context, this diploma thesis investigates the integration of ammonia (NH_3) as an alternative marine fuel.

Detailed descriptions of ammonia distribution systems outline the complexities of fuel storage at high pressures and controlled temperatures, followed by efficient delivery to main engines through sophisticated pumping and heating mechanisms. Simulation and modeling aspects using Simscape are meticulously detailed, addressing assumptions, simulation domains, and selection criteria for modeling components like storage tanks, pipelines, pumps, and heat exchangers.

The thesis further delves into a comprehensive analysis phase, leveraging sensor data to monitor critical variables across the distribution network. Insights from pressure, temperature, and flow rate readings inform optimizations in system design, highlighting strategies for minimizing energy losses, enhancing thermal efficiency, and ensuring operational safety.

In conclusion, this research contributes significant findings to the field of maritime fuel systems, demonstrating the efficacy of ammonia as a sustainable alternative amidst evolving regulatory landscapes. Recommendations for future research and development focus on scaling up technology adoption, refining simulation methodologies, and advancing infrastructure requirements to support widespread implementation of ammonia-based marine fuels.

Keywords

Design, Ammonia fuel, Simulation, Operational efficiency, Simscape Analysis, Marine fuel systems.

FINITE ELEMENT SIMULATIONS OF BICYCLE FRAME MECHANICAL SAFETY REQUIREMENT TESTS FOR PRE AND DURING PRODUCTION STAGES: A CASE STUDY OF AN ELECTRIC BICYCLE FRAME

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ABSTRACT

The Mechanical strength simulations are of great importance during the design stages of a bicycle frame, as a structural component. There are five tests a bicycle frame needs to pass in order to get production certification, according to DIN EN 15194, three of which are fatigue tests and two impact tests. In the current Thesis, these tests will be simulated using the Finite Element Method, aiming to pose a useful tool that can be utilized for limiting the number of prototyping iterations during the Detailed design phase. A case of an Electric power assisted bicycle frame will be examined, in association with IDEAL bikes. The 3D model of the frame and necessary parts is designed and then input in ANSYS Mechanical, which will be used to run the simulations. After the definition of the frame's material, Fatigue analysis simulations will be conducted using the Static Structural module and the Impact test simulations using the Explicit Dynamics module. The obtained results will be correlated to the inhouse bench tests performed by the manufacturer.

Keywords

Finite Element Method, Detailed design phase, Electric power assisted bicycle, Fatigue Analysis simulation, Impact test simulation

FRICTION MODELS IN ARTIFICIAL KNEE JOINT

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ABSTRACT

This paper analyzes the development of a mixed lubrication friction model in an artificial human knee joint using code creation. Since the first half of the 20th century, science has been addressing artificial joints. Many experimental and computational studies have since been conducted to increase their lifespan. Artificial joints are used in cases where the natural joint fails either due to injury or disease. Since the cause of destruction of artificial joints is friction leading to wear, and experimental setups for calculating these quantities are particularly expensive, the development of a computational model to calculate these quantities was considered important. Initially, the principles governing the problem were studied. Between the two surfaces of the joint, synovial fluid is interposed and a lubrication regime develops. The theory of bearings and the Reynolds equation for hydrodynamic lubrication were used. For greater accuracy, the equations of Patir & Cheng with flow factors, which take into account the roughness in hydrodynamic lubrication, were used. Next, the effect of roughness on the model was studied using the Greenwood & Tripp theory for areas where contact occurs as lubrication is mixed. Data on kinematics, load and speed distributions over time, statistical roughness parameters, viscosity, and geometry were introduced from official sources and ISO standards. The geometry of the lubricant was approximated with the geometry of an ellipsoidal ball bearing on each condyle. All equations were non-dimensionalized and then discretized using the finite difference method after a grid was created. The computational process is presented in detail, along with a flowchart. Simulations were then conducted for pressure and friction distributions in the MATLAB environment for various Youngs' modulus of UHMWPE and different viscosities of synovial fluid, with the results presented in diagram form. It was found that increasing the elasticity modulus results in a slight increase in pressure distribution and a slight decrease in the friction coefficient, while viscosity variation does not significantly affect the friction coefficient. Additionally, almost the entire load is taken by the roughness rather than by hydrodynamic flow. Finally, the results were discussed, and the bibliography was provided.

Keywords

Biotribology, Artificial joint, Friction, Wear, Mixed lubrication

DECISION SUPPORT WORKFLOW FOR REPAIR WITH ADDITIVE MANUFACTURING: A CASE STUDY IN DED PROCESS

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ABSTRACT

Advanced manufacturing processes are transforming both the design and the production of parts. Metal Additive Manufacturing (AM) is one of the revolutionary processes, providing unprecedented design freedom coupled with the capability for reasonable priced low volume productions of metal components. AMs versatility has attracted various industrial sectors are, with one of them being the repair and manufacturing industry. AM when coupled with conventional subtractive manufacturing processes, can enable the repair of a damaged part by filling the damaged area using additive processes and then finishing it by subtractive methods. However, there are few guidelines and metrics that quantitatively dictate if the best approach is to repair or remanufacture a part. To address this, this thesis delves into a decision support workflow aiming to provide a systematic approach for the feasibility study of a repair operation on a damaged part using Additive Manufacturing with the help of conventional process, based on a detailed analysis of metrics like design constraints, sustainability considerations, and techno-economic metrics. The implementation is done through a software in order to assist with the calculation of the technoeconomical model but mainly with gathering all of the required information in a single point. The decision support workflow is verified through a case study involving the repair of shafts used in marine vessels. These shafts are made from stainless steel AISI 316L, but additional analysis was done with titanium Ti-6Al-4V considered as an alternative material. The repair process is conducted using a wire laser-based DED system (DED-LB/M) on a Hybrid Manufacturing robotic cell. The study identifies process and machine-related limitations and demonstrates the impact of part size and material selection on key performance indicators (KPIs). This case study results is creating a robust decision support tool that enhances the efficiency and sustainability of repair processes in additive manufacturing, providing valuable insights for both industry practitioners and researchers.

Keywords

AM, Hybrid Manufacturing, Repair, Decision Support, DED

MODELLING & CONTROL OF ELECTRIC REGENERATIVE BRAKING ON A BATTERY - IPMSM POWERED EV WITH FUZZY LOGIC

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ABSTRACT

The deployment of Electric Regenerative Braking Systems (ERBS) in the contemporary Electric Vehicle (EV) and Electric - Hybrid Vehicle (EHV) industries as a method of reducing the carbon footprint of these vehicles and extending their range is prevalent. ERBS are a type of energyrecovery systems that work by operating the electric motor that is normally used for propulsion as a generator during braking, thereby providing a way of harvesting a part of the vehicle's kinetic energy and converting it to electric energy which can be used to charge the battery. In most applications, conventional braking systems (CBS), for example, friction brakes, are used in conjunction with ERBS because of the power-absorbing limitations of the electric motor and the battery. A properly designed ERBS can help achieve multiple objectives crucial for the energy efficiency and overall performance of EVs/HEVs. More specifically, electric regenerative braking can extend the driving range by capturing and storing some of the kinetic energy that is normally converted into heat when conventional friction brakes are used, as well as prolong the lifetime of the battery and the mechanical braking system that is required to assist the regenerative braking system. The primary goal of this study is to develop a fuzzy rule-based method for the control of a Series Electric Regenerative Braking System (Series – ERBS) for a Front-Wheel-Drive (FWD) Electric Vehicle (EV) driven by an Internal Permanent Magnet Synchronous Motor (IPMSM). A comprehensive electric vehicle (EV) model is developed for this purpose, incorporating IPMSM powertrain, Electronic–Hydraulic Braking (EHB), and Longitudinal Vehicle Dynamics (VD) modules. This is accomplished using the MathWorks Simulink system modeling software. The distribution of braking load on the vehicle's front/rear axles is taken into consideration by examining three (3) distinct braking allocation methods: the Ideal Curve (I – Curve) method, the Fixed Ratio method, and a Composite (I – Curve, ECE Curve) method. The key objective of distributing the front axle braking load between the ERBS and the conventional braking system (which uses Disk Brakes) in a way that provides both adequate braking performance and optimal energy recovery is realized through the design of a Fuzzy Logic Controller that uses the motor speed, the required braking strength and the battery state of charge (SOC) as fuzzy inputs and yields a braking allocation factor as its output, which is then used to calculate the portion of the braking force which will be assigned on the CBS and the ERBS. The energy-recovery performance is evaluated by testing the proposed EV model and associated control system on a variety of standardized driving cycles that correspond to different braking requirements (urban or high-speed braking scenarios).

Keywords

Electric Vehicle (EV), Regenerative Braking, Fuzzy Logic, Internal Permanent Magnet Synchronous Motor (IPMSM), Electronic – Hydraulic Braking (EHB)

DESIGN OF PIN ON DISK TRIBOMETER APPARATUS IN VACUUM OPERATIONAL CONDITIONS

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ABSTRACT

Tribometers are specialized tools for the study of friction, wear and lubrication phenomena, and the pin on disk type tribometer is one of the most widely used types due to its simplicity and effectiveness in reproducing friction conditions. Its operating principle is based on the contact of a rotating disk with a pin that applies a constant force to it. In particular, the pin on disk tribometer under vacuum operational conditions allows the study of friction and wear of materials under extreme pressure conditions, simulating the space environment or other applications where the presence of air may affect the results. The analysis and design of a pin on disk tribometer for vacuum operational conditions requires a specialized approach, taking into account the unique challenges presented by vacuum, such as managing temperature variations and ensuring seal integrity. This paper focuses on these challenges, offering a comprehensive approach to developing a functional vacuum tribometer. In this context, each stage of the design process, from the definition of the functions and technical specifications to the development of each system and subsystem of the device in the CATIA V5 design program, is extensively discussed. At this stage, every technical detail and manufacturing process is analyzed in detail, seeking maximum accuracy and performance of the tribometer, with the aim of translating the design principles into a real, physical tribometer. At last, the present work includes the structural integrity check of the vacuum chamber, using Ansys Mechanical software as well as analytical calculations.

Keywords

Tribometer Design, Pin on Disk Tribometer, Vacuum Conditions

TRIBOTRONIC DESIGN AT COMPRESSION RING IN INTERNAL COMBUSTION ENGINE UNDER THE INFLUENCE OF CAVITATION

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ABSTRACT

The present work focuses on the tribological characteristics of compression springs within internal combustion engines under the influence of the cavitation effect.

Initially, the concept of Internal Combustion Engines (ICEs) is examined, detailing their composition and emphasizing the role of springs. Moreover, the cavitation phenomenon and how it affects the engines is analyzed. Subsequently, the Swift – Stieber differential equations, utilized in our computational model, are outlined.

Following this, the Finitie Difference method employed for problem – solving is discussed, and the mesh structure is defined. Furthemore, MATLAB is used to calculate the maximum pressures exerted by the compression spring at various crankshaft angles and the problem is simulated in the SIMULINK computational space using the equations of Fmep and maximum pressure Pmax as a function of revolutions n.

This study aims to derive valuable insights into the behavior of compression springs under the influence of cavitation to optimize the operation of Internal Combustion Engines.

Keywords

Tribology, Internal Combustion Engines, Compression Springs, Swift - Stieber Equation, Finite Element Method.

DIVISION OF ENERGY, AERONAUTICS AND ENVIRONMENT (JUNE 2024)

PLASMA KINETICS MODELS FOR COLD ATMOSHERIC PRESSURE PLASMA

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ABSTRACT

This thesis focuses on the study of cold plasma kinetics, based on two approximate simulations of cold plasma models at atmospheric pressure. Initially, some theoretical elements are analyzed with the main pillars being the following, what exactly plasma is, what categories it is reduced to, what methods are used for its production and what are its technological applications. Next, the simulation model of the plasma is explained, which in our case is one-dimensional and concerns spheres of charge. Then the model is implemented through the Matlab programming language based on two different approaches. Finally, the results (diagrams) resulting from the implementation of the two models are listed and commented on, focusing on where they converge and where they diverge.

Keywords

plasma, cold, atmospheric pressure, simulation, model, kinetics

THERMAL INSULATING CAPABILITY OF STORAGE MATERIALS ON CRYOGENIC FUELS APPLICATION

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ABSTRACT

The use of renewable energy sources (RES) as fuels is of vital importance in the modern era. Creating a sustainable energy system and addressing environmental pollution are major issues that require necessary and drastic actions. This work focuses on the characteristics of cryogenic fuels, providing data on liquid hydrogen among others, as its safe use in the near future is the challenge of our time. Beyond the networks that will be developed within cities, a significant parameter is the safe transport and storage of cryogenic fuels. In this thesis, the advantages of these fuels, as well as the risks inherent in their transport (navigation) and storage, will be discussed, and some data will be provided for their comparison. A significant portion of the work involves a satisfactory numerical simulation concerning the durability and thermal insulation performance of the composite panel (sandwich) material from which a membrane tank is constructed. This type of tank is expected to become the most widely used for the transport and storage of cryogenic fuels in the near future.

Specifically, the membrane tank serves as the physical model for the numerical simulation conducted using Ansys Steady-State Thermal and Ansys Fluent programs. The goal of the numerical simulation is to analyze the thermal transfer that develops through the tank's surfaces with the liquid fuel. In the GTT Mark-III-Flex+ and NO-96 Perlite models, the numerical setup applies only to boundary conditions that remain constant throughout the year. For the computational simulation of this model, basic principles of fluid mechanics, heat transfer, and static analysis were studied and used. The results offer a thorough understanding and the potential for improving the performance of the tank and its materials.

At this point, it must be emphatically stated that the initial tank model chosen (Mark-III Flex+) was first used in my Student Project (SP) under the supervision of Assistant Professor Dr. Angelos Filippatos. In the context of this thesis, the model was further developed with better discretization and the extraction of more accurate results following a more precise sensitivity

grid analysis with the help of the full version of Ansys Fluent. In the same manner, a comparison of results with the NO-96 Perlite tank model is made.

Keywords

Numerical simulation, Cryogenic fuels, Membrane Tank, Fluid mechanics, Heat transfer

CORRELATION STUDY OF THE MAIN DESIGN PARAMETERS OF AIR-VEHICLES WITH THE NOISE GENERATED

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ABSTRACT

In the contemporary aviation industry, the noise produced during the operation of a new aircraft or helicopter is considered a significant factor in its design. In recent years, there has been an increased stringency and demand for compliance with international environmental regulations, leading to a greater emphasis on the reduction of noise generated for the comfort of passengers. We will analyze the key design features of the aircraft in order to determine their impact on noise levels. This study utilizes data from currently operating aircraft to establish findings and mathematical formulas that will guide the development of an initial design model incorporating aircraft noise considerations. Our research encompasses all types of civil aircraft, including both jets and helicopters. The findings of this investigation revealed a strong relationship between the noise produced by an aircraft and its fundamental design characteristics, including its take-off weight, engine thrust, dimensions of the fuselage, wing, and tail section, as well as the size of its engines, landing gear, and propellers for both airplanes and helicopters. Furthermore, an analysis has been conducted to determine the impact of these variables on the sensitivity of noise, identifying the most influential factors within each category and corroborating the primary sources of noise for an aircraft. The most significant accomplishment of this thesis lies in the development of a design algorithm suitable for a range of aircraft and helicopter models. This algorithm enables the design of a novel aircraft with an emphasis on achieving a specific noise level for take-off. The specified algorithm demonstrates effective performance and has the capability to assist the manufacturer in determining the initial dimensions of the new aircraft. The algorithm provides results for only a limited number of geometric features in certain categories, but for civil jets, which must comply with more stringent environmental regulations and reduce noise, the algorithm effectively generates all fundamental parameter dimensions (fuselage, wing, tail).

Keywords

Aircraft, Helicopter, design, noise, sensitivity, correlations

COMPUTATIONAL SIMULATION OF AIR CONDITIONING FLOW FIELD FROM ORTHOGONAL MULTI-VANES DIAPHRAGMS AND CIRCULAR CEILING GRILLES

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ABSTRACT

This thesis deals with the study of air flow through grilles in a room of specific dimensions. It examines the variation of the flow characteristics with increasing flow rate until the grille outlet velocity reaches the maximum allowed by the comfort conditions namely 10 m/s. The characteristic values are measured on the basis of the area of interest namely the volume of the air flow with the boundaries being those points having a velocity greater than 0,5 m/s. A presentation was made of the different types of grilles available. The computational study was performed in the ANSYS FLUENT package, where a Realizable k-ε turbulence model was used for the study. The other turbulence models, discretization methods and equation solving algorithms are also reported. In addition, a comparative thermal analysis study was performed, where the characteristic sizes of each grille were compared for an input temperature difference of 5°C above and below room temperature.

Keywords

Grilles, Computational Fluid Dynamics, Air Supply, Comfort, Air Conditioning.

DEVELOPMENT OF A COMPUTATIONAL TOOL FOR THE ESTIMATION OF BUILDINGS' ENERGY CONSUMPTION USING THE HEATING DEGREE DAYS METHOD

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ABSTRACT

The energy crisis and climate change are two major problems that are massively impacting many areas of our lives. The buildings' sector is one of the most energy-intensive and polluting sectors, with the reduction of energy consumption and emissions being the focus of solutions. This paper deals with an introspection on the heating functions of a building and the quantification of the issue they cause. The study is based on the development of a computational tool that calculates the thermal energy demand, final and primary energy consumption, and air pollutant emissions, based on the heating degree-days method. The functions of the tool are demonstrated through the analysis of a building in the context of a case study. First, an energy audit was conducted to extract the data to be fed into the tool. For the comparison and evaluation of the results, actual consumption of the building and predicted values from the TEE-KENAK software are used. In the last part, a few different proposals are made regarding energy improvement solutions, adapted to the building, and substantiated with the help of the newly developed tool. Decarbonization is Europe's top priority and by solving the individual energy problems with innovative solutions, we can lead to sustainable development for the well-being of the environment.

Keywords

Energy consumption prediction, tool, heating degree-days, energy efficiency improvements, buildings

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING VENTS WITH GRILLES OF SLOT TYPE WITH REGULATING DAMPER OF THE FLOW DIRECTION

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ABSTRACT

In this master's thesis, the objective is to study the airflow from air conditioning outlets with slottype grilles and flow control sliders to determine their characteristic sizes. These sizes are related to the distribution of velocity, uplift, drop, diffusion, pressure drop of the airflow, and the noise produced in the study area. The computational domain where the experiment is conducted is a digital twin of the experimental study area of the Fluid Mechanics Laboratory at the University of Patras, and the grilles are of the STS type from the company AIRTECHNIC HATZOUDIS E.P.E. Finally, it should be noted that the pre-study grilles were designed with the help of the SOLIDWORKS design program, while the computational analysis was carried out using ANSYS Fluent.

Keywords

Airflow, slot-type grilles, HVAC, CFD

SIMULATION OF PLASMA ACTUATOR INDUCED AIR FLOW OVER AN AIRFOIL

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ABSTRACT

This study examines the impact of a plasma actuator applied to an NACA 0012 airfoil across different Reynolds numbers. Utilizing the OpenFOAM computational package, the actuator was simulated and implemented as a source force over a designated cell zone using the fvOptions utility. This zone was defined using the topoSet directory. Initially, the actuator was configured with a base frequency of 3kHz and a voltage amplitude of 10kVpp. To model this setup, the study employed steady-state governing equations for continuity and momentum, along with the k-ω Shear Stress turbulence model. The simulation utilized 100,000 cells.

Initially, two actuators were placed at different locations: the first at x/c = 0.1 of the airfoil's hord and the second at x/c = 0.003 of the airfoil's chord. These simulations were conducted at a free stream velocity of 3 m/s and a Reynolds number of 200,000. Based on these simulations, we concluded that the actuator positioned closer to the leading edge of the airfoil yielded superior results. This was evidenced by a reduction in the separation zone over the airfoil, along with an increase in the lift coefficient and a decrease in the drag coefficient. Following that, the actuator positioned at x/c = 0.03 underwent further analysis.

Two different freestream velocities were applied: 1 m/s, corresponding to a Reynolds number of 150,000, and 6 m/s, resulting in a Reynolds number of 400,000. The findings from these simulations indicate that the effectiveness of the actuator is most pronounced when the freestream velocity, and consequently the Reynolds number, is low. Conversely, when the freestream velocity exceeds 6 m/s, the effects of the actuator become negligible.

Finally, simulations were conducted with the same voltage amplitude (10 kVpp) but at two different frequencies: 1kHz and 3kHz, resulting in variations in the actuator's body force. It was noted that when the body force was higher (with the 3kHz base frequency), the actuator operated at its optimal condition.

Keywords

Plasma, actuators, low-Reynolds, airfoil, CFD

EXPERIMENTAL INVESTIGATION ON REACTION TO FIRE OF WIRE INSULATING MATERIALS WITH A CONE CALORIMETER

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ABSTRACT

This thesis investigates the reaction to fire of cable insulation materials using the cone calorimeter method and the standards ISO-5660 and EN 45545-2. The aim is to determine the properties of the materials in case of fire and to categorize them according to relevant fire safety standards.

The study includes an extensive literature review on fire protection, the theory of solid combustion, and the role of insulation materials in fires. Through this research, key parameters affecting the combustion of materials are analysed, such as heat release rate, ignition time, smoke production, and carbon monoxide release. The results aim to understand the behaviour of cable insulation materials during combustion and to implement measures to enhance safety.

The findings of this research provide valuable insights for the selection of safer insulation materials and the improvement of existing fire protection standards. Understanding the thermal decomposition and volatile product generation is crucial for effective firefighting and safety measures involving cable insulation materials.

Keywords

Fire, Fire safety, Cable enclosure, Fire reaction, Cone thermometer

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD IN CIRCULAR DAMPERS FOR THE AIR FLOW REGULATION IN AIR-CONDITIONING PIPES

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ABSTRACT

In this diploma thesis, the flow of air is studied, which passes through a flow control damper and ends in a room of known dimensions. The quantities calculated are the pressure drop that occurs in the damper, the range, the lift, the drop and the dispersion of the flow, as well as the noise level produced due to the damper. The air flow studied for entry velocities smaller than 10m/s. In total were studied 2 different flow categories for supply and exhaust air for three different dampers at two different angles of the disc. For the computational simulation of the flow, Ansys Fluent was used, while the construction of the flow geometry was carried out in SolidWorks. The k-ε Realizable turbulence model was chosen with the SIMPLE algorithm.

Keywords

Circular Dampers, CFD, HVAC, Pressure Drop, Ansys Fluent

NUMERICAL INVESTIGATION OF DELTA WINGLET PAIRS EFFECT ON THE FLOW AND THERMAL FIELD IN A U-TURN DUCT, FOR DIFFERENT ARRANGEMENTS OF THE PAIRS, FOR LAMINAR AND TURBULENT FLOW

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ABSTRACT

Vortex generators are α very efficient way to enhance heat transfer within pipelines. However, although numerous experiments have been conducted on their use within straight pipelines, there are minimal studies within curved pipelines. So, in this paper three different arrangements of triangular vortex generator, in the form of common flow down, within a curved pipeline are evaluated to enhance heat transfer. More specifically, the analysis was carried out at constant wall temperature for different Reynolds numbers which are in the range of laminar and turbulent flow, in order to study the wider effect of the vortex generator on the flow and thermal field.

First, the necessary basic theoretical knowledge of fluid mechanics and heat transfer is presented. Then the special phenomena of flow within curved pipelines and the basic characteristics of vortex generators are discussed. Finally, an introduction to computational fluid mechanics and the Fluent Ansys, where the simulations of this paper are performed, is given.

The main part of the paper presents the designs and the meshing process, the quality of the mesh, while a grid independence study is carried out and the optimal number of computational elements required is derived. Then the initial conditions and the turbulence models used in each case are mentioned.

At first the results of the analyses are presented for all Reynolds numbers. A significant increase in the Nusselt heat transfer coefficient is observed, as high as 115% in the geometry with most vortex generators. But there is also a significant increase in the friction coefficient, reaching 383% at the higher Reynolds numbers. Then the results of the analyses are presented along the pipe for Reynolds numbers 1000 and 20000 to study laminar and turbulent flow respectively.

In conclusion, the use of vortex generators within curved pipes is optimal near the transition from laminar to turbulent flow, while at extremely high Reynolds numbers there is a very large increase in the friction coefficient compared to the small increase in the Nusselt coefficient. However, their use in curved pipes can be very efficient and is worth further analysis.

Keywords

Curved pipes, vortex generators, Heat transfer enhancement, Computational fluid dynamics.

EXPERIMENTAL STUDY OF INGERNALLY FORCED CONVECTION IN A WATER LOOP

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ABSTRACT

Heat transfer is an important field of engineering science, of utmost importance due to the energy crisis that humanity is experiencing in the modern era and with multiple applications in everyday life. The purpose of this work is to study the enhancement of heat transfer by conducting an experiment in a water loop. The experiment is performed under internally forced turbulent convection conditions at reference temperatures of 30°C, 35°C, 40°C and 45°C.

In the first chapter of the work, a theoretical approach to the phenomenon of internally forced heat convection is made and the fundamental equations used to process the experimental results are presented. Then, in the second chapter, a literature review follows, where nanofluids are presented, which are a revolutionary method to improve heat transfer. Also, experimental results from the literature are presented, while at the end there is a reference to the improvement of the thermal efficiency of the devices through reinforced heat transfer pipes. In the third chapter, the characteristics of the experimental installation are given. More specifically, information is given regarding its construction and mode of operation as well as the protocol followed during the experimental study and the recording of the measurements of the quantities of interest. In the fifth chapter, the experimental data are processed and the results are presented in appropriate diagrams, where they are compared with the corresponding theoretical ones. Finally, in the sixth chapter, the conclusions and proposals for further study of the subject are listed.

Keywords

Heat transfer, forced convection, turbulent flow, nanofluids, constant heat flux condition

EXPERIMENTAL INVESTIGATION OF THE FLOW FIELD CHARACTERISTICS DOWNSTREAM A BLUFF-BODY CONFIGURATION SUITABLE FOR THE STABILIZATION OF STRATIFIED GASEOUS FLAMES

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ABSTRACT

This thesis aims to interpret the uncertainties associated with the experimental equipment when studying the flow field in a prototype experimental burner configuration. In this device, a bluff-body has been installed to stabilize stratified flames of gaseous mixtures.

Initially, the fundamental theoretical background and the main phenomenological aspects of combustion required for a full understanding are presented. A detailed analysis of the four scientific fields affecting the combustion process is provided, accompanied by an extensive description of the classification of these phenomena. An extensive investigation of elemental combustion is provided, and the limits of flammability are clearly indicated. Flame-stabilizing bodies, known as bluff body flameholders, are then mentioned. The principles of their operation are examined, with emphasis on the main flow characteristics when applied as stabilizing agents, while the effect of preheating on these devices is analyzed.

Moreover, the experimental setup and the equipment required to conduct the experiments are presented. Finally, special emphasis is given to Particle Image Velocimetry (PIV), highlighting the basic elements that make up the technique, while the uncertainties that characterize it are highlighted and analyzed.

Keywords

Combustion, Bluff Body Flameholders,Velocity Profile, Particle Image Velicometry, Uncertainties

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING VENTS WITH GRILLES OF DIFFERENT CONFIGURATIONS - EFFECT OF TURBULENCE MODEL AND TEMPERATURE FOR COOLING AND HEATING CONDITIONS

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ABSTRACT

In the current diploma thesis, the aim is to study the air flow through the grilles in a room of specific dimensions, in order to calculate and evaluate their characteristic variables. These are related to the velocity distribution, the rise, the throw, the drop, the spread and the pressure drop of the air beam. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (Vc = 10 m⁄s). The region of interest is where a person feels comfortable in room conditions, which in this study was defined as the one with air velocity of V = 0.5 m⁄s. The turbulence model used to predict the region is the Realizable k-ε, the k-omega and the Spalart Allmaras. Among other things, the turbulence models, discretization methods and algorithms for solving the equations are presented. The temperature difference for heating and cooling are ΔT = +5 °C and ΔT = -5 °C respectively. Grilles of different types of design and use were tested and compared. The grilles to be studied were designed in SOLIDWORKS, while the computational investigation and visualization of the results were performed with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was performed by a colleague, which is not included in this study.

Keywords

Grilles, Air beam, Comfort, Finite elements, Computational fluid dynamics.

NUMERICAL STUDY OF THE AERODYNAMIC PERFORMANCE FOR A TRACTOR SEMI-TRAILER COMBINATION

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ABSTRACT

Heavy-duty vehicles are responsible for a significant portion of transport-related emissions. In Europe, they account for around 5% of total greenhouse gas releases, while in the US approximately 20% of transportation fuel consumption and carbon emissions come from trucks. Therefore, studying and enhancing their aerodynamic performance results in a drastic reduction in pollutants and fuel costs. The main objective of this diploma thesis is the computational study of the aerodynamic performance for a tractor semi-trailer combination. A European model was selected to be analyzed at four different velocities. Simulations were run in OpenFOAM, including two different turbulence models. As far as the structure of the thesis is concerned, the first chapter highlights the importance of studying truck aerodynamics whereas the second one provides a thorough view of the theory concerning drag, wake, viscosity, truck aerodynamics and drag reduction devices. Furthermore, an analysis of the mathematical modelling takes place, involving the governing equations of fluid dynamics, the Reynolds Averaged Navier Stokes and the $k-\omega$ SST and the Spalart-Allmaras turbulence models. Afterwards, the computational modelling is presented, focusing on the truck model, the parameters selected for generating the mesh, the boundary conditions, the chosen values concerning turbulence, the numerical schemes and lastly the solution algorithm. After setting up the cases, the results are presented in detail, followed by an evaluation of the outcomes and a comparison between the turbulence models. Finally, a mesh independence analysis is conducted, to complete the computational study. By investigating truck aerodynamics, new solutions can be introduced. This would enable the entire truck industry to advance towards sustainable development, aligning with global initiatives to address environmental challenges and achieve a greener future.

Keywords

CFD, Truck Aerodynamics, Tractor Semi-Trailer Combination, Turbulence, OpenFOAM

SOLAR THERMAL COLLECTORS WITH SPECULAR AND DIFFUSE REFLECTORS

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ABSTRACT

The global shift towards more sustainable production and consumption systems is gaining momentum, particularly in the energy sector. As humanity aims for a low-carbon economy, the need to harness renewable energy sources is becoming increasingly apparent.

In this context, this research focuses on investigating the exploitation of solar energy and in particular on improving the efficiency of solar thermal collectors. Furthermore, the solar geometry, the solar reflection process and existing efficient solar thermal technologies are described and presented.

The main research of the paper, however, focuses on the modeling of various solar thermal panel arrangements, which will either be equipped with specular or diffuse reflectors or generate a large amount of reflection from the layout. Then, the theoretical efficiency gain of each reflection ratio array will be calculated given the location of the system is Patras Greece and the results will be commented in detail. The analysis will include comparisons of the performances of different arrangements, offering valuable insights for the optimal use of reflective surfaces in solar thermal collector systems. This investigation aims not only to provide solutions to the energy problem facing the planet, but also to offer ideas for further research to improve and widely apply these technologies.

Keywords

Renewable energy, Solar energy, thermal solar systems, diffuse reflectors, specular reflectors

LIFE CYCLE ASSESSMENT OF GEOTHERMAL EXPLORATION

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ABSTRACT

Geothermal energy, as a sustainable alternative to conventional energy sources, has gained significant attention in recent years. However, the exploration and drilling processes involved in harnessing geothermal energy can have considerable environmental impacts. This thesis conducts a comprehensive examination of the environmental implications of geothermal drilling, with a specific focus on the Rate of Penetration (ROP) in granite formations, examined through the methodology of Life Cycle Assessment (LCA) on four real-life cases. The study commences with a thorough review of renewable energy sources, emphasizing their role in fostering environmental sustainability, energy security, and economic growth. Then, the complexity of the drilling process of geothermal wells is described, and the rate of penetration factor is underlined, along with its implications on the various emission factors such as the Global Warming Potential and Fossil Fuel Depletion. Next, the four wells are described, taken from the detailed literature of the Soultz-sous-Forêts and Rittershoffen geothermal sites. Their structural dimensions are described along with the various types of granite formations that were encountered when drilling and the three sets of maximum, average and minimum ROP values that were measured with their respective interval lengths. This data was used to conduct the methodology of LCA, starting from defining the scope and goal of the approach and ending in the interpretation of the results. The inventory analysis part of the LCA includes the emission factors that were used, taken from the SimaPro database. The results show clearly that in order to minimize the emissions produced by the drilling process, lower ROP values are required. This is also present in the analysis that was made with a separate sequence of ROP values for each well, in which the effect of the ROP on the emissions is better described through various individual diagrams. Furthermore, a sensitivity analysis for the fuel consumption of the drill rig was conducted, that yielded a 9% decrease of chlorofluorocarbon production and an 8% decrease of fossil fuel depletion. Another sensitivity analysis on the distance required for the transportation showed a lower than 1% decrease in emissions when using green trucks.

Keywords

Geothermal Energy, Geothermal Drilling, Life Cycle Assessment, Rate of Penetration, Enhanced Geothermal Systems

LIFE CYCLE ASSESSMENT FOR AN APPLICATION OF BUILDINGS EQUIPPED WITH GREEN ROOFS

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ABSTRACT

The energy upgrade of buildings is a critical step towards sustainability development. According to the Ministry of Environment and Energy of Greece, buildings are responsible for approximately 40% of the total energy consumptions as well as 36% of CO_2 emissions. By improving the energy efficiency of buildings, energy consumption and greenhouse gas emissions are significally reduced. The current thesis focuses on the energy upgrade of an apartment in the center of Karditsa, a city located in mainland Greece, with significant energy requirements and climatic challenges throughout the year. The apartment presents several challenges regarding its energy efficiency, due to not only its location, but also the age of the building materials and installations since the building's construction dates back to 1970. This apartment is on the 7th and last floor of the building and as a result it is completely exposed to weather conditions and solar radiation. The main objective of this thesis is to assess the energy efficiency, through energy retrofitting, as well as the environmental impact, through a Life cycle assessment, of the materials used for the energy upgrade of the apartment. The changes made to the installations and materials of the apartment regard the apartment's shell insulation (thermal facade), the roof insulation as well as the window and door frames of the structure. After the energy retrofitting of the apartment, the environmental impacts of these materials used for the installation of the thermal insulation of the apartment, are assessed through a Life Cycle Analysis. Life cycle assessment measures the environmental impact of a product, process, or service throughout its entire life cycle.

Additionally, to the building's energy retrofitting and the environmental impact assessment of the thermal insulation materials of the apartment, the installation of an extensive green roof as a more sustainable and profiting solution will be investigated. Green roofs offer numerous benefits regarding the building industry, since they decrease surface temperatures and enhance thermal comfort. In this study the LCA will be carried out with the help of the SimaPro software.

The current thesis aspires to contribute to the promotion of both energy-efficient and sustainable solutions for the building industry by presenting a practical example of the application of modern technologies on an existing structure.

Keywords

Life Cycle Assessment, green roofs, energy retrofitting, thermal insulation, SimaPro

PROPAGATION OF HIGH-INTENSITY NOISE

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ABSTRACT

The propagation of sound originating from high intensity sound sources such as fighter jets, supersonic aircrafts or powerful explosions, is of interest as the propagation deviates from prediction of the linear acoustic theory. The signal undergoes nonlinear distortion as it propagates until a shock is generated after a certain propagation distance. In the present thesis an algorithm is presented that switches back and forth between the time domain and the frequency domain and predicts the propagation of sinusoidal signals in the atmosphere. The atmosphere is considered still and homogeneous with main absorption mechanisms thermoviscosity and the molecular relaxation of oxygen and nitrogen. The nonlinear propagation effects combined with the absorption effects are mathematically described by a form of the Burgers equation. The equation is solved term-by-term at each propagation step, the nonlinear distortion and the thermoviscous effects are calculated in the time domain and the molecular relaxation effects in the frequency domain. Firstly, the accuracy of the algorithm is investigated. The results are compared with analytical solutions for a lossless medium at different distances from the source (pre-shock and after-shock regions). Results are also compared for the linear case with results from the ANSI SI.26-1995 standard tables. Subsequently, results are presented for the effect of: (i) the characteristics of the initial sound signal and (ii) of the atmospheric conditions during propagation. It is shown that initial signals with high intensity and low frequency cause increased noisiness (that is large peak values of the acoustic pressure and short rise times from zero-valued pressure to the maximum pressure). A high intensity signal of low frequency causes increased noisiness as it propagates under conditions of high temperature and high relative humidity). A high intensity signal of high frequency causes increased noisiness as it propagates under conditions of low temperature and low relative humidity.

Keywords

Burgers equation, Time and Frequency domains, Nonlinearity, Atmospherical absorption, Increased noisiness

COMPUTATIONAL SIMULATION OF AIR CONDITIONING FLOW FIELD FROM CIRCULAR SWIRLING GRILLES

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ABSTRACT

In this thesis, the aim is to study the air flow through grilles in a room of specific dimensions, to calculate and evaluate their characteristic variables. These are related to the velocity distribution, rise, throw, drop, spread and the pressure drop of the air beam. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (V_c = 10 m/s). The region of interest is where a person feels comfortable in room conditions, which in this study was defined as the one with air velocity of 0.5 m/s. The turbulence model used to predict the region is the k-omega. Among other things, the turbulence models, discretization methods and algorithms for solving the equations are presented. Grilles of different types of design and use were tested and compared. The grilles to be studied were designed in SOLIDWORKS, while the computational investigation and visualization of the results were performed with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was performed by a colleague, which is not included in this study.

Keywords

Grilles, Air beam, Comfort, Finite elements, Computational fluid dynamics

COMPARISON OF THEORETICAL AND ACTUAL ENERGY CONSUMPTION OF BUILDINGS FROM ENERGY PERFORMANCE CERTIFICATES & ENERGY AUDITS

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ABSTRACT

The present study aims to compare the theoretical and actual energy consumption of buildings through the collection of Energy Performance Certificates & Energy Inspections and the collection of relevant data from field research through Energy Inspections of selected buildings. The comparison of theoretical and actual energy consumption of buildings is of major importance, as through this, we can make more realistic estimates of energy consumption and pollutant emissions. This thesis includes two main axes of research. The first axis is the collection, process and comparison of theoretical primary energy consumption and CO_2 emissions from available Energy Performance Certificates with the actual electrical and thermal energy consumption from electricity and fuel bills, of the buildings which we have data. This is followed by the correlation od theoretical values of primary energy consumption and emissions with the actual values, with the aim of calculating a linear relationship between the results and to derive correction factors for each building category.

In the meantime, the updated values of the conversion factors for the final to primary energy consumption (Primary Energy Factor) and the calculation of emissions per unit of energy are determined. On this basis of the updated coefficient, the values of actual primary energy consumption and pollutant emissions shall be recalculated and compared with the initial values. The second axis of the thesis is the energy audit of three buildings of different ages and HVAC installations and the study of three scenarios of energy interventions in each building. The software "TEE-KENAK" was used for the calculations. From the calculations, the theoretical energy consumption and energy savings are obtained for each energy intervention scenario. Finally, the empirical correction factors for final energy, were applied and the actual energy savings for each energy intervention scenario were estimated.

Keywords

Empirical Final Energy consumption coefficients, Energy Performance Certificate (EPC), Primary Energy Conversion Factors (P.E.F.), Energy Inspection of Buildings, Hellenic regulation on the energy performance in the building sector (KENAK)

PHOTOVOLTAIC COLLECTORS WITH SPECULAR AND DIFFUSE REFLECTORS

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ABSTRACT

Initially, a theoretical background on the operating principles of photovoltaic systems, their applications, and the factors affecting their performance is presented. Following this, the geometry of the Sun, the law of reflection, and models for predicting the monthly incident solar radiation are analyzed. The aim of this thesis is to study the performance behavior of a photovoltaic array using flat specular or diffuse reflectors. To achieve this goal, three mathematical simulation models of the arrays were developed and subsequently implemented in the Matlab programming language. Specifically, the first model aims to increase the incident solar radiation using diffuse reflection from a layer of white reflective paint on the ground. The second model uses a flat specular reflector placed at a fixed angle, while the third utilizes a diffuse reflector. The solar geometry and radiation data were obtained from the TOTEE-3 for the region of Patras. The results are analyzed and compared in the form of tables and charts using an Excel spreadsheet. Finally, histograms of the points of incidence of the reflected rays on the surface of the frame are presented to avoid the creation of hot spots.

Keywords

Phtotovoltaic systems, Sun geometry, solar radiation, specular reflectors, diffuse reflectors

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING GRILLES OF JET TYPE WITH ROTATED NOZZLE SUITABLE FOR WALL AND ROOF INSTALLATION

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ABSTRACT

The aim of this dissertation is to examine the air flow from JET type nozzles in a room of defined dimensions and to analyze its characteristic quantities (velocity at the nozzle outlet, throw, rise, drop, spread, pressure drop, noise level). The characteristic quantities of the flow were identified through simulations in ANSYS Fluent for the case of zero temperature difference between the incoming air and the air present in the room, as well as for DT=-5 K and DT=+5 K. The first chapter presents the introduction which includes a brief history of air conditioning as well as the purpose of the study and the structure of the dissertation. The second chapter presents the theoretical framework where the functions of ventilation are described as well as the basic principles of air conditioning and the components of its systems. Particular emphasis is given to grilles, their types and the definition of characteristic flow sizes. The third chapter gives a detailed description of the experimental study (installation, instruments, procedure) conducted and compares its results with the computational results. In the fourth chapter, reference is made to the Computational Fluid Dynamics (CFD) and the algorithms for solving CFD equations, turbulence and viscosity models are presented. Chapter five presents the methodology and problem design (discretization methods, mesh generation methods for the geometry and nozzles analyzed). In the sixth chapter the results are presented. For the analyses, the maximum tolerable air exit velocity from the nozzles was 10 m/s and the air velocity that defined the area of interest (the <<balloon>> air) was 0.5 m/s. Finally, the seventh chapter includes the discussion and the conclusions of the present study in which the findings of the current study are discussed in comparison to other relevant experimental studies and important conclusions are drawn for the use of the nozzles.

Keywords

Nozzle, air flow, characteristic sizes, computational fluid dynamics, finite elements

OPERATIONAL SIMULATION OF SHELL AND TUBE HEAT EXCHANGER FOR INDUSTRIAL APPLICATIONS USING COMPUTATIONAL FLUID DYNAMICS

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ABSTRACT

This thesis focuses on the study of the operation of a shell and tube heat exchanger using computational fluid mechanics (CFD), specifically the cooling of transformers' oil with water as a coolant. The simulations performed showed that the exchanger achieves a high heat transfer rate, indicating that its design is efficient in transferring heat from the hot oil to the cold water. The effectiveness of the system is attributed to the large contact surface between oil and water and the use of materials with high thermal conductivity. Also, optimizing the flow of water and oil inside the exchanger contributed to efficient heat transfer. The results showed that the exchanger manages to effectively cool the oil of the transformers, with a significant reduction in oil temperature and a very small increase in water temperature, thus maintaining high energy efficiency.

The use of CFD provided valuable information to optimize system performance, allowing the analysis of parameters such as flow velocity and inlet and outlet temperature. This allows for testing and improvements without the need to build physical prototypes. Future research could focus on exploring different exchanger construction materials and the use of other coolants, offering alternative solutions for oil cooling.

Keywords

Heat exchanger, Computational fluid mechanics (CFD), Shell-and-tube exchangers

SOLUTION OF BENCHMARK FLOW PROBLEMS USING PINNs (PHYSICS INFORMED NEURAL NETWORKS)

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ABSTRACT

The numerical solution of partial differential equations (PDEs) plays an important role in understanding and predicting various physical phenomena such as fluid dynamics and heat transfer. In recent years, the use of Neural Networks has been proposed as a means of solving such equations, and recent research highlights them as a promising approach to address the challenges presented when applying classical numerical solution methods. The present study focuses on the problem of fluid flow over a square-shaped cavity, a classic scenario where a fluid is enclosed inside a square container and its motion is guided by one of the container boundaries. It begins with a brief introduction to the theoretical basis of simple Neural Networks and then Physics Informed Neural Networks, demonstrating their ability to integrate the differential equations and physical constraints of the problem. The ability of the constructed model to solve the differential equations of the problem is then examined through a series of experiments and analysis of results. In summary, this work provides a comprehensive overview of the operation and application of neural networks to solve flow problems while simultaneously opening doors to explore PINNs in more complex fluid flow scenarios.

Keywords

Neural Networks, PINN (Physics-Informed Neural Network), Partial Differential Equations (PDEs), Lid-driven cavity flow, Navier-Stokes equations

EXPERIMENTAL INVESTIGATION OF AIR FLOW FIELD FROM AIR-CONDITIONING LINEAR GRILLES WITH FIXED VANES INSTALLED WITH DIFFERENT STEP AND INCLINATION OF THE JET AND LINEAR GRILLES OF SLOT TYPE WITH INTERNAL CYLINDRICAL REGULATOR OF THE FLOW DIRECTION

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ABSTRACT

This thesis aims to study the airflow from grilles within a room of specific dimensions, in order to calculate and evaluate certain characteristic metrics. The objective of indoor air conditioning is to create conditions of comfort and a healthy environment for the occupants, which is achieved by examining key characteristics of an air conditioning system. These characteristics include throw, rise, drop, spread, noise level, pressure drop and critical velocity. Experimental measurements take place in a laboratory room of the Fluid Mechanics Laboratory at the University of Patras, in the Department of Mechanical and Aeronautical Engineering. The room has dimensions of (10 m x 5.5 m x 2.75 m) and simulates a workspace environment, similar to an office setting or a classroom. The experimental section consists of three categories of grilles, with the first two categories containing three grilles each and the third containing two, which are differentiated based on certain criteria. The upper limit of critical velocity from the free surface of each grille is defined as Vc = 10 m/s. The experimental procedure followed is based on taking measurements of air velocity in all three axes with a constant step for each axis, until air velocity equal to 0.5 m/s is found in all three axes of the space. Velocity measurements are made for different air flows to form a profile for the grille under study, while for each flow the noise level of the grille is also measured. The achievement of this process is done with the help of measuring instruments, specifically an anemometer and a sound level meter. The aim of the experimental measurements is to investigate the variation of the characteristic metrics for each category of grilles. To verify the experimental

measurements, a computational study using computational fluid dynamics was conducted by a colleague for category A grilles.

Keywords

Grilles, air beam, ventilation system, comfort, experimental measurements

Division of Management and Organization Studies (June 2024)

INTELLIGENT SOLUTIONS FOR THE RECRUITMENT PROCESS

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ABSTRACT

The recruitment process has undergone significant transformation in recent years with the advent of advanced technologies, such as the introduction of artificial intelligence (AI) tools. These technologies have created new solutions for candidate sourcing, resume analysis, interviews, and other aspects of the recruitment process. The integration of these technologies has changed how organizations approach human resource management, offering new ways for automation, optimization, and more effective management of processes.

The purpose of this literature review is to provide a comprehensive overview of current advanced recruitment solutions, including the advantages and limitations of each technology. The first chapter reviews traditional methods and means of recruitment. Then, in the next two chapters, various technologies such as Natural Language Processing (NLP), Machine Learning Algorithms, and chatbots are examined. The ways in which these technologies improve the accuracy and efficiency of recruitment, providing a more objective and fair candidate evaluation process, are analyzed.

Additionally, reference is made to specific tools and platforms such as Fetcher, XOR, AllyO, and Talkpush, which utilize artificial intelligence to automate and optimize the recruitment process. Each tool is presented with details about its functionality, the technologies it uses, as well as user evaluations and experiences.

Finally, a new recruitment platform idea for startups and innovative ideas, Bridg-IT, is presented. This platform aims to bridge the gap between individuals with innovative ideas and professionals with the necessary skills to implement these ideas. This platform will use advanced AI technologies, mentioned in previous chapters, to match ideas with the right collaborators and will provide integrated project management solutions to facilitate real-time collaboration.

With the completion of this literature review, the innovations brought by new technologies in the recruitment process are highlighted and it is analyzed how these can be used for the further improvement of human resource management.

Keywords

Recruitment, Artificial Intelligence, Machine Learning, Human Resource Management

PREDICTIVE MAINTENANCE IN ERP SYSTEMS: STUDY OF DIFFERENT CASES AND SUCCESSFUL APPLICATIONS IN MODERN INDUSTRIES

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ABSTRACT

This thesis examines the significant importance of Enterprise Resource Planning (ERP) systems in modern industrial facilities and the critical role of integrating predictive maintenance into ERP through a literature review. ERP systems are essential in contemporary industries due to their ability to streamline various business processes, enhance productivity, and facilitate real-time data management. By providing a centralized platform for data integration and process automation, ERP systems enable companies to achieve operational efficiency, reduce costs, and improve decisionmaking. The implementation of predictive maintenance within ERP systems represents a significant advancement in maintenance strategies. Predictive maintenance leverages data analysis and machine learning to predict equipment failures before they occur, thereby optimizing maintenance schedules and minimizing downtime. By integrating predictive maintenance into ERP systems, businesses can fully utilize their data, leading to more accurate and timely maintenance interventions, contributing to cost savings, preventing unexpected failures, and reducing unnecessary maintenance activities. Finally, a case study on predictive maintenance of pumps using the SAP data platform is analyzed, and five different algorithms are compared in terms of their performance.

Keywords

ERP Systems, Modern Industry, Predictive Maintenance, SAP Platform, Machine Learning Algorithms

DEVELOPMENT OF A PYTHON TOOL FOR GRAPH-BASED REPRESENTATION OF MULTIPLE TEXTS

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ABSTRACT

In this thesis, we present the construction of a Python code, a tool for representing an entire corpus of documents as a single graph, as proposed by Giarelis et al. (2020). This model enables the representation and operation of a wide variety of graph-based algorithms in fields such as natural language processing, along with a bibliographical study of the graph theory used and the evolution of the field from earlier techniques of information retrieval (IR) to the graph approaches prevalent today.

Our tool introduces a novel approach, describing and creating a single graph that incorporates all the documents from a given set. This capability allows operations on the entire set with functionalities that were previously unattainable due to limitations in earlier approaches, such as the lack of metrics between different documents and the absence of a structural framework to analyze words, sentences, and documents as a cohesive unit.

It is implemented in Python 3.9 and utilizes other libraries such as NetworkX (Hagberg, Swart & Chult, 2008), offering flexibility in creating the appropriate graph-of-docs. Chapter 2 presents the theoretical background of graph theory and state-of-the-art approaches, while Chapter 3 demonstrates use cases, providing an explanation of the code as an implementation of the graph-of-docs representation model. Finally, chapter 4 concludes our work and proposes future directions.

Keywords

Graph-of-docs, Natural language processing, Graph-based algorithms, NetworkX, Document Representation, Graph Theory

STOCK PRICE PREDICTION USING REAL STOCK MARKET TRANSACTIONS DATA THROUGH THE INTEGRATION OF MACHINE LEARNING TECHIQUES (MLT) AND NATURAL LANGUAGE PROCESSING (NLP) METHODS

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ABSTRACT

This thesis investigates the application of Deep Learning and Natural Language Processing (NLP) techniques in predicting the stock prices of the Magnificent Seven stocks, namely Apple (AAPL), Microsoft (MSFT), Amazon (AMZN), Alphabet (GOOGL), Meta Platforms (META), Tesla (TSLA), and Nvidia (NVDA). The primary objectives are to demonstrate the superior performance of deep learning methods, particularly a novel architecture combining Generative Adversarial Networks (GAN) with NLP, over traditional approaches, to evaluate the impact of incorporating NLP data on prediction accuracy and to address the implications for the Efficient Market Hypothesis (EMH), which posits that stock prices fully reflect all available information. A quantitative methodology was employed, utilizing stock price data sourced from Yahoo Finance. The study finds that models based on Long Short-Term Memory (LSTM) networks and GANs, when integrated with NLP data from tweets, outperform traditional methods such as the AutoRegressive Integrated Moving Average (ARIMA). However, the performance of these models varies according to the specific stock and its volatility, suggesting that different models may be optimal under different conditions. These results highlight the potential benefits of advanced deep learning models, particularly those augmented with NLP, in enhancing the accuracy of stock price prediction. Moreover, the findings contradict the EMH by demonstrating that our models achieved statistically significant improvements in prediction accuracy. The findings contribute to the growing body of knowledge on the application of AI and Machine Learning in financial markets and suggest directions for future research.

Keywords

Stock Prediction, Deep Learning, Long Short-Term Memory, Generative Adversarial Networks, Natural Language Processing

ENERGY COMMUNITIES IN GREECE AND IN EUROPE

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ABSTRACT

The rapid development of the environmental crisis has created a major energy issue, which is constantly getting worse. The energy crisis was exacerbated by the military, political, economic and social crises of the modern era due to the turning points in history, such as the wars in Ukraine and Palestine. Highlighting the energy crisis makes it even more necessary to democratize energy and combat or even examine "Energy Poverty", which makes the creation of related actions particularly imperative. The Energy Communities (ECs) and the use of Renewable energy sources for energy production can yield those tools, which will lead to the democratization of energy, but also of its management. The establishment and administration of the ECs. is done by citizens, who have equal rights regardless of share, a fact that ensures the equality of the community. The purpose of the ECs is the benefit of the members, without making profit their own goal, but access to energy and its management as a social good with the aim of eliminating or even reducing "Energy Poverty". This work was addressed to the members of the ECs in order to investigate their mode of operation, their motivations, but also their mode of operation, according to the answers to the questionnaires.

Keywords

Environmental Crisis, Renewable energy sources, Energy Communities, Energy Poverty, Democratization of Energy

ANALYSIS AND DESIGN OF AN INNOVATIVE PUBLIC DELIBERATION PLATFORM

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ABSTRACT

The subject of the present diploma thesis is a meticulous examination of existing public deliberation platforms through comprehensive registration and comparative study, followed by the conceptualization and design of a pioneering platform. The initial phase entails a detailed exploration of established systems, documenting key features, functionalities, and shortcomings while conducting a comparative analysis to identify prevailing trends and technological architectures. Subsequently, the thesis transitions into proposing the design of a novel deliberation platform, integrating original concepts and methodologies aimed at enhancing user engagement and addressing identified limitations. Detailed sketches and prototypes of the platform's user interface (UI) are presented, informed by a synthesis of research findings and user-centric principles. This thesis contributes to advancing digital tools for democratic engagement and civic discourse, with a focus on fostering inclusive, transparent, and participatory deliberative processes to inspire new directions in the field of digital democracy and public engagement.

Keywords

Deliberation, Platforms, Comparative Study, Analysis, Design

INVESTIGATION AND PRESENTATION OF THE SUPPLY CHAIN PRODUCTION OF LIQUID BIOFUELS IN GREECE

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ABSTRACT

Investment in biofuels, as sustainable alternatives for fossil fuels, has gained momentum over the last decade due to the global environmental and health concerns regarding fossil fuel consumption. Hence, effective management of biofuel supply chain (BSC) components, including biomass feedstock production, biomass logistics, biofuel production in biorefineries, and biofuel distribution to consumers, is crucial in transitioning towards a low-carbon and circular economy.

This thesis presents the basic concepts of bioenergy and biomass, examines the current sources of biomass at the global and Greek level, the current technological applications and the level of adoption in energy production.

The liquid biofuels sector in Greece is then analyzed and an emerging but dynamically evolving landscape is revealed, characterized by increasing investments in technology, infrastructure and regulatory frameworks. The development of the biofuels sector is expected to have profound effects on the Greek energy sector. By reducing dependence on imported fossil fuels, biofuels contribute to greater energy security and stability. The environmental benefits are just as important, as biofuels emit fewer greenhouse gases compared to conventional fossil fuels, helping Greece meet EU emissions targets.

At the same time, the perspectives of the biofuel supply chain (BSC) are analyzed, focusing on possible improvements, innovations and growth expectations in Greek energy. Designing a sustainable biomass-biofuel supply chain is a major challenge, starting from the choice of the type of energy plants/raw material and their cultivation areas, the collection, storage and transport of biomass, the choice of technologies and the construction size of processing units and conversion into intermediate products and biofuels.

Keywords

Bioenergy, Biomass, Biofuels, Supply Chain.

RECCOMENDATION PLATFORM FOR MUSICAL COMPOSITIONS

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ABSTRACT

In the current era, where competition of digital services keeps rising, designing information systems that can implement modern technological advancements, and correspond to the needs of those for whom they're designed for, is a field where many engineers are involved. The present thesis consists of a literature review of some kinds of information systems, and a design proposal for an information system, based on the literature review.

The first part of the literature review refers to recommendation systems. Basic concepts are presented, followed by the basic algorithm categories. In detail, Collaborative Filtering, Content based Filtering and some complementary algorithms are presented, together with hybrid algorithms, which are mostly present in today's meta.

The second part of the review consists of a presentation of music analysis and categorization systems. This chapter begins with a reference of the moderns means of digital music representation and continues with a presentation of the contributions of machine learning in the field of music categorization and analysis. There is also a case study of a recommendation system which categorizes works of music using a neural network.

In the third and final part of the literature review, there is a presentation of some existing digital tolls used for music learning assistance, with a focus on how these tools help the musician develop their skillset.

The information system designed for the purpose of this thesis is a complete musical learning assistance system, intended to be used by self- taught musicians, with a focus on versatility and low cost of maintenance and further development. The system is able to make personalized recommendations of musical works and exercises to the user and supplement him with the tools required to study them.

Keywords

Recommendation Systems, Machine Learning, Music, Information Systems

OPTIMAL GROUPING OF EMPLOYEES WITH DIFFERENT LEVELS OF WORK EXPERIENCE IN PROJEXT ACTIVITIES

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ABSTRACT

Human Resources allocation to project activities throughout its scheduling seems to constitute one of the most fundamental pillars and indicators of the social as well as the financial prosperity of a modern enterprise. Thus, the optimization methods are considered to be crucial with the aim of decreasing the operational cost, deploying all the available personnel and minimizing the inactivity of each employee. It should be noted that this category of problems is being studied with the assistance of evolutionary algorithms, particularly genetic ones, since it is a rather complicated case and a lot of time is required for the aforementioned problems to be addressed. As for the genetic algorithms, which are the most widespread form of evolutionary algorithms, follow the principles of Evolutionary Theory (using the suitable software) and provide the optimum solutions in everyday life problems of human resources allocation in project activities, within a reasonable time with quite a lot of application flexibility. This is precisely what the current thesis tried to approach in order to optimize the construction processes of a metal building by applying evolutionary algorithms using the ExtendSim v8 software. The primary focus was on modeling the system of this case study to apply evolutionary optimization in determining the optimal mix of working times for two types of workers with different levels of experience in the project activities. The ultimate goal was to minimize the labor cost of constructing the metal structure.

Keywords

Allocation of Human Resources, Project scheduling, Evolutionary Optimization, Project staffing.

MULTICRITERIA ANALYSIS OF ALTERNATIVE SITES FOR THE INSTALLATION OF SOLAR PARKS

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ABSTRACT

The purpose of this thesis is to investigate the possibility of integrating solar energy systems with Geographic Information Systems (GIS) in order to enhance the effectiveness and efficiency of solar energy implementation. In addition to being an important kind of renewable energy, solar energy also offers a myriad of benefits to both the economy and the environment. However, it faces challenges like as poor energy conversion, large upfront expenditures, and the variable nature of solar light. These are all disadvantages. This study investigates the characteristics of solar radiation, namely the direct, diffuse, and reflected types, as well as the impact that these characteristics have on the effectiveness of energy acquisition. In order to have a better understanding of the performance metrics, scalability, and cost-effectiveness of various energy conversion technologies, such as photovoltaic systems and solar thermal systems, an analysis is carried out on these technologies. The research highlights the critical significance of Geographic Information Systems (GIS) in addressing significant issues, such as identifying the most appropriate locations, storing energy in an efficient manner, and integrating with the power grid. The Geographic Information System (GIS) offers detailed geographical analysis and visualization, which in turn allow for more informed decision-making processes. The study demonstrates how geographic information systems (GIS) may be used in combination with solar energy systems to significantly improve the location and efficiency of solar installations. This, in turn, leads to improved energy management and a smaller environmental imprint. In addition, the thesis investigates the prospective uses of solar energy in the future, assessing the advancements in technology as well as the rising acceptability of innovative solutions. In addition to this, it investigates the legislative and planning implications of using GIS for renewable energy programs. It emphasizes the need of evidence-based policies and comprehensive planning in order to achieve long-term development. According to the findings, geographic information systems have the potential to significantly enhance the

efficiency of solar energy efforts in terms of both strategy and execution. The purpose of this research is to provide a comprehensive analysis of the positive results that may be achieved by combining contemporary GIS methods with solar energy technology. Additionally, it provides solutions that may be put into practice to conquer the challenges that are now being faced and to encourage additional research and policy development within the renewable energy sector.

Keywords

Solar Energy, Geographic Information Systems (GIS), Renewable Energy, Solar Radiation, Photovoltaic Systems, Energy Conversion, Site Selection, Energy Storage, Grid Integration, Sustainable Energy, Decision-Making, Energy Efficiency, Environmental Impact, Renewable Energy Planning, Smart Grids.

DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS (SEPTEMBER 2024)

HYDROGEN EMBRITTLEMENT OF AUSTENITIC STAINLESS STEEL PROCESSED BY ADDITIVE MANUFACTURING

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ABSTRACT

In this thesis, the mechanical degradation of 304L austenitic stainless steels (ASS) produced by additive manufacturing (AM) under the influence of hydrogen embrittlement (HE) is examined. Hydrogen, while a significant energy carrier, has disadvantages that can render it hazardous and unpredictable when interacting with metallic alloys. Initially, a brief review of the fundamental principles of HE and its effects on ASS is presented. ASS is widely used in industry due to its good mechanical and corrosion properties. Moreover, AM is a promising method for producing ASS, allowing the fabrication of geometrically complex components. The microstructural characteristics of AM-ASS differ from those of conventionally manufactured (CM) due to the layer-by-layer printing process and the associated complex thermomechanical cycles. In specific, the material exhibits characteristic cellular solidification structures, the boundaries of which have dense dislocations. The dislocation cells provide significant work hardening to the material, however their role on HE is unknown.

In this study, AM 304L ASS specimens produced by Laser Powder-Bed Fusion (LPBF) were used, both in their As-Built condition and following annealing treatment at 800 °C and 1100 °C, to dissolve the dislocation cell or to fully grow the grains in the material, respectively. To determine the impact of HE, a cathodic charging setup was used to introduce hydrogen into the examined steels. The charging parameters were a constant charging time (48 hours) and current densities of 20 and 40 mA/cm² for the hydrogen-charged specimens. The materials exhibit different strain hardening due to the deformation-induced martensite (TRIP effect) and different HE behavior. Thus, immediately after the cathodic hydrogen charging, tensile tests were conducted to determine the influence on ductility for the hydrogen-charged specimens. The observations are discussed in the context of different microstructures in the three material variations. Finally, the results for all types of steel were compared, and scanning electron microscopy (SEM) was used to obseve the fracture characteristics.

Keywords

Hydrogen embrittlement, austenitic stainless steels, additive manufacturing, Laser Powder-Bed-Fusion (LPBF), cathodic hydrogen charging, loss of ductility, work hardening rate.

ANALYTICAL MODELING OF FRACTURE BEHAVIOUR OF DELAMINATION TYPE SPECIMENS UNDER MODE II HIGH-SPEED LOADING CONDITIONS

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ABSTRACT

In this work, an analytical model is developed for the calculation of the Energy Release Rate (ERR) under high-rate mode II loading conditions, specifically at crack initiation. The model analytically represents an End-Loaded Split (ELS) specimen. Timoshenko beam theory is used to model both bonded and unbonded regions of the specimen and a simple contact condition is applied for the unbonded region. This study introduces the influence of shear in the dynamic behavior of the specimen under high- rate loading conditions through Timoshenko beam theory. It also investigates the presence of pure mode II conditions under high- rate loading. The presented analytical model is validated by a 2D FEA model that simulates the experiments. It is also compared with an analytical model available in literature, that uses the Euler-Bernoulli beam theory to model the specimen. Additionally, a method is suggested to determine a minimum threshold for crack initiation time, beyond which the loading conditions can be considered pure mode II when employing the standard End-Loaded Split configuration. The results demonstrate the dependency of the ERR on the vibrational characteristics of the specimen, highlighting that incorporating shear effects in the analytical model provides results closer to those obtained numerically. The study confirms that, in order to achieve pure mode II loading in an ELS specimen under high-speed conditions, displacement must be applied to both adherents. If the displacement is applied to both adherents, there is no need to model complex contact conditions. Also, the fact that symmetrical boundary conditions are applied, prevents the development of a mode I component in the ERR.

Keywords

Mode II fracture, End Loaded Split, High-speed loading, Beam vibration, Energy Release Rate, Timoshenko Beam Theory

STRUCTURAL ANALYSIS OF CRYOGENIC HYDROGEN TANKS AND THEIR INTEGRATION INTO AIRCRAFT FUSELAGE

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ABSTRACT

In this Diploma Thesis entitled "Structural analysis of cryogenic hydrogen tanks and their integration into aircraft fuselage" the importance of turning to hydrogen as a fuel to cover the energy needs of modern society is primarily analyzed. Its abundance in the environment and the zero emissions of carbon dioxide during its combustion lead to the study of its introduction and use in another important area, that of aviation. However, the obstacle of the environmental impact of hydrogen production methods has not yet been overcome, since up to now they are extremely expensive and energy-intensive. Then, the use of hydrogen is a huge challenge for engineers, as its storage methods require thoroughness and specific conditions to meet all safety protocols. In addition, in this work, the structure and dimensioning of an internal tank, carrying hydrogen in cryogenic conditions, and the external auxiliary tank, the connection of them and the materials used are presented. At the same time, the design of a fuselage section, in which the hydrogen tanks are integrated, is carried out, and the support between them (i.e. tanks with fuselage) is chosen. Finally, with the help of the ANSYS Mechanical APDL program, the geometry to be studied is designed, the necessary results are extracted and evaluated and optimization methods of the problem are proposed.

Keywords

Cryogenic hydrogen tanks, Support, Fuselage, Construction materials, Structural analysis

DESIGN, ANALYSIS AND OPTIMIZATION OF A DE-ORBITING SYSTEM FOR NANO-SATELLITES

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ABSTRACT

This thesis focuses on the design, analysis, and optimization of a deorbiting system for 6U nanosatellites using a drag sail. The system aims to reduce the time nanosatellites remain in low Earth orbit (LEO) after the end of their operational life, helping to prevent the accumulation of space debris. The study includes the CAD design of the deployment mechanism for the foldable components, material analysis, and the conduction of experiments to evaluate the performance of the mechanism. Additionally, a key advantage of the design is its flexibility. This feature not only improves mission performance but also extends the system's applicability to a wide range of deorbiting scenarios. Finally, MATLAB simulations demonstrated that with the use of the drag sail, the satellite would re-enter the atmosphere within approximately 4 years, compared to the 37 years that would be required without it. The results confirm the system's effectiveness, supporting compliance with international regulations that mandate satellite deorbiting within 25 years of mission completion.

Keywords

Nanosatellites, Deorbiting system, Deployable booms, drag sail, Computer-Aided Design (CAD)

CONCEPTUAL DESIGN OF A TURBOFAN-BASED LOYAL WINGMAN UAV: TOWARDS A CLASS-III AIRCRAFT

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ABSTRACT

This thesis presents the conceptual design of a 1-tonne turbofan-based Unmanned Combat Aerial Vehicle (UCAV) envisioned to function as a Loyal Wingman, designed to operate in tandem with manned aircraft and enhance mission versatility through advanced electronics, sensors, and AI integration. The study begins with a comprehensive review of UAV classifications, historical developments, and state-of-the-art technologies, emphasizing the critical role of AI in flight control systems for unmanned aerial systems (UAS). The unique mission requirements and lack of empirical data for UCAVs prompted the decision to develop a new design from scratch. The comparative outlines key characteristics for a competitive UCAV and informs the conceptual design, where aircraft requirements are defined based on data from developmental UCAVs, supplemented by data from Class-III UAVs (NATO classification) and comparable manned aircraft. After concluding the conceptual design, performance sizing is conducted, validating the minimum thrust and reference area based on five performance criteria. The next step involves the wing design, focusing on optimizing the sweep angle, taper ratio, and thickness-to-chord ratio to minimize drag and meet fuel storage and transonic flight requirements. Once the necessary thrust is determined, engine selection and fuselage design are conducted concurrently to ensure internal layout efficiency. A V-tail design is implemented based on transformations on the conventional tail that was previously designed for reference, achieving desired stability characteristics. The thesis also addresses center of mass estimation, refined using OpenVSP software for subsystem placement, and the design of a functional landing system within geometric constraints.

Finally, technical considerations such as radar cross-section mitigation, potential aerodynamic optimizations, and weight reduction strategies are discussed. The study concludes with future work recommendations to guide further analyses and detailed design efforts, mainly focusing on using more sophisticated CFD tools for the aerodynamic analysis to further enhance the overall efficiency and performing extensive material and aeroelasticity analyses to determine the aeroelastic and structural behavior of the UCAV. The final design can serve as a reference point for future studies on conceptual and preliminary UCAV design, providing a foundation for further research and development in this field and electronic system and flight control design and integration.

Keywords

Unmanned Aerial System, Loyal Wingman, UCAV, turbofan, Conceptual Design, Aircraft layout optimization

LAMB WAVES BASED DAMAGE DETECTION, QUANTIFICATION AND LOCALIZATION USING SIMULATION BASED REDUCED ORDER MODELING AND ARTIFICIAL INTELLIGENCE

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ABSTRACT

In recent years, Structural Health Monitoring and its aspects, including Damage Detection, Quantification, and Localization, have gained significant attention and scientific interest from the engineering community. The increasing complexity and performance demands of advanced engineering structures operating in harsh environments and under extreme loading conditions necessitate high-precision information about their structural conditions to ensure high levels of safety. Accurate structural monitoring allows for proper evaluation based on real data, enabling early maintenance actions that can extend the useful lifespan of structures. This proactive approach is a marked improvement over traditional scheduled-based maintenance practices. One important technique in structural monitoring that has been a focus of recent research is the use of Lamb waves, which propagate in thin-walled structures, a common configuration in modern engineering. The capabilities of Lamb wave monitoring, combined with advances in data-driven and machine learning techniques in SHM, offer considerable advantages in overcoming the drawbacks that have previously hindered the widespread implementation of structural monitoring systems. This thesis presents an implementation of a monitoring system framework for a simple structural member, specifically an aluminum plate, utilizing Lamb wave propagation and Artificial Intelligence. The Finite Element Method is employed to produce numerical data for a grid of virtual sensors on the plate. Artificial damages are modeled on the plate using eight Young's modulus reduction factors to simulate different damage scenarios. After this, damage detection, quantification, and localization are performed using machine learning and deep learning techniques. These techniques extract features from the time, time-frequency domains and also autoregressive models to achieve accurate results. To address the high computational cost of numerical simulations, surrogate and reduced order models are constructed using deep learning techniques to replicate the numerical solver and generate highquality data rapidly. From this analysis, important conclusions are extracted about modeling such a system with Machine Learning based Surrogate Models. This integrated approach showcases the potential of combining Lamb wave monitoring with AI to enhance the effectiveness and efficiency of structural health monitoring systems.

Keywords

Finite Element Method, Uncertainty Quantification, Machine Learning, Deep Learning, Surrogate Modeling, Reduced Order Modeling, Structural Health Monitoring, Artificial Intelligence, Lamb Waves

SYSTEM DESIGN FOR VLEO SMALL SATELLITE MISSION

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ABSTRACT

This thesis explores the design of a system tailored for the operation of Very Low Earth Orbit satellites. VLEO orbits, characterized by altitudes below, 450 kilometers, pose unique challenges and opportunities for satellite missions. Understanding the intricacies of this orbital regime is paramount for developing effective satellite systems capable of thriving in this demanding environment.

The introductory chapter provides a comprehensive overview of VLEO, elucidating the heightened atmospheric drag, radiation exposure, and short orbital lifetimes that distinguish this orbital domain. By contextualizing the significance of VLEO research in the broader landscape of satellite technology, the thesis underscores the approaches to address the challenges posed by VLEO operations.

The core of the thesis centers on the systematic design and analysis of essential subsystems critical for the functionality of VLEO satellites. Propulsion, communication, power, and payload systems are meticulously designed to optimize performance metrics while mitigating the inherent risks associated with VLEO operations. Leveraging insights from existing literature and technological advancements, the proposed system architecture represents a holistic approach to addressing the unique demands of VLEO satellite missions.

Methodologically, the thesis employs state-of-the-art simulation tools and modeling techniques to evaluate the performance of the designed system under varying environmental conditions and mission scenarios. Simulation results offer valuable insights into the feasibility and efficacy of the proposed VLEO satellite system, enabling informed, decision-making in mission planning and execution.

The discussion section critically interprets the findings, elucidating the implications, limitations, and future directions of the proposed VLEO satellite system design. Through rigorous analysis and synthesis of data, the thesis contributes to advancing knowledge in satellite engineering.

In conclusion, the thesis underscores the significance of systematic design methodologies in tackling the challenges inherent in VLEO satellite missions. By proposing a comprehensive system architecture and substantiating it with rigorous analysis, this research lays a foundation for future advancements in VLEO satellite technology, with far-reaching implications for applications ranging from Earth to observation to telecommunications.

Keywords

VLEO, System Design, Satellite Engineering, Simulation Modeling, Mission Feasibility

DIVISION OF DESIGN AND MANUFACTURING (SEPTEMBER 2024)

FAULT DIAGNOSIS OF QUADCOPTER PROPELLERS UNDER NORMAL FLIGHT CONDITIONS VIA VIBRATION-BASED MACHINE LEARNING METHODS

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ABSTRACT

This study investigates the potential of diagnosing structural faults (damages) in the propellers of a commercial quadcopter, with diagnosis referring to damage detection and damage type identification, based on vibration signals and machine learning methods. Considering the importance of remote health monitoring for aerial vehicles, a timely and effective damage diagnosis can lead to increased operational safety and reduced maintenance costs, which are desirable goals for aeronautical operators as well as the industry. Vibration signals provide useful and precise information sources about the dynamics of a system, while the collection of such data can be readily achieved during the aircraft's normal operation without the need for complex equipment, forming the basis for Structural Health Monitoring (SHM). The acceleration signals of quadcopter DJI Mavic 3, acquired in the hovering phase of the aircraft, showed that the effects of six propeller damage scenarios, ranging from incipient damages, to significant structural deterioration, are significantly masked by those caused by the varying operating rotational speed of the rotors, therefore compromising the success of the diagnosis. Subsequently, the need for a robust to uncertainty, approach to the considered problem, is indicated. This study attempts to address this problem, using robust Machine Learning (ML) methods, which base their potential on scalar and vector stochastic AutoRegressive (AR) modeling of the dynamics. The examined methods, namely the Multiple Models (MM), Principal Component Analysis Multiple Models (PCA-MM), and Support Vector Machine

AutoRegressive (SVM), are implemented for damage detection in their unsupervised versions, with damage type identification being performed utilizing similarly founded, supervised versions of the said methods. The methods' experimental performance is evaluated using 1400 (unknown) test cases with the healthy aircraft as well as with the investigated propeller damage scenarios, with the PCA-MM-AR demonstrating an exceptional, first-rate 99.9% damage detection accuracy, while the supervised version of the SVM algorithm, MultiClass Support Vector Machine (SVM), exhibiting damage type identification accuracy of 97.4%, superior to that of every currently employed method.

Keywords

Structural Health Monitoring, quadcopter, drone, propeller damage, vibration signals, statistical time series methods, machine learning methods, damage detection, damage type identification

FINITE ELEMENT ANALYSIS OF LAG SCREW INSERTION PROCEDURE FOR BASICERVINAL HIP FRACTURE AND DESIGN OF CONTROL LOOP FOR ROBOTIC ARM IMPLEMENTANTION

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ABSTRACT

Hip fractures, especially those caused by age-related pathological conditions, are severe conditions, associated with high quality of life reduction and mortality rates. They are also a growing concern for health systems worldwide, due to the cost of management and the growing incidence rate. Basicervical femoral neck fractures, a subset of femoral neck fractures, are associated with especially high fixation failure rates, due to the inherent instability of the fracture pattern. One intra-operative concern for these types of fractures is the relative rotation of the femoral head during lag screw insertion, for osteosynthesis systems. The scope of this work is the development of a Finite Element Model to assess the efficacy of a novel surgical technique developed by the surgeons at the university hospital of Patras, in terms of limiting femoral head rotation and the subsequent simulation of a manipulator for automation of the lag screw insertion.

Firstly, a literature survey is conducted, to assess the state of the art in the finite element (FE) modelling of the mechanical behavior of bones and fracture fixation, with focus on the modeling of internal fixation systems for the proximal femur. It is concluded that FE modeling has unique advantages in the case of fracture fixation assessment, but until now, it has been limited to post-fracture fixation comparisons between implants. Then, the fundamental theoretical framework for the work is established, including bone composition and experimental mechanical behavior, physiology of the proximal femur and fracture classification and management.

Secondly, the development of the finite element model used for this work is detailed and the results presented. The process starts with quantitative computed tomography (QCT) scans, then meshing, inhomogeneity modelling and contact definition and finally end with boundary condition definition, according to the surgical technique proposed. The results obtained indicate that the method does have the potential to limit relative sliding while highlighting the geometry and boneinterface frictional properties as critical to intra-operative behavior.

Thirdly, the simulation of the manipulator is set up in Simulink and the response of the control scheme to the surgery boundary conditions is assessed. The interaction of the end-effector of the manipulator is modelled using a screw joint coupled with a translational spring along the main axis of the screw, to model environmental compliance. Control is implemented through a hybrid position/force scheme, in which rotation is controlled by the position controller, while tractive force is controlled by the force controller. The simulation showed that the manipulator followed the reference inputs adequately well, with less than 1% position error and 7.5% force error, while joint torque remained within the specification limits.

The results of this work show that the implementation of a semi-automated basicervical femoral neck fracture surgery, by which the surgeon would initiate lag screw insertion, and the robot would complete it, may be feasible. It also highlighted the importance of personalized presurgical planning, as both patient- pecific bone mechanical properties and fracture geometry are important parameters in surgery outcome.

Keywords

FEA, Biomechanics, Hip Fractures, Control, Simulation

MODELING AIR-FUEL MIXTURE FLOW IN A MARINE FOUR-STROKE DIESEL ENGINE FOR PERFORMANCE OPTIMIZATION AND EMISSION REDUCTION

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ABSTRACT

Marine four-stroke diesel engines are essential for the propulsion of a wide range of vessels, from commercial to pleasure crafts. Optimizing their performance and minimizing emissions is critical to ensure efficient operation, reduce fuel consumption and limit environmental impact. This study investigates the intricate relationship between engine parameters and emissions performance in marine applications, which contributes significantly to both marine engineering and environmental sustainability. The primary objective was to simulate and improve the air-fuel mixture flow and combustion process in a Perkins 404D-22 four-stroke diesel engine, with a focus on enhancing overall performance and reducing harmful emissions, a critical issue in the maritime industry.

Two types of simulations were carried out: base-speed and parametric. Two discrete operating speeds of the engine, 2200 RPM and 3000 RPM, were simulated to assess the effects of different engine speeds on output of power, combustion efficiency, and emissions formation. After that, several parametric simulations were performed to investigate how engine performance and emissions formation were affected by the initial air temperature, pressure, and injected fuel mass. The results showed that engine parameters, such as speed and pre-combustion conditions, interact in a complex way, significantly affecting both engine performance and emissions. In general, higher engine speeds produce more power, but they can also result in more pollution and less fuel efficiency. The optimum speed depends on the application. The interaction between the initial air temperature, pressure and mass quantity of injected fuel significantly affects engine performance and emissions. While higher values can improve certain aspects, they also introduce potential trade-offs.

This research aims to improve the operation of marine diesel engines and reduce emissions in order to meet the stringent environmental regulations set by the International Maritime

Organization (IMO). The results of the study can be used to develop strategies to improve engine design and operation, thus contributing to the protection of the marine environment and the achievement of sustainable shipping development goals.

Keywords

Marine Diesel Engine, Performance Optimization, Emissions Reduction, Air-Fuel Mixture Flow, Simulation Modeling

SUSTAINABILITY ASSESMENT BASED OF AIRCRAFT USING MULTI-CRITERIA DECISION SUPPORT MCDS METHODS

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ABSTRACT

In today's world, where global climate change is an undeniable reality, humanity has set mandatory restrictions, regarding the aviation industry, with sustainability taking a critical role in aircraft design in order to achieve net zero emissions by 2050. This thesis incorporates multicriteria decision support (MCDS) to assess sustainability in commercial aircraft. Main considerations of the problem occur in the performance, environmental impact, cost, circularity and social criteria that an airplane can be evaluated. This research starts with a brief review of the history of aviation focusing on the recent needs and benefits of applying sustainable technologies. The study develops an aircraft dataset consisting of eight models, including five short-medium range and three longrange, with two conceptual models featuring hydrogen-powered population. The MCDM methods that were selected form a hybrid model featuring the Analytical Hierarchy Process (AHP) for deriving the weights of the main and sub criteria and then for the aggregation and computational process of the sustainability index are utilized Weighted Sum Model (WSM) and the Technical for Order of Preference by Similarity to Ideal Solution (TOPSIS). The implementation of the model is done in MATLAB and reveals significant results, highlighting the variability in aircraft sustainability assessment regarding the criteria that were prioritized. Overall, the data analysis indicates that hydrogen-powered aircraft and more environmentally friendly technologies have promising results with some of them already applied while others not yet being practical for commercial use. Furthermore, the thesis includes a graphical user interface (GUI), aiming to visualize the aircraft assessment, providing access to a broad range of users that are interested in the topic. The platform is modular and developed in a matter where the decision maker can select what method and how much consideration to give to each field, featuring place for future improvements and expansions to this or relevant other areas. Further steps for future investigations include

expanding the Dataset of the aircraft models, improvements regarding the MCDM tool with additional methods and subsequent development of the GUI application.

Keywords

sustainability, sustainable aviation, aircraft selection, sustainable assessment index, conceptual aircraft design, MCDM methods

INTEGRATION OF UNMANNED AERIAL VEHICLES (UAV) IN MANUFACTURING

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ABSTRACT

New technologies such as Unmanned Aerial Vehicles (UAVs) are constantly being introduced under the Industry 4.0 framework. Although UAVs are mainly used in civil and military applications, the opportunities for industrial integration must be examined, namely real-time remote monitoring, wireless coverage, and remote sensing. Therefore, UAVs can be considered as proactive solvers, simultaneously contributing to enhanced decision making as they are considered to be Internet of Things (IoT) platforms for efficient cost-effective data collection and monitoring. However, the use of UAVs in confined and crowded industrial environments, for example machine shops, need further research. Therefore, this thesis focuses on highlighting the limitations regarding the integration of UAVs in modern manufacturing systems as well as on presenting and comparing two intelligent frameworks based on Industrial Internet of Things (IIoT) for real-time machine shop monitoring. The contribution of the thesis extends to the design and development of two frameworks for monitoring and guiding of a UAV in indoor industrial environments (i.e., shopfloors), based on the utilization of 3D path-planning algorithms and collision avoidance.

Keywords

Unmanned Aerial Vehicles, Real-time Monitoring, IoT, Path-planning, IIoT

TRIBOLOGICAL DESIGN OF TURBOCHARGER SLIDING BEARINGS

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ABSTRACT

The current diploma thesis focuses on the study and analysis of floating ring bearings, which are a special category of sliding bearings specialized for high-speed turbocharger systems. The operation of this type of bearing is based on the development of two hydrodynamic films on either side of a freely rotating ring, which is inserted between the bearing and the shaft.

In the theoretical part of the thesis an extensive reference is made to the basic principles of turbocharging and turbo engines. In particular, the importance of turbocharging and how it contributes to compliance with environmental regulations is highlighted. In the next stage, there is an in-depth description for the processes that take place in a turbo engine, the main parts that make up a turbo engine and the different types. This is followed by a presentation of current trends in scientific research on issues related to design optimization of floating ring bearings and techniques developed to reduce wear and instability phenomena. Next there is a presentation about the principles of hydrodynamic lubrication and the mathematical background of Reynolds equation, which is the basis of the present study.

For the purposes of this thesis Matlab software was used, in which we aimed to simulate the operation of ring bearings and understand their response under various operating conditions through the development of mathematical algorithms. Specifically, the Newton method was used to find the static equilibrium position of the shaft-ring system, the pressure distribution around the two lubricant films was calculated both through the short bearing approach and the finite difference method. Moreover, we had the calculation of friction forces, and the determination of linear coefficients for the two lubricant films under various operating conditions by applying the small perturbation method to the Reynolds equation.

The results obtained from the application of the above methods are used to make conclusions regarding to the understanding of the operation of floating ring bearings, their design techniques, and the further development of their technology.

Keywords

Floating ring bearing, Turbocharger, Equilibrium position, Hydrodynamic film, Dynamic coefficients

COLLABORATIVE PRODUCT DESIGN ASSISTED BY EXTENDED REALITY (XR)

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ABSTRACT

Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) can be considered as the cornerstones of the lifecycle of a manufacturing asset. Since the above-mentioned processes often involve multiple engineers, from different departments even from different companies, it is crucial to ensure the flawless communication between the different individuals as well as to make the design process more intuitive. In the era of digitalization and Internet of Things, digital technologies such as Mixed Reality (MR) are utilized by engineers in order to leverage the capabilities of existing computer aided tools (CAx). Therefore, in this research work, the design and development of a Cloud-based and Mixed Reality-based framework is presented. The purpose of the framework is to facilitate engineers in the design of new products/components based on the advanced interface between the engineers and the holograms. In order to tackle this issue, the development of an editable point cloud is required, along with the development of basic tools for the design of 3D geometries. The basic idea of the proposed framework is based on the visualization of 3D models in an augmented reality environment. This capability combined with the use of CAD software can provide the design team a more immersive design experience. The Augmented Reality (AR) interface can enable engineers to visualize and manipulate virtual objects in a real-world context. For the implementation of the AR technology in the design process of a product, an application is developed. The application is also supported by a server for the basic communication between the users. In this diploma thesis, it is investigated whether the use of such an application can improve the design process. The AR technology, part of the Industry 4.0, combined with the existing computer aided tools is a rapidly growing product design solution and will keep engineers and developers busy in the coming years as it can improve the cost and completion time of the design process, can contribute to collaborative product design and minimize design errors.

Keywords

Industry 4.0, Collaborative Design, Augmented Reality, Cloud Technologies

SIMULATION OF COOPERATIVE ROBOTIC ARMS FOR MANIPULATING FLEXIBLE ROPE-LIKE OBJECTS

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ABSTRACT

This thesis investigates the modeling and simulation of robotic manipulation of Deformable Linear Objects (DLOs), such as ropes, cables, and wires, which are widely used in various industries but present unique challenges due to their flexible and dynamic nature. Unlike rigid objects, DLOs undergo significant deformations when subjected to external forces, complicating tasks such as grasping, assembly, and routing. The research focuses on improving the handling and modeling of these objects, crucial for applications ranging from industrial automation to medical procedures.

Traditional model-based methods used for DLO manipulation are computationally demanding and often impractical for real-time applications. This study explores the use of the catenary curve model as a more efficient approach for simulating non-stretchable ropes and employs a combination of MATLAB and CoppeliaSim environments to model and simulate rope manipulation tasks using two 6DoF robotic arms (Niryo). The catenary curve model was experimentally validated using different types of ropes, and simulations demonstrated its effectiveness in real-world applications. The cooperation of two robots was achieved, their trajectories were calculated, and the wrapping of a rope around an object was successfully simulated.

The results show that the model provides an accurate representation of the rope's behavior in controlled scenarios. The findings contribute to advancements in the collaborative robotic manipulation of DLOs, allowing for more efficient handling of flexible objects in automated environments. This research has potential applications in a wide range of industries, including industrial manufacturing and healthcare.

Keywords

Deformable Linear Objects, Modeling, Co-manipulation, Catenary Curve, Simulation

ROBUST DAMAGE DIAGNOSIS FOR A COMPOSITE AEROSTRUCTURE UNDER RANDOM VIBRATION VIA PZT MEASURED SIGNALS

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ABSTRACT

Structural Health Monitoring (SHM) systems are now considered necessary in both infrastructure and aviation structures as they help to preserve the safety of the structure and the individual, reduce maintenance costs and prevent the spread of damage in time, preventing total failure scenarios. In particular, the use of piezoelectric sensors in SHM systems offers many advantages over alternative types of sensors e.g. acoustic sensors or accelerometers as the sensors are very economical, offer flexibility in practical application, act as both exciter and response sensor without high energy requirements etc. In this paper, an SHM system with piezoelectric sensors is applied to a composite material coupon which is part of the tail section of an unmanned aerial vehicle. The studied coupon is excited by a piezoelectric sensor, and carries two additional response sensors, a piezoelectric (Sensor 1) and a strain gauge (Sensor 2) which receive the vibration response signals of the structure. During normal operation it is clamped under varying tightening torque, thus simulating an operating condition under uncertainty. A total of 6 early failure scenarios are considered, which involve the spot addition of two different sized masses at 3 different points of the structure. The purpose of this study is primarily to provide robust fault diagnosis under existing uncertainty, which is hierarchically composed of detecting the 6 artificial fault scenarios, then identifying their location in the structure, and finally characterizing the magnitude of each fault. Still, the artificial damage scenarios are caused by adding an 11g mass and a 21g mass at three different locations on the structure. Robust time series methods of the broader family of multi-model time series methods based on parametric autoregressive type input-output models with exogenous input (ARX) and autoregressive type output-only (AR) are used to diagnose faults under varying operating conditions. Both methods are based on the dynamics of the structure through the parameter vectors of the ARX and AR stochastic models respectively for the measurements of both response sensors. For fault detection, both methods are used in their unsupervised form while for location detection as well as size characterization they are used in their supervised form. For a complete overview and better evaluation of the performance of the fault detection methods, a total of 295 experiments are conducted in a controlled laboratory environment. The results of the methods for the fault detection problem are presented through ROC curves and bar graphs, while for the location identification and size characterization problem through confusion matrices and bar graphs. In conclusion, the piezoelectric response sensor-based methods show better performance in the single fault diagnosis problem compared to the strain gauge sensor-based methods.

Keywords

Structural Health Monitoring, Aerostructure, Composite Material, Varying Operating Conditions, Piezoelectric Sensor, Robust Statistical Time Series Methods, Damage Detection, Damage Location Identification, Damage Size Characterization

COOPERATIVE CONTROL OF ROPE-TETHERED QUADCOPTERS FOR GRASPING AND TRANSPORTING OBJECTS

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ABSTRACT

Aerial robots like quad-copters, and their ability to move freely indoors and in confined spaces, gives them an advantage over other ground robots. Through the collaboration of multiple quad-copters, an aerial swarm is formed, and many real-world industrial applications are enabled. One such application is the transport of payloads using a rope hanging from the quad-copters in the swarm. The current literature is mostly focused on the manipulation of flexible objects and the transport of a payload by two or more quad-copters, while the autonomous grasp of the payload is not fully addressed. Therefore, a path planning algorithm is introduced that is responsible to carry out the whole process of approaching, grasping, lifting and transporting the load by a swarm of two quad-copters. Its only inputs are the initial positions of the quad-copters and the load, while utilising the results from the rope modelling. This outputs the flight sequence for the swarm from takeoff to landing. The experiments were carried out by two rope-tethered Crazyflie 2.1 nano quad-copters and their control by a cascaded PID controller structure. The experimental results prove the system's viability and set the foundations for further use in industrial applications and larger swarms.

Keywords

Aerial robots, quad-copters, aerial swarm, rope-tethered, payload, path planning, grasp, transport, Crazyflie

A PARAMETRIC STUDY OF CARBON FOOTPRINT OPTIMIZATION FOR HYBRIT MANUFACTURING PROCESSES

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ABSTRACT

All environmental issues and particularly climate change has irreversible social, environmental and economic impacts. Eliminating carbon emissions by 2030, which are the biggest contributor to climate change, is a vital goal for the EU as expressed in European Green Deal. In this direction, sustainable manufacturing intends to reduce negative impacts by minimizing energy use, lowering emissions, and optimizing resource efficiency. Hybrid Manufacturing (HM), combining additive (AM) and subtractive manufacturing (SM) techniques, offers a sustainable solution by optimizing material use, reducing waste, and minimizing energy consumption. The aim of this paper is to identify the carbon intensive systems of a HM cell, perform carbon footprint calculations through mathematical modelling and Life Cycle Assessment (LCA) and minimize the CO_2 emissions via optimizing the process parameters. This methodology is implemented in a HM case that involves Direct Energy Deposition (DED) and CNC machining, successively alternating between the two to complete the part. Material related emissions (51% of the total emissions) dominate slightly the energy related emissions (49% of the total emissions). Powder consumption is responsible almost solely for the material related emissions. Within the energy related emissions, the most carbon intensive systems found to be the systems comprising the AM cell with the largest contributor to be the chiller (accounting for 28.3% of the total emissions), proceeding with the AM head motion system (10.9% of the total emissions), and laser machine (9.6% of the total emissions). Process optimization of the HM showed that the overall carbon emissions acting on machine level can be lowered by 58% when increasing the laser power output to a maximum of 1100 W and the scanning speed to a maximum of 1100 mm/min to ensure a stable and optimal linear energy density, balancing the quality and efficiency of the deposition process, without compromising part integrity.

Keywords

Hybrid Manufacturing, Carbon Footprint, Sustainability, Life Cycle Analysis, Parametric Optimization

SOFT CONTACTS, MODELING FOR ROBOTIC SYSTEMS DESIGN, ASSISTING PEOPLE WITH SPECIAL NEEDS

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ABSTRACT

This thesis focuses on the modelling of soft contacts to develop robotic systems that support individuals with special needs. It introduces fundamental theories of contact mechanics and dry friction, emphasizing their importance in enhancing robotic interactions with the environment. These theories lay the groundwork for improving robotic systems' dexterity, adaptability, and overall functionality, allowing them to handle objects effectively. Central to the research is the development of finite element models (FEM) for soft contacts, which help in understanding the stresses, pressures, and deformations during interactions. Using ANSYS APDL software, a finite element model is created to approximate an existing validated model, ensuring reliable data and accurate simulations. This approach aids in optimizing robotic performance, making the systems safer and more adaptable for real-world use, particularly for people with mobility challenges. The study also examines the integration of tactile sensors, such as the BioTac sensor, which detect contact forces and changes in impendances during interactions. This sensory input provides robots with a refined sense of touch, enabling them to respond adaptively to various object properties, such as texture and shape. The sensors enhance the robot's capability to perform delicate tasks, ensuring precise handling and safe interactions. In addition, the thesis explores deep learning neural networks that utilize tactile sensor data to classify objects. By analyzing pressure data, these networks improve the robot's ability to recognize and adjust to different objects, enhancing accuracy and reliability in object manipulation. This adaptive learning approach allows robots to operate effectively even in complex or unpredictable settings. Overall, the work highlights the potential of robotic systems with advanced modelling and sensory integration to assist people with mobility impairments. These technologies empower robots to perform everyday tasks, offering greater autonomy and significantly enhancing the quality of life for individuals with special needs. The research bridges theoretical modelling with practical applications, paving the way for more intelligent, adaptable, and user-friendly robotic solutions.

Keywords

Soft contact engineering, Finite elements, Robotics - Sensors, Neural networks

DEVELOPMENT OF A CARBON FOOTPRINT FRAMEWORK IN MANUFACTURING: A COMPARATIVE STUDY OF ADDITIVE MANUFACTURING VS CONVENTIONAL MANUFACTURING PROCESSES

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ABSTRACT

The motivation behind this work is due to the need for a transition to more eco-friendly solutions in manufacturing one of the largest carbon dioxide emitting sectors, as the world moves steadily to a more sustainable and eco-friendly future. One of the most frequently used options is the implementation AM methods which require minimum preparation as well as promoting a more autonomous process. However, in order to drive this transition, a proper visualization of the manufacturing emissions of a product is needed, allowing the manufacturer to take all the necessary measures for their minimizations. In recent years, many frameworks have been published with key interest in the sustainability of the manufacturing sector, focusing on the limitations of scrap material, optimizing energy efficiency and utilizing eco-friendly and recycled material, posing AM as an ideal option. But few of them showcase the comparative differences these processes have regarding their emissions and how they are affected altering the manufacturing parameters. The current thesis aims to design a calculation framework, estimating the carbon dioxide emissions of a product, designed and manufactured with Additive Manufacturing (AM) compared to conventional manufacturing. This framework is later applied in the case of the production of protective phone cases for different phone models. The scope of this framework is to offer a visualization of the optimal manufacturing method between the AM and its conventional manufacturing for the production of protective phone cases based on the inserted manufacturing parameters. After the calculations results showed that AM processes emit less carbon dioxide than the CM method until they are surpassed with the increase of the batch size produced. Considering other key factors such as cost, consumables and post processing, a decision of the best manufacturing method will be made. The chosen method will be then

subjected to further optimizations where the framework will provide design suggestions, alternative raw materials and process parameters aiming to reduce even further the environmental footprint of the manufactured product.

Keywords

Framework, carbon dioxide emissions, Additive Manufacturing, Conventional Manufacturing, Environmental footprint

HYBRID TYPE INTERNAL COMBUSTION ENGINE DESIGN

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ABSTRACT

This work is specialized on the "Hybrid type internal combustion engine design", carried out by the author and the professor Mr. Pantelis Nikolakopoulos.

In particular it focuses on the design and analysis of hybrid vehicles, with a main focus on two types: mild hybrids (Mild HEV) and full hybrids (Full HEV). Through simulations carried out in the SIMULINK environment, the performance of the vehicles in real driving conditions was examined, taking into account the behavior of the power systems, fuel consumption and emissions.

The study highlighted the advantages of hybrid vehicles, especially in terms of saving energy and reducing emissions. Particular emphasis was placed on the comparison of the two types of hybrids, where Full HEVs showed greater autonomy in purely electric mode, while Mild HEVs were a more economical and easily applicable solution.

Overall, the paper concludes that hybrid vehicles have the potential to play a central role in the future of motoring, while also paving the way for further improvements in battery and energy management technologies.

The author wishes to further develop the current topic.

Keywords

Full HEV, Mild HEV, Pollutants, Battery, ICE, Electric Motor

DIVISION OF ENERGY, AERONAUTICS AND ENVERONMENT (SEPTEMBER 2024)

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING GRILLES OF JET TYPE WITH ONE OR MORE SERIES OF INDEPENDENT MANUAL REGULATED PLASTIC NOZZLES

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ABSTRACT

In this thesis, the aim is to study the air flow through grilles in a room of specific dimensions, in order to calculate and evaluate their characteristic variables. These are related to the velocity distribution, rise,throw, drop, spread and the pressure drop of the air beam. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (V_c = 10 m/s). The region of interest is where a person feels comfortable in room conditions, which in this study was defined as the one with air velocity of 0.5 m/s. The turbulence model used to predict the region is the Realizable k-ε. Among other things, the turbulence models, discretization methods and algorithms for solving the equations are presented. Grilles of different types of design and use were tested and compared. The grilles to be studied were designed in SOLIDWORKS, while the computational investigation and visualization of the results were performed with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was performed by a colleague, which is not included in this study.

Keywords

Grilles, Air beam, Comfort, Finite elements, Computational fluid dynamics

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING ORTHOGONAL VENTS WITH GUIDE VANES OF ONE, THREE AND FOUR DIRECTIONS

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ABSTRACT

In this thesis, the air flow through three grilles in a room of a certain size was investigated. The aim of the thesis is to evaluate the basic flow quantities such as throw, rise, drop, diffusion and pressure drop as well as to compare isothermal flows with non-isothermal flows. First, a brief history of air conditioning is given and then the basic components of an air conditioning unit are discussed. Then, a brief description of the experimental procedure and the experimental instruments and spaces is given. Then, extensive reference is made to basic issues of computational fluid dynamics such as the basic equations, turbulence models and discretization of a field tobe applied. Furthermore, the procedure followed to complete the analysis in the Ansys Fluent program is described, explaining exactly the steps performed to extract the results. Also, screenshots are provided for a better understanding of the procedure. Next, the isothermal airflow results are presented for each grille individually and for selected flow rates. Also, overall graphs are provided showing the variation of the key variables with respect to airflow rate. Then, the results for each grille and the non-isothermal flow case (heating and cooling) results are also presented. Finally, the results are compared and the final conclusions are drawn.

Keywords

Grilles, isothermal flow, computational fluid dynamics, finite elements, thermal comfort

STUDY OF THE INSTALLATION AND ENERGY EFFICIENCY OF A 22MW WIND FARM - A TECHNICAL AND FINANCIAL ANALYSIS

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ABSTRACT

This thesis constitutes an energy and techno-economic analysis of a wind farm with a total nominal capacity of 22 MW. It is a study of a real installation of 10 wind turbines with a capacity of 2.2 MW each, from the company Vestas, located on a peak in the Agrafa mountain range, a project that has already received an installation permit from the Regulatory Authority for Energy (RAE). The organization of the thesis follows this structure:

In the 1st chapter, there is an introductory discussion about the need to utilize renewable energy sources, given the impending depletion of conventional fossil fuels and the observed changes in the planet's climate. In this context, some examples of alternative ways to utilize energy from natural sources are provided, and the advantages of exploiting energy from renewable sources compared to the burning of fossil resources are presented.

In the 2nd chapter, the prospects of exploiting wind energy are discussed, and the different categories of wind machines, their main structural components, and their operating principles are presented, as well as the way they cooperate to convert wind energy into electricity.

In the 3rd chapter, the concept of wind potential is analyzed, as well as the way it is estimated by engineers. Knowledge of the wind characteristics of an area is essential for the proper evaluation of a forthcoming project and the assessment of its future performance. In this context, the various technologies of instruments measuring wind characteristics (speed, direction, etc.) are listed. Additionally, there is a reference to how the terrain of the installation area affects wind speed and to the topological criteria by which a location should be selected for the erection of a wind farm.

In the 4th chapter, the theoretical elements of fluid mechanics are provided, which describe the aerodynamic phenomena occurring during the operation of a wind turbine, as well as the mathematical tools for calculating the power harnessed from the wind. There is an extensive reference to the Betz limit, while the way wind speed and density change as a function of height is presented. Alsp the stochastic nature of the wind is examined, along with the most appropriate statistical tool (Weibull distribution) that allows us to simulate the average wind speed throughout the year and properly assess the quality of the wind potential of an area.

In the 5th chapter, the operation and performance of a real wind farm, which has been licensed by RAE, are examined. In the first stage, the measurements are analyzed and statistically processed, and then the curve of the average wind speed at the height of the wind turbines is constructed, which is approximated using a Weibull distribution. Finally, the theoretical and actual power generated at the specific wind farm is calculated, and an estimate of the total losses as a percentage of the nominal power is made.

The 6th chapter concerns the full costing of the entire project, which is based on the guidelines provided by the most established technical report, Technical Report NREL/TP-500-40566. This includes a series of mathematical relations through which the cost of the individual mechanical and electrical systems, the cost of their interconnection, as well as the necessary engineering permits, can be calculated.

In the last chapter, there is an overview of the project under study, and the final conclusions are drawn regarding the evaluation of the wind farm and its overall performance.

Keywords

Wind farm, Wind Turbines, Renewable Energy, Production of Electricity, Cost analysis of Wind farm

STUDY OF THE ENTRY PATH OF A SPACE VEHICLE IN THE PLANET ATMOSHERE OF OUR SOLAR SYSTEM

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ABSTRACT

As the exploration of space and primarily of the familiar planets of our solar system intensifies and progresses, the optimization of the critical phase of spacecraft entry and deceleration within the planetary atmosphere becomes all the more necessary. The foremost aim of the present diploma thesis is to lay the theoretical foundation regarding the formation of the entry path during this process, as well as the basic methods of atmospheric entry and deceleration. Emphasis is placed on the rate of deceleration in relation to height and the atmospheric and design factors affecting it. Finally, the comparative consideration of the above is attempted, through the calculation of the reduction in aircraft's speed during the entry in the unique atmospheres of the planets of our solar system, for different types of entry and structural parameters. As a result, conclusions are drawn regarding the main conditions influencing the process of manned approach and planetary landing.

Keywords

Entry path, Spacecraft, Deceleration, Planetary atmosphere, Method of entry

PARAMETRIC COMBUSTION STUDY OF MATERIALS IN A CONE CALORIMETER WITH THE FDS SIMULATOR

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ABSTRACT

Fire has accompanied man since the beginning of his history, being both a tool of progress and a threat. As a means of heating, cooking, and protection, fire has played a decisive role in the development of civilizations, while as an uncontrolled phenomenon it has caused enormous destruction to human lives and property. Understanding the mechanisms of combustion and developing techniques to prevent the spread of fire are key goals to protect human life. In this direction, the selection of suitable materials in constructions is of key importance to minimize the risk of fire. With the advancement of technology, especially since the late 20th century, the development of computer simulations has changed the way we study fire. These simulations allow the analysis of the behavior of materials in combustion conditions in a more economical and fast way, without the need for large-scale experimental tests.

In this work, the computational simulation of the combustion of composite wood products is attempted through the implementation of the cone calorimeter model using the Fire Dynamics Simulator (FDS) software. The materials to be studied are composite woods (plywood, OSB, PB, MDF, LDF, HDF), with the aim of creating a model that approximates the properties of wood and allows the reliable simulation of its behavior in a three-dimensional environment. In parallel, the work includes a literature review on fire and combustion, material testing methods, and analysis of the properties of wood composite products. Understanding these phenomena and applying them to simulations can help improve fire safety in modern constructions.

Keywords

FDS, computer simulation, cone calorimeter, plywood, MDF, wood.

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING VENTS WITH LINEAR GRILLES OF DIFFERENT DIMENSIONS WITH VANES FOR THE REGULATION OF THE FLOW DIRECTION

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ABSTRACT

The objective of this dissertation is to examine the airflow emanating from linear grilles within a room with specified dimensions, and to assess its various parameters (such as outlet velocity, range, lift, drop, diffusion, pressure drop, and noise levels). The flow's characteristic values were determined using simulations in ANSYS Fluent for the case of no temperature difference between the incoming air and the air in the room and then compared to the experimental findings obtained in the lab. The first chapter provides an overview of fluid flow in ducts, including a brief discussion of turbulent flow and fundamental principles of air conditioning and ventilation. In the second, special attention is given to grilles, their various types, and the determination of distinct flow characteristics. The third chapter provides a comprehensive overview of the experimental study, including the installation of equipment, details of the instruments used, and the procedural methodology. The fourth chapter introduces the concept of Computational Fluid Dynamics (CFD) and provides an overview of the algorithms used to solve CFD equations, as well as the turbulence and viscosity models. Chapter five details the approach and problem formulation, specifically discussing discretization methods and mesh generation techniques utilized for analyzing the geometry and nozzles. The findings are outlined in chapter six. In the analysis, the highest allowable air exit velocity from the nozzles was determined to be 10 m/s, while the air velocity that was considered to define the area of interest (the balloon) was 0.5 m/s. The seventh chapter ultimately offers conclusions, providing commentary on the results of the analyses, comparing them with each other and with the experimental results. Additionally, significant findings are drawn for the application of nozzles.

Keywords

Nozzle, air flow, characteristic sizes, computational fluid dynamics, finite elements

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM LINEAR AIR-CONDITIONING GRILLES OF SLOT TYPE WITH INTERNAL CYLINDRICAL REGULATOR OF THE FLOW DIRECTION

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ABSTRACT

This present thesis investigates the airflow through linear slot orifices in a space with predefined dimensions using computational software to calculate the parameters that characterize the flow of each grille. These orifices feature slots and an internal cylinder per slot that can be adjusted to direct the flow. The characteristic quantities mentioned are the pressure drop before and after the orifice, the range, lift, drop and spread for a specific and suitably defined area of interest of the beam and the noise level achieved by each grille. The area of interest is the beam zone with a velocity of 0.5 m/s, considered to provide comfortable conditions. These quantities are studied for different airflow rates with the upper limit being defined by the maximum allowable exit velocity from the orifice which is 10 m/s. Computational analysis was performed using Ansys Fluent for the predefined flow rates and temperature differences of each grille. An experimental analysis was also carried out by a colleague to verify the technical specifications of each diffuser, and the experimental data were compared with the computational analysis results.

Keywords

Orifice, air beam, air distribution, air conditioning, computational fluid dynamics

COMPUTATIONAL SIMULATION OF JET AIR FLOW CHARACTERISTICS FROM AIR-CONDITIONING LINEAR GRILLES WITH VANES INSTALLED WITH FIXED STEP AND FIXED 15 DEGREE INCLINATION OF T HE JET FLOW AND DIFFERENT TEMPERATURE OF THE SUPPLIED AIR

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ABSTRACT

In this thesis, the objective is to analyze the airflow from grilles within a room of specific dimensions to calculate and evaluate their characteristic parameters. These parameters include velocity distribution, rise, fall, diffusion, and pressure drop of the air jet. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (Vc = 10 m/s). The area of interest is where a person sits comfortably, which in this study is defined as having an air velocity of 0.5 m/s. The turbulence model used for predicting the area is the Realizable k-ε model. Additionally, the thesis presents turbulence models, discretization methods, and equation-solving algorithms. Grilles with different designs and uses were tested and compared. The grilles were designed in SOLIDWORKS, while computational research and visualization of the results were conducted with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was conducted by a colleague, which is not included in this study.

Keywords

Grilles, air beam, comfort, finite elements, computational fluid dynamics

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING VENTS WITH CIRCULAR GRILLES OF DIFFERENT DIMENSIONS AND WITH REGULATED VANES

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ABSTRACT

This thesis presents a study of airflow from circular grilles with adjustable vanes within a room of specific dimensions, aiming to calculate and evaluate the characteristics of various parameters. These include the distribution of velocity, rise, drop, throw, spread and pressure drop of the air jet. The upper limit of the airflow was determined based on the air velocity exiting the grille (Vc = 10 m/s), which is the maximum permissible speed to maintain comfort conditions. The key characteristics are measured based on the area of interest, defined as the volume of airflow bounded by points with speeds above 0.5 m/s. Ansys Fluent was used for the computational simulation of the flow, and the turbulence model and algorithm employed were the k-ε Realizable and SIMPLE, respectively. Circular grilles of different sizes were tested and compared in the case where the vanes were positioned at a 45° angle with the floor. Additionally, results were compared for each grille in cases where the incoming air was the same temperature, 5°C warmer, and 5°C cooler than the room temperature.

Keywords

Grilles, Vanes, Air jet, Comfort, Air Conditioning

AERODYNAMIC PERFORMANCE OF A SYMMETRICAL AIRFOIL IN HAIL: A COMPUTATIONAL STUDY

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ABSTRACT

The subject of this thesis is the presentation, study, and depiction of the theoretical background required for the computational study of the aerodynamic performance of the symmetrical airfoil NACA 0012 under one-phase air flow conditions as well as three-phase air-waterdrops-hailstones flow conditions, along with the computation using a computational package. The study begins by presenting some basic principles governing the creation of wind in the environment and hail as a flow and analyses the operational parts that make up a wind turbine. Subsequently, after analyzing the operation of the wind turbine and the utility of its blades, the details and technical characteristics of the NACA 0012 airfoil under study are presented, along with basic aerodynamic elements and aerodynamic coefficients. The calculations performed included the aerodynamic quantities for airflow and hailstorm conditions with a wind speed of 29.215 m/s. After modeling the problem and deriving results for single-phase air flow, the discrete phase model was employed, introducing raindrops and hailstones particles into the system. After extracting the results, they are presented and compared with the literature. Specifically, the study examined the aerodynamic lift and drag coefficients, pressure and velocity distributions, pressure coefficient, water film height, erosion rate, and particles behavior before and after their impact on the airfoil surface. Finally, the power coefficient for a three-blade wind turbine with blades made from the NACA 0012 airfoil was estimated, revealing that its performance decreases under hailstorm conditions.

Keywords

Airfoil NACA 0012, Hail, Lift, Drag, Power coefficient

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD IN GRAVITY GRILLES WITH GROUPS OF FREE MOVING VANES IN AIR-CONDITIONING PIPES

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ABSTRACT

In this thesis, the aim is to study the air flow through grilles in a room of specific dimensions, in order to calculate and evaluate their characteristic variables. These are related to the velocity distribution, rise, drop, spread and the pressure drop of the air beam. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (Vc = 10 m/s). The region of interest is where a person feels comfortable in room conditions, which in this study was defined as the one with air velocity of 0.5 m/s. The turbulence model used to predict the region is the Realizable k-ε. Among other things, the turbulence models, discretization methods and algorithms for solving the equations are presented. Grilles of different types of design and use were tested and compared. The grilles to be studied were designed in SOLIDWORKS, while the computational investigation and visualization of the results were performed with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was performed by a colleague, which is not included in this study.

Keywords

Grilles, air beam, comfort, finite elements, computational fluid dynamics

COMPUTATIONAL INVESTIGATION OF THE EFFECT OF A VORTEX GENERATOR IN A LONGITUDINAL PLANE SHAPE ALUMINUM SHEET ON THE FLOW AND THERMAL FLOWFIELD OF A RECTANGULAR PIPE WITH CONSTANT WALL TEMPERATURE FOR DIFFERENT ASPECT RATIOS OF CROSSECTION DIMENSIONS AND SHEET WIDTH IN TURBULENT FLOW

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ABSTRACT

Nowadays, vortex generators are presented as an innovative and effective heat transfer enhancement mechanism. Specifically, this paper presents the theoretical background and the introduction to the investigation of the effect of a vortex generator type of a flat thin aluminum plate on the thermal and flow field of a pipe with a rectangular cross-section that will be studied subsequently in the diploma thesis.

This paper begins with the reference and explanation of the basic concepts and definitions of fluid mechanics mainly in pipes and heat transfer with an emphasis on convection. In addition, the techniques for the heat transfer enhancement mainly of the vortex generators and the advantages they have in the effect of the thermal and flow field are presented.

Finally, there is an introduction to computational fluid dynamics and the Ansys Fluent environment. This program will be used to design the geometry and perform the simulations after the discretization and the input of the parameters and conditions of the problem.

Keywords

Turbulent flows, vortex generators, heat transfer enhancement, flow simulation inside a pipe

EXPERIMENTAL INVESTIGATION OF AIR FLOW FIELD FROM AIR-CONDITIONING LINEAR GRILLES WITH FIXED OR FREE MANUAL REGULATED VANES OR WITH FIXED INCLINATION OF THE JET AND LINEAR GRILLES OF MULTI SLOT TYPE

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ABSTRACT

The aim of this thesis is to study the airflow through grilles in a room with specific dimensions, in order to calculate and evaluate key characteristics of air conditioning systems. Indoor air conditioning aims to create a comfortable and healthy environment, which is achieved by analyzing certain parameters such as throw, rise, drop, spread, noise level, pressure drop, and the outlet velocity of the air jet. The study takes place at the Fluid Mechanics Laboratory of the University of Patras, in a room with dimensions (10 m x 5,5 m x 2,75 m), simulating a typical office environment. Three categories of grilles, each consisting of three grilles, were examined, grouped based on specific characteristics. The maximum outlet velocity from the grille surface is defined as Vc = 10 m/s, and measurements were then taken along three axes with a constant step until it decreases to 0.5 m/s in all directions. This approach enabled the creation of an airflow profile for each grille, while measuring the noise level for each flow rate. The purpose of the experimental investigation is to analyze how the main characteristics of an air jet differ depending on the grille category. Additionally, to validate the experimental results, a computational study was conducted by my colleague Vasiliki-Aikaterini Koroli, using Computational Fluid Dynamics (CFD) for grille category A, in order to compare with the experimental data.

Keywords

Air grilles, ventilation system, air jet, experimental study, comfort.

EXPERIMENTAL INVESTIGATION OF AERODYNAMICALLY STABILIZED FLAMES WITH INLET MIXTURE STRATIFICATION WITH VISUALIZATION OF THE CHEMILUMINESCENCE EMISSIONS

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ABSTRACT

This study focuses on the investigation of the flame topology during combustion of a propane-air mixture. Initially, the theoretical background is presented, which includes the fundamental principles of combustion, followed by a brief description of turbulence phenomena and some flame stabilization methods. Additionally, the operation of the experimental setup is explained and finally, the measurements and results of this thesis are presented and discussed.

This analysis is based on the development of an innovative experimental setup consisting of two cylindrical coaxial jets, which was constructed in the Laboratory of Technical Thermodynamics at the University of Patras. A series of experiments were conducted, through this setup, aiming at examining the stratification of the fuel-air mixture and the creation of recirculation with aerodynamically stabilized flames. The experiments were performed under various flow conditions and fuel-air ratios, allowing the observation and recording of the effects of the parameters that can trigger the flame's behaviour. The visualization of the flame topology was achieved using an optical imaging system, capturing the chemiluminescent radicals OH* and CH* emitted during combustion.

In summary, this research contributes to a deeper understanding of the phenomena affecting flame stability and offers new methods for improving combustion systems, as well as the existing experimental setups, with the goal of developing technologies with a lower environmental impact and setting the path towards a cleaner combustion.

Keywords

chemiluminescence, flame, turbulence, coaxial flow, recirculation.

LIFE CYCLE ASSESSMENT OF ENERGY INTERVENTIONS IN BUILDINGS

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ABSTRACT

This thesis, within the context of the need for sustainability, examines energy interventions in buildings from the perspective of their environmental footprint. Specifically, it studies the energy performance of an old apartment in Greece, before and after renovation, and assesses the environmental impact of the proposed solutions for improving its energy efficiency. Initially, a detailed inspection of the current condition of the apartment is conducted, which faces numerous energy challenges due to its age and location. Following a thorough recording of the necessary data, the software T.E.E.-KENAK reveals the apartment's low energy efficiency, and targeted interventions are proposed to improve its energy performance. These changes include upgrading the insulation of the building envelope, roof insulation, window frames, glass panes, as well as the heating and cooling systems. The energy class of the apartment improves from D to B+, with a significant reduction in annual primary energy consumption and carbon dioxide emissions. Particular attention is given to the roof insulation, for which the installation of a cool coating or a cool membrane is proposed in addition to upgraded insulation layers. Cool materials are innovative materials with high solar reflectivity and a high infrared emissivity coefficient, reducing the temperatures of the surfaces where they are applied, the internal building temperatures, and consequently the energy demand.

At the turning point of the study, the environmental footprint of the apartment's thermal insulation is evaluated through Life Cycle Analysis (LCA). Life Cycle Analysis is a technique for assessing and quantifying the environmental footprint caused by all stages of a product's, process's, or system's life cycle. Using SimaPro software, the environmental impacts of wall insulation, roof insulation, the roof insulation system with an additional cool coating, and with an additional cool membrane are analyzed and compared. Focusing on the roof, it was found that the environmental footprint of the insulation was not affected by the additional installation of the cool coating, while an increase was observed with the cool membrane.

Keywords

Energy upgrade, Cool materials, Environmental Footprint, Life Cycle Assessment, SimaPro

NUMERICAL COMPUTATIONAL SIMULATION OF FLOW AROUND AN AIRCRAFT USING OPENFOAM

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ABSTRACT

Aerospace engineering is a multidisciplinary field, offering students the opportunity to engage with various domains, such as structural analysis, computational fluid dynamics, and automatic control systems. In this thesis, computational aerodynamics was selected as the main subject, with a particular emphasis on studying the airflow around an unmanned combat aerial vehicle (UCAV) in three dimensions (3D) and under compressible flow conditions. For this purpose, the OpenFOAM software was utilized, which is considered one of the most suitable tools for computational aerodynamic analysis.

Due to the complexity of the task, a stepwise methodology was deemed necessary. Initially, a simulation of incompressible flow around an airfoil in two dimensions (2D) was conducted, employing the k-omega-SST and Spalart-Allmaras turbulence models, along with the simpleFoam solver. The results of this simulation were compared with the relevant literature, with the aim of selecting the most appropriate turbulence model. Following this, a three-dimensional (3D) simulation of the airflow around a wing was carried out under the same conditions. After the results were deemed satisfactory, the investigation of compressibility effects followed, for which the rhosimpleFoam solver was used. The flow speed was increased to values exceeding 0.3 Mach, and after the validation of the results, the final stage of simulating the flow around the UCAV was completed.

Keywords

OpenFoam, UCAV, rhoSimpleFoam, turbulence

THERMAL ANALYSIS AND PARAMETRIC DESIGN OF COOLING PIPES IN AN INJECTION TYPE MOLD

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ABSTRACT

The aim of this thesis is to study the heat dissipation pipes of an injection mold and to propose the optimization of its cooling circuits. The initial geometry of the mold and the steps of the computational modelling of the thermal problem are first presented. The algorithms for solving the problem are also discussed as well as the methodology followed. The theory of production of plastic objects by the molding method is analyzed along with the problems it presents and the techniques to prevent them. The mechanical components of an injection type mold and the functions performed by each of them are presented, followed by the heat transfer and flow phenomena that take place inside the control volume. The mesh created to solve the thermal problem computationally is analyzed and information on its optimization is provided, while the way to control its quality is indicated. The turbulence models available for the present thermal problem are analyzed and information on them is provided to find the optimal one. The thermal problem considered consists of a two-cavity injection type mold, in which a steady-state thermal analysis is first conducted to find any hot spots in its cavity. From the comparison of results, a new cooling piping geometry is proposed to minimize cavity hot spots, which can be fabricated by conventional machining methods. The parametric design of the cooling pipes for each component of the mold is explained and presented. A second thermal analysis is then performed with the new cooling circuit geometry to determine if and to what extent the hot spots of the first analysis were mitigated. The amounts of heat fluxes exchanged between the control volume and the coolant, and the surface temperatures of the mold cavity are finally compared.

Keywords

CFD, Thermal analysis, Injection type molds, Cooling pipes, Parametric design

NUMERICAL SIMULATION OF FIRES

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ABSTRACT

This thesis focused on simulating the evolution of a fire in a large apartment comprising two bedrooms, one bathroom, kitchen and living-dining room, using Computational Fluid Dynamics (CFD) through Fire Dynamics Simulator (FDS) software. The simulation results were generally expected and in line with relevant literature on fire behavior in confined spaces.

The fire started from an ignition point in the living-dining room and gradually spread to neighboring furniture in the area. The relatively limited heat release and the distance from other combustible elements of the apartment resulted in the fire being confined to one part of the apartment without reaching flashover. The effects of the plume and ceiling jets were obvious and expected, resulting in an increase in temperature throughout the living space. In contrast, the temperature rise in the bathroom was smaller due to the position of the opening to it, which acted as a barrier to the flow of hot gases.

One of the main findings was the significant reduction of visibility inside the apartment due to the soot, which increases the risks for the occupants and makes the work of fire and rescue teams more difficult. While the bathroom appeared to temporarily function as a safe space due to the lower temperature, the concentration of soot makes it clear that there must be immediate firefighting or evacuation of the apartment.

Overall, the work highlighted the importance of immediate fire response, the necessity of effective fire protection systems and the utility of partition walls in reducing fire spread and temperature.

Keywords

Fire Simulation, Apartment, Computational Fluid Dynamics (CFD), Fire Dynamics Simulator (FDS), Fire Protection

COMPUTATIONAL STUDY OF THE EFFECT OF A TWISTED TAPE INSERT ON THE FLOW & THERMAL FIELDS OF A SIMPLE ELLIPTICAL HELIX, WITH CONSTANT WALL TEMPERATURE, FOR 3 ECCENTRICITY RATIOS UNDER TURBULENT FLOW OF 5 DIFFERENT Re NUMBERS

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ABSTRACT

The installation of vortex generators (VGs) is a proven method of heat transfer enhancement within pipes, by causing mixing and swirling. In this diploma thesis, the effect of a twisted-tape vortex generator on the flow and temperature field of helical pipelines is investigated. The pipes have an elliptical thread while, the tape is of rectangular cross-section with a constant twist ratio. A total of 15 cases are studied, for 5 Re numbers and 3 eccentricities.

In the first part of the thesis, a theoretical review of the main concepts of fluid mechanics and thermodynamics is given. This is followed by a literature review on vortex generators, curved pipes and their governing phenomena, with emphasis on helical pipes and twisted tapes. The reader is then introduced to computational fluid dynamics simulations, via the Ansys Fluent software, and an extensive discussion of its operating principles is given. In the second part of the thesis, the studied geometries are presented as well as the simulation procedure. Subsequently, the verification of the CFD code's validity is performed, the results are presented, and conclusions are drawn.

The mixing induced by the twisted tape is noticeable, leading to an increase in the Nusselt number ranging from 16.7% to 34.5% in the cases analyzed. However, this improvement comes at the cost of a significant pressure drop. The use of twisted tape is mainly recommended for low Reynolds number flows, but it should be avoided when the geometry is connected to a fixed power pump. Finally, regarding the elliptical thread, it is advised to use configurations that closely resemble the circular pattern.

Keywords

Vortex Generators, twisted tape, helical pipes, Ansys Fluent, heat transfer enhancement

COMPUTATIONAL FLUID DYNAMICS ANALYSIS OF NATURAL GAS WITH HYDROGEN INJECTION IN A NATURAL GAS TRANSPORTATION PIPELINE

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ABSTRACT

The rapid increase in fossil fuel consumption has created an ecological crisis worldwide. Thus, there is an urgent need to transit to cleaner forms of energy. Hydrogen, a substance with zero carbon dioxide emissions and high energy content, will play a key role in this energy transition. However, there is considerable concern about its transport and distribution. The injection of a certain percentage of hydrogen in natural gas into the existing transportation network of the latter is a solution to this problem. The flow of both natural gas and its mixing with hydrogen gas in pipelines is extremely complex and carries serious risks in the event of leakage or mismanagement. In such an investigation, the contribution of Computational Fluid Dynamics (CFD) is important, as it can predict through simulations the behavior of the two gases under various conditions and, consequently, the probability of error if these conditions are not suitable. In this thesis, a CFD analysis is performed firstly to analyze the flow of methane, which is the main component of natural gas, in a pipeline and then the injection of hydrogen gas into methane flow, using the open-source software OpenFOAM. The analysis is performed for a pipeline with two gas inlet points and the geometry is simplified to a two-dimensional wedge-shaped section for convenience. The pure methane flow is analyzed for two different OpenFOAM solvers, one for solving turbulent, incompressible and transient flow and one for turbulent, compressible and transient flow. Furthermore, the two-gas mixing problem is analyzed with the solver for turbulent, compressible and transient flow. The results of the analyses are compared with each other and with a scientific paper related to the mixing of methane with hydrogen. Good agreement between the solutions and the paper is observed, which indicates that the mixing of the two gases can be accomplished under these conditions. The logical variations of the physical quantities indicate correct assumptions and initial conditions and therefore a safe operating environment. Finally, some suggestions for further development of the study are given.

Keywords

Natural gas, Methane, Hydrogen, Computational Fluid Dynamics, OpenFOAM, Wedge

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING LINEAR GRILLES WITH FIXED VANES INSTALLED WITH FIXED STEP AND CAPABILITY OF DIFFERENT INCLINATION OF THE JET FLOW

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ABSTRACT

The purpose of this thesis is to investigate the air flow through grilles in a room of defined dimensions and to analyze the basic characteristic quantities of the flow. These characteristic quantities are summarized as follows: outlet velocity, throw, rise, drop, spread, pressure drop and noise level. All the above characteristic quantities were determined both computationally using the ANSYS Fluent program and experimentally, except for the pressure drop which was only calculated computationally. More specifically, we carried out analyses and simulations using the ANSYS Fluent program for three different grilles (L13 400x100, L13 500x200, L13.15 400x100). The experimental measurements were carried out in a specially designed room (with dimensions 10 x 5.5 x 2.75 m) at the Fluid Mechanics Laboratory of the University of Patras. The first chapter is introductory and includes the purpose of the study and the historical background of air conditioning. The second chapter covers the theoretical framework, describing the basic principles of ventilation and air conditioning, as well as the components of these systems, with emphasis on the different types of grilles and the definition of the characteristic flow quantities. In the third chapter, we provide a detailed description of the experimental study (installation, instrumentation, procedure) carried out. The fourth chapter deals with Computational Fluid Dynamics (CFD), where the algorithms for solving the CFD equations, turbulence and viscosity models are presented. In chapter five, the methodology and design of the problem are discussed, while chapter six presents the results of the analyses. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille, which was set at 10 m/s. The area of interest is the zone where comfort conditions prevail for the seated occupants, with the air velocity limited to 0.5 m/s in this study. Finally, the seventh chapter draws conclusions, commenting on the results of the analyses, comparing them with each other and with the experimental data, and drawing important conclusions for the use of the grilles.

Keywords

Grilles, air flow, computational fluid dynamics, characteristic sizes, experimental measurements

DESIGN A FIRE-WHIRL ARRANGEMENT ON A POOL FIRE AND INVESTIGATION OF THE FORMATION AND DEVELOPMENT FEATURES

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ABSTRACT

Fire whirls exhibit a powerful intensification of combustion which has been extensively studied over time by the fire research community. The hazards inherent during these phenomena, which take place in both wildland and urban fires, have led the research community to modelling them on both small and large scales in appropriately organized laboratory areas. The development of this phenomenon is based on the existence of an organized angular momentum which in turn will lead to an increased angular velocity of the air entering the flame's plume. The height of a fire whirl exceeds in most cases the height of a simple conventional flame. In addition, fire whirls have the potential to spread, creating new fire spots over several meters, with devastating effects on the surrounding landscape.

In this thesis we experimentally study the possible existence of a fire whirl in a pool fire for various flow conditions that we enforce. In addition, a comparison is made of the flame height between the pool fire and the fire whirl to identify any differences. In the first parts of the thesis, a thorough analysis of the theoretical background on pool flames and the fire whirl is presented, while reference is made to previous research on the fire whirl phenomenon. Subsequently, the experimental setup used in our research is analyzed and the image processing procedure used in the computer language Matlab is explained. Further, the results of the experimental procedure are presented and analyzed. During the experimental procedure we used some variations in the flow conditions with the main pillars: fuel flow rate, burner diameter and gap opening in the fixed frame. The first two variations relate to the change in flame load while the opening of the gap relates to the change in angular momentum. In conclusion, by observing the plots we can extract useful conclusions between the height and the parameters mentioned above.

Keywords

Pool Fires, Fire Whirl, Flame Load, Flow Conditions, Flame Height

EVALUATION OF THE APPLICATION OF COOL AND GREEN ROOFS IN THE ENERGY EFFICIENCY OF BUILDINGS

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ABSTRACT

The Urban Heat Island (UHI) effect, characterized by temperature increase in urban areas compared to the surrounding rural ones, represents one of the greatest challenges of modern urban life. Directly linked to intense urbanization, this phenomenon has serious consequences that degrade the microclimate of cities and the quality of life for their inhabitants. Among the various strategies for mitigating UHI, the application of cool and green roofs emerges as one of the most effective and sustainable solutions, contributing to both the reduction of temperature and the improvement of the energy efficiency of buildings. The importance of these technologies becomes even more critical, given that the building sector is responsible for nearly 40% of total energy consumption, which has a direct impact on the urban environment.

The aim of this study is, after analyzing the mechanisms of action and the benefits of these two roofing technologies, to evaluate their application in the energy performance of a real building. Using the software TEE-KENAK, the energy behavior of a residential building with partial thermal insulation is simulated, while two scenarios of cool roofs with different coatings and two scenarios of green roofs, extensive and semi-intensive types, are examined in terms of the energy savings they offer. Additionally, the application of the same scenarios is investigated in two hypothetical thermal insulation conditions of the roof: a) without any insulation (uninsulated) and b) sufficiently insulated, according to the requirements of KENAK.

The results of the simulations showed that green roofs were the most efficient solution for the specific building, achieving a reduction in total energy consumption of up to 50% in the case of the uninsulated roof. In contrast, cool roofs, while showing slightly better results in the cooling performance of the building, increased thermal loads, thus burdening the overall energy consumption. The thermal insulation of the roof significantly affected the magnitude of the results. Green roofs maintained a positive effect in every case, while cool roofs had a negative impact, with the magnitude of the effect varying significantly depending on the initial thermal insulation condition of the roof.

Keywords

Urban Heat Island, cool roofs, green roofs, energy efficiency, thermal insulation

COMPUTATIONAL SIMULATION OF AIR FLOW FIELD FROM AIR-CONDITIONING VENTS WITH LINEAR HIDDEN GRILLES OF SLOT TYPE

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ABSTRACT

In this thesis, the aim is to study the air flow through grilles in a room of specific dimensions, in order to calculate and evaluate their characteristic variables. These are related to the velocity distribution, rise, drop, spread and the pressure drop of the air beam. The upper limit of the airflow was determined based on the maximum critical velocity exiting the grille (Vc = 10 m/s). The region of interest is where a person feels comfortable in room conditions, which in this study was defined as the one with air velocity of 0.5 m/s. The turbulence model used to predict the region is the Realizable k-ε. Among other things, the turbulence models, discretization methods and algorithms for solving the equations are presented. Grilles of different types of design and use were tested and compared. The grilles to be studied were designed in SOLIDWORKS, while the computational investigation and visualization of the results were performed with ANSYS Fluent. To verify the accuracy of the computational fluid dynamics (CFD) simulations, a corresponding experiment was performed by a colleague, which is not included in this study.

Keywords

Grilles, air beam, comfort, finite elements, computational fluid dynamics

COMPUTATIONAL SIMULATION OF AIR CONDITIONING FLOW FIELD FROM ORTHOGONAL SWIRLING CEILING GRILLES WITH MANUAL OPERATED VANES ADJUSTED IN FOUR GROUPS FOR DIFFERENT TURBULENCE MODELS

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ABSTRACT

The aim is to record and evaluate key flow parameters, such as velocity distribution, diffusion, noise level and pressure drop of the air stream of the air stream at a given dimension room. The study focuses on the comfort zone where the air velocity reaches 0.5 m/s, while the maximum exit velocity from the grille is set at 10 m/s. To predict the flow, the work uses the Realizable k-ε turbulence model, SST k-ω and Spalart-Almaras to compare the models and presents details on various turbulence models, discretization methods, and algorithms for solving the equations. In addition, the research includes the design and comparison of different grilles using SOLIDWORKS, the implementation of computational fluid dynamics (CFD) with ANSYS Fluent, the visualization of measurements and results.

Keywords

Grilles, Hvac, CFD, Thermal Comfort, Airflow

ECONOMIC AND TECHNICAL ANALYSIS OF NATURAL GAS INTRODUCTION AND ITS TOTAL USE IN GREECE

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ABSTRACT

The purpose of this diploma thesis is a generalized study of the fundamental technical and economic parameters governing the process of natural gas transmission through the Greek national transportation and distribution network. In particular, the paper deals with a technical and economic analysis that interprets whether a full use and penetration of natural gas in the country's energy market is feasible. Therefore, one of the objectives of the study is to draw useful conclusions regarding the viability of an overall financial investment in the expansion of the natural gas network of Greece, especially in areas of the country with high energy needs where until today their consumers do not have access to the National Natural Gas Transmission System. In the first chapters of the thesis, reference is made to the general theory of natural gas, its historical development, its types, the processes of its formation, extraction and exploitation as well as information about its composition, properties and uses on the planet. Then, the total consumptions related to natural gas units for each region of the mainland are highlighted in detail and based on their results, the last part of the paper describes a model of three scenarios concerning the implementation of possible future projects for the expansion of the network of the National Natural Gas Transmission System in northern, central and southern Greece.

Keywords

Natural gas, Consumers, Greece, NNGTS, Extension

EXPERIMENTAL INVESTIGATION OF THE REACTING FLOW FIELD OF AERODYNAMICALLY STABILIZED STRATIFIED FLAMES USING PARTICLE IMAGING VELOCIMENTRY

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ABSTRACT

In this student research project, the theoretical background, measurement setup, and experimental laboratory installation used for the study of the reacting flow field of aerodynamically stabilized, stratified flames are presented. The installation used was designed and developed at the Laboratory of Applied Thermodynamics at the University of Patras and consists of two coaxial cylindrical ducts through which air and air-propane mixture flow. The high velocity ratio between the outer and inner air jets creates a recirculation zone that enhances flame stabilization. The visualization of the flow and the measurement of the velocity fields are carried out using the Particle Image Velocimetry (PIV) method, which is a non-intrusive method. Initially, a brief reference to the theory of combustion and the laws of thermodynamics is made. Then, the theory of turbulence is discussed, specifically examining turbulent premixed combustion, the methods of stabilizing turbulent flames, and the necessary theory of coaxial flows with recirculation. Furthermore, the experimental setup and all the equipment used for the experiment are presented, with an extensive reference to the Particle Image Velocimetry (PIV) method. At the end, the results obtained from the PIV measurements of axial and radial velocities in the reacting flow field are presented and appropriately discussed.

Keywords

Recirculation zone, PIV, Coaxial flow, Turbulence, Premixed combustion

COMPUTATIONAL STUDY OF FUEL FLOW IN COAXIAL JET

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ABSTRACT

This study is a computational analysis using the OpenFOAM software, aiming to examine the flow of fuel mixed with air at high Reynolds numbers within a coaxial jet. The study focuses on the case of fully developed fluid dynamics flow. The software was used to solve the Navier-Stokes equations for turbulent and incompressible flow. Through the visualization and analysis of the results in three-dimensional space, the interaction region of the flows at the outlet of the coaxial jet was examined until their full merging into the surrounding environment was achieved. The results depict the various merging zones of the flows and the interaction morphologies formed in the region of interest, with the most significant being those of the inner and outer dynamic cores, as well as the central recirculation zone (CRZ) formed between them. The dimensions of these turbulent morphologies, along with the identification of the Upstream Stagnation Point (USP) and the Downstream Stagnation Point (DSP), represented the main challenge of this study.

Keywords

Coaxial Jet, Turbulent Flow, Incompressible Flow, High Reynolds Numbers, Computational Fluid Dynamics (CFD), OpenFOAM, Navier-Stokes Equations, Central Recirculation Zone (CRZ), Upstream Stagnation Point (USP), Downstream Stagnation Point (UPS), Dynamic Cores.

DIVISION OF MANAGEMENT AND ORGANIZATION (SEPTEMBER 2024)

RECOMMENDER SYSTEMS AND SUPPORTING ALGORITHMS

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ABSTRACT

In this thesis, a thorough analysis of recommendation systems and their support algorithms was carried out. In particular, the different types of systems were fully analyzed, the advantages and disadvantages of each approach were mentioned, and their operation was explained through real examples and appropriate flow charts. The typical problems faced by recommender systems were also mentioned, with the most common ones, being the cold-start problem, problems with data privacy and cases of lack of sufficient available data for proper recommendation formulation. Furthermore, the algorithms that support the operation of these systems were analyzed in detail, with the most basic ones being SVM (Support Vector Machine) algorithms, Neural Networks and clustering algorithms (K-Means Clustering etc.). Finally, an indicative movie recommendation system is implemented, in which movie titles are suggested to the user based on his/her preferences. In particular, the user has the option to select the type of films, their average rating, and the year of their production. There is also the option to rate a film title that is selected, thus affecting the average rating of the movie.

Keywords

Recommendation Systems, Machine Learning, Algorithms, Flow Charts, Neural networks

FORECASTING METHODS FOR WEATHER TIME SERIES

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ABSTRACT

At a time when climate change has already begun to affect people's daily lives, the need to model temperature data so that we can capture future patterns and changes is greater than ever. Time series analysis is the most appropriate tool with which we can examine the time course of many phenomena in different fields such as in our case in the field of Meteorology. For this purpose, in this paper the basic methods of time series forecasting will be presented and applied to the monthly and daily mean temperatures of Larissa, Sparta and Alexandroupolis for the time period 1 January 2011 to 31 December 2020. Initially the study will be carried out through the classical ARIMA/SARIMA. These models describe well the average monthly and daily temperatures, giving good short-term forecasts. Alternatively, Artificial Neural Networks (ANNs) can be used to predict the average monthly and daily temperatures of the above cities, which can also capture the non-linearities that may be inherent in the data. In this paper, RNNLSTM neural networks were used which are suitable or time series temperature data and were found to outperform the classical SARIMA models in terms of mean square and absolute error, especially in the case of mean daily temperatures.

Keywords

Temperature, Time series analysis, Box-Jenkins methodology, SARIMA models, Prediction, Artificial Neural Networks, RNN-LSTM models

TRANSITION TO MICRO-MOBILITY: ASSESSMENT OF TECHNICAL AND INSTITUTIONAL INTERVENTIONS AND POLICIES THE CASE OF THE CITY OF PATRAS

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ABSTRACT

One of the greatest and most important challenges facing by modern society is the congestion of urban centers and the problems arising from this. A shift towards sustainable mobility solutions is more than necessary. Micromobility offers an alternative form of transportation with multiple benefits, both for its users and for the environment, as it is considered a form of the so-called "green" transportation. The use of micromobility vehicles is economical, ecological, practical, and easy for citizens to use, regardless the gender or age. As more and more people gain access to micromobility vehicles, either through private ownership or through shared micromobility service networks, micromobility has a significance larger share of overall transportation, particularly in large urban centers. This represents a period of transition towards micromobility, which begins in metropolitan areas that serve as hubs for daily commutes.

This trend is also evident in the case of Patras, a city with many points of interest and a suitable flat terrain, ideal for the use of micromobility vehicles. At the same time, the city of Patras, being a university town, is filled with young people, who are generally more familiar with the use of such vehicles.

Currently, in Greece, the framework establishes safety measures for micromobility riders as well as general traffic regulations. However, the transition to micromobility also requires the corresponding infrastructure that will ensure and guarantee the safety of users and their unobstructed movement within the urban environment of cities. In the case of Patras, the necessary studies related to the Sustainable Urban Mobility Plan (SUMPs) and the Sustainable Urban Development Strategy (SUDS) have been completed, reflecting the general policy of the competent institutional stakeholders towards the creation of "smart" cities with zero emissions.

For the transition to the era of micromobility, the necessary infrastructure plays an essential key, as do the relevant campaigns aimed to inform citizens about the benefits of this form of transportation and raise awareness among users regarding accident prevention.

Finally, equally important is the evaluation of technical, institutional interventions, and policies, because through this process, the current situation in the area of Patras is recorded, providing an overall picture in terms of transportation. At the same time, harmful actions are prevented, issues that may arise are corrected, and the best policy decisions are sought for the benefit of citizens, enhancing the credibility of local authorities.

Keywords

Micro-mobility, transportation, micro-vehicles, e-scooters, hoverboard, Personal Electric Vehicle (PEV)

EXPLOITING DEEP LEARNING TECHNIQUES FOR FAKE NEWS DETECTION: ADDRESSING IMBALANCED DATA AND PROVIDING MEANINGFUL INSIGHTS THROUGH EXPLAINABILITY FEATURES

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ABSTRACT

The constant proliferation of misinformation poses a significant threat to modern society. This study aims to mitigate the effects of this problem by developing deep learning models for fake news detection in the German language, given the limited research in this area compared to English. We explored architectures such as CNN, LSTM, and BERT, and applied over-sampling and under-sampling techniques, including Random Over-sampling and Borderline SMOTE, to combat data imbalance. Our results indicate that these methods effectively enhance model performance, particularly in recall and F1-score. Among the models evaluated, a fine-tuned BERT model with random oversampling exhibited superior performance, achieving high recall and F1-score. However, selecting the optimal model is not always straightforward due to subtle differences in performance. Multi-criteria ranking methods like PROMETHEE I and II can aid in this process, but careful consideration of the specific requirements is essential. Finally, to enhance transparency and trust in our models, we incorporated the explainability features LIME and SHAP. These methods provide human-understandable explanations for model predictions, fostering greater confidence in the results.

Keywords

Fake News, Natural Language Processing, Deep Learning, Imbalanced Data, Explainability

APPLICATIONS OF RECOMMENDER SYSTEMS

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ABSTRACT

The use of recommender systems is increasingly applied in all aspects of daily life, as it facilitates the user of online entertainment and e-commerce applications to receive the best possible recommendations with their preferences and their needs. The purpose of the thesis below is to present in detail the various uses of these systems, analyzing the most basic methods of their approach (Collaborative filtering, ContentBased filtering, Knowledge-Based filtering και Hybrid filtering) and using examples of their application in various areas, to make clear the process through which the respective recommendations are derived. At the same time, by referring to the limitations that govern these approaches, possible ways to overcome the specific difficulties are explored. Simultaneously, some ways of evaluating these systems are described in detail. Finally, an analysis and design of a service application of personalized health and economic programs is carried out with the aim of fully understanding the operation and the process by which the appropriate services are recommended to the user, using the hybrid approach.

Keywords

Recommender Systems, Collaborative filtering, Content-Based filtering, Hybrid filtering, Data Mining Techniques, Recommender Systems Drawbacks, Analysis and Design of a System

APPLICATION AND COMPARATIVE ANALYSIS OF THE MULTI-CRITERIA METHODS PROMETHEE II AND ELECTRE III FOR THE SITE SELECTION OF ELECTRIC VEHICLE CHARGING STATIONS

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ABSTRACT

Electric vehicles (EVs) penetrate the automotive market at a relatively increasing rate, gradually displacing conventional vehicles. The present study deals with the EVs' technologies and specific characteristics, presenting the EVs' categories and discussing their main advantages and weaknesses. In the second part of this thesis, the types of batteries of EVs are examined, highlighting their cost and the cruciality of the related supply chain. The charging process of EVs is analyzed in detail, referring to both the speed and methods of charging and the stations where the charging process takes place, which, as this study shows, do not offer sufficient capacity to accommodate many new EVs and reduce the driver's anxiety about autonomy.

Given the need to increase the number of Electric Vehicle Charging Stations (EVCSs), their site selection problem is investigated following the Multi-criteria Decision Analysis (MCDA) framework, a scientific field that supports decision making by considering a multiplicity of criteria with different weighting factors, in order to select the 'best' alternative solution under uncertainty. In the present thesis, a sample of 16 studies on the siting of EVCSs was examined, with various criteria. The study records the frequency of occurrence of these criteria on the current sample and which methods of MCDA are mostly applied.

Finally, after studying these applications, the thesis proceeds by applying MCDM techniques, specifically PROMETHEE II and ELECTRE III, in Attica prefecture by comparing 11 municipalities in terms of their attractiveness for EVCS installation. The alternatives are being compared in 8 criteria, and a sensitivity analysis is conducted, through varying criteria weights, in separate scenarios that differentiate from each other as it comes to decision maker's (DM's) preferences. The aforementioned scenarios prioritize the environment, investments, society and safety of the power network, while there is also another scenario that allocates equal values to all criteria weights. The analysis shows a similar ranking for the alternatives between PROMETHEE and ELECTRE. However, there is a significant differentiation when veto is applied. Optimal solutions' profile shows the most suitable municipalities, which are populous and densely populated, not far from the city center.

Keywords

Electric Vehicles (EVs), Electric Vehicle Charging Stations (EVCS), Multi-criteria Decision Making (MCDM), Multi-criteria Decision Analysis, site selection

ARTIFICIAL INTELLIGENCE TECHNOLOGIES FOR SMART BUILDINGS

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ABSTRACT

This thesis explores the application of artificial intelligence (AI) algorithms to optimize energy consumption in smart building networks. The study includes a detailed analysis of various AI methods, such as demand forecasting and consumption optimization, and examines the technologies and methods employed for predicting and managing energy needs. A key outcome of this research is the development of a taxonomy that categorizes these technologies, highlighting their advantages and disadvantages. By evaluating successful case studies of AI implementation in smart buildings, the thesis assesses the performance of these technologies in comparison to traditional methods. The findings demonstrate that AI has the potential to significantly improve energy efficiency and sustainability in smart building networks. Recommendations for future research are provided, focusing on further development and refinement of AI-based solutions for energy management in smart buildings.

Keywords

Artificial Intelligence (AI), Smart Buildings, Energy Management, Consumption Optimization, Demand Forecasting