University of Patras

Department of
Mechanical Engineering and Aeronautics

Diploma Thesis

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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 2021)

ANALYSIS OF SEISMIC RESPONSE OF RC COLUMN IN MARINE ENVIRONMENT

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ABSTRACT

Corrosion of reinforcing steel is the world's leading factor degrading the durability of reinforced structures concrete in time. In Greece in particular, where much of the building stock is located in coastal areas, where the action of ions chlorides (environmental exposure category XS according to EN206-1), causes significant problems to the Structural Reliability Integrity of constructions. And because of the intense Seismic activity of the Greek area, the issues of degradation are much greater. In the present work is studied the influence of corrosion damage of reinforcement steel in combination with the accumulation of low cycle fatigue damage (simulation of seismic loads), in total hysteresis response of a typical reinforced concrete column. Focusing in existing (old) structures, an attempt is made to model one "typical" column (in terms of design), based on usual practices followed in previous decades, studying or ignoring the importance of its corrosion damage to reinforced steel. To evaluate the results of the Analysis, (comparative) data were taken into account from the experimental study such as these are presented in the published work "Seismic assessment of RC column under seismic loads » of the Technology Laboratory and Durability of Materials members. The development of the two simulation models of seismic response, was performed using the open source software Opensees. In order to introduce reliable values in the hysteretic model of steel, dynamic stress experiments were performed (fatigue) in steel reinforcing bars with nominal diameter 16 mm, taking into account the

energy degradation of the material due to fatigue loads, as well as the occurrence of buckling phenomena. The results of the simulation showed that, in the non-corroded conditions, the modeling of steel material based on its dynamics response, and not based on the adoption of the monotonic curve (symmetrical in tension and compression) as followed in most cases, leads to reliable results as its deviation hysteresis curve of the model in relation to that of the experimental results is negligible. On the other hand, in the corroded conditions, the conception of uniform corrosion damage along the steel bars appear to be lagging behind to evaluate the overall response of the structural member. This happen due to the fact that the caused local damage (pitting) in boxed steel inside concrete, it becomes critical to the overall structural member behavior. Therefore, further study is deemed necessary, to be able to accurately evaluate and quantify its influence local corrosion damage of steel.

DEVELOPMENT OF MULTI-FUNCTIONAL NANO-REINFORCED EPOXY ADHESIVES

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ABSTRACT

It is widely known that one of the most common ways to bond composite materials is by using adhesives. Epoxy adhesives are used more in industry due to their excellent properties. They are one of the most important categories of structural adhesives although they exhibit insulating behavior, which limits their use in various applications. In order to be applied in various sectors (aerospace, aeronautics, etc.) it is necessary to increase their electrical and thermal conductivity without degrading their mechanical properties. One of the main ways mentioned in the bibliography is to reinforce these materials by using conductive nanoparticles and mainly carbon. The idea and the purpose of the present undergraduate thesis was to develop the multi-functionality of a two-component epoxy adhesive. Two types of adhesives have been developed: normal and nano-reinforced. Two types of nanoparticles were used to prepare the nano-reinforced materials: multilayer graphene (GNPs) in content of 8% wt and multi-walled carbon nanotubes (MWCNTs) in contents of 2% and 1% wt. In addition, the two nanoparticles were used simultaneously to develop a hybrid material (8% wt GNPs and 1% wt MWCNTS). The processing of the two phases (epoxy adhesive and nanoparticles) was achieved by using a high-shear mixing machiner in which strong shear forces are developed that are responsible for combating the growth of agglomerates. Afterward, to characterize the developed materials, tests were performed to determine the single lap shear strength of joints (Single lap shear, ASTM D5868-01) while measurements of thermal and electrical conductivity were accomplished. The introduction of nanoparticles caused significant increases in electrical and thermal conductivity. The multilayer graphene in content of 8%wt recorded the largest increase, at a rate of 207% in the thermal conductivity of the material. In addition, the carbon nanotubes in content of 2% showed the largest increase, nine orders of magnitude, in the electrical conductivity of the material. Finally, it was observed that the hybrid system successfully contributed to the development of a multi-functional epoxy adhesive, which has improved thermal and electrical properties without significantly degrading its mechanical properties.

Keywords

Epoxy adhesives, Single lap shear strength, Electrical conductivity, Thermal conductivity, Nanoparticles.

OPTIMIZATION OF SHAPE OF REPAIR PATCHES FOR COMPOSITE MATERIAL STRUCTURES

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ABSTRACT

Repair of composite structures constitutes a directly applicable and cost-effective solution for the extension of a structure's servive life. Especially, repairs that include the implementation of a composite repair patch into a suitably formed niche with the same geometry as the patch and the stabilization of the patch by an adhesive film are widely adopted. Nevertheless, conventional circular patches have been proved to be overly conservative for the repair of composite structures and they allow the optmization of a repair patch's shape, in terms of both strength and amount of pristine material removal that is needed for the formulation of the niche.

At the present diploma thesis, an investigation was coducted in order to determine optimized geometries of elliptical composite stepped repair patches, as compared to the optimum circular repair patch. Furthermore, the evaluation of the performance of several repair design methodologies was an additional purpose of the current study.

Each one of the repair patches was designed based on 4 fields: the orientation of each ply's ellipse, the type of load under which the repair is designed to exhibit sufficient strength , the method of scarf angle's calculation and the method of step length's calculation. For each filed alternative methodologies were implemented. The design methodologies of scarf angle and step length were proposed in literature for the design of stepped and scarf repair patches or simple 2D joints. These equations were suitably adapted to calculate the minor and major axis of the patches' ellipses. Thus, in conjuction with the necessary geometrical limitations, 42 elliptical patces of different dimensions were designed in Matlab and each repair patch originates from a different combination of design methodologies.

Among the aforementioned 42 patces, 31 of them were modelled in Abaqus, since only these specific ones remained inside the bordere which the anti-buckling support defined. Each model consisted of a composite laminate plate repaired with an elliptical patch of the same material. An anti-buckling support was added to the repair and a compressive load was

implemented across x direction (parallel to the length of the plate). The strength of the repair was calculated via Abaqus analysis for all models and afterwards the ratio of strength per unit of undamaged removed material volume was also calculated. The above two quantities were compared to the corresponding quantities of the repaired plate with an optimum circular patch of scarf ratio 1/50.

The design methodologies of each design field were evaluated and the method or methods of each filed that led to optimum results, on average, were detected. Among the 31 modelled repairs, 5 of them exhibited optimum performance over the circular form, in terms of compressive load on x direction. These 5 optimum repair shapes were modelled under uniaxial compressive load on the directions of 90◦ and 45◦, in order to further investigate their credibility under more general loading conditions. For comparison puproses, the repaired plate with the optimum circular patch was also modelled under load on directions of 90◦ and 45◦ ans finally 2 repair geometries were proved to optimum compared to the circular patch for the 3 kinds of loading

ANALYSIS OF LATTICE STRUCTURES WITH AN EMPHASIS ON ROMBOID, ISOGRID AND KAGOME LAYOUTS

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ABSTRACT

The experience gained till today from the multiple research projects concerning pro-composite fuselage construction have shown that the main difficulties in increasing weight and cost efficiency are caused primarily by the absence of a novel, effective approach to the analysis, development and manufacturing of high-loaded composite structures.

Presently, most efforts concentrate on constructing aircraft fuselages with the same design philosophy and replacing the widely used metallic materials with composites. This precludes the designers from fully utilizing the properties of composite materials. History however has shown that, a change in materials used means that a change in design philosophy is also necessary.

A very promising design philosophy for pro-composite aircraft fuselage construction, entails the use of lattice/frame layouts. Lattice structures allow for a significant reduction in the weight of an aircraft while with a proper design philosophy, lattice grids can sustain all possible loads by means of tension-compression of UD-ribs only.

The purpose of this thesis is an initial analysis on the feasibility of using lattice grids in aircraft structures. In particular, the analysis will focus on the Rhomboid, Isogrid and Kagome grids.

Initially, some general information on composite materials, the current methods of aircraft fuselage construction with conventional and composite materials are presented.

This is followed by a detailed analysis on the loads that a fuselage is subject to under certain conditions, and the process continues with the analysis of the unit cells of the three types of grids.

Then, part of the fuselage is analyzed using the load values obtained in the above analysis, and an evaluation of the analysis results is performed.

Keywords

Aircraft, Fuselage, Lattice Structures, Design, Composites

FABRICATION AND CHARACTERIZATION OF DYE-SENSITIZED SOLAR CELLS

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ABSTRACT

The fact that the energy needs are constantly increasing, while at the same time conventional fuels are declining at a very fast pace, was the reason for starting this diploma's thesis.

Initially, there was a report on how the exploitation of energy started from the very old years until today, where there are even more modern methods for the exploitation, mainly of renewable energy sources.

Next, there are presented the main characteristics of solar energy and solar radiation and the factors that affect the way photons can be absorbed by a solar cell.

Then, it was made an extensive reference to both photovoltaics type p-n silicon junction and their operation mode, as well as to dye-sensitized solar cells and the materials used for fabrication. In the context of this thesis and the study on the improvement of dye-sensitized solar cells, there were made solar cells of different materials and with different manufacturing techniques in order to find the combination that achieves the highest efficiency combined with low cost and flexibility in their application.

At the beginning of the experiments, and for the study of the influence of the substrates in the cell, solar cells were made from different types of conductive substrates, while the semiconductor, the dye and the electrolyte were the same in each measurement. Solar cells with different heating time of the electrode and anti-electrode were then fabricated in order to study its influence on cell performance. It was also identified, the need for electrode sensitization time, by constructing cells whose electrodes were left in room conditions immersed or not in dye solution for 24 hours to complete semiconductor sensitization by the dye.

Also, in the laboratory, was made a solid polymeric electrolyte which was used in the manufacture of the same types solar cells and the results of their efficiency were compared

with those initially made and containing the already-made electrolyte EL-HSE High Stability by Dyesol.

Another study that carried out in this thesis, was concerned the change of the short-circuit current density and the open-circuit voltage produced by solar cells as a function of incident solar radiation.

Finally, it is found that dye-sensitized solar cells could improve more, with the maximum theoretically possible efficiency of conversion of solar energy into electricity of this dye exceeding 30%. These solar cells are offered for further study, because they do not require expensive manufacturing equipment, like those of the previous generation, while as mentioned several times they are considered more environmentally friendly and with low manufacturing costs.

ANALYSIS OF THE LIFE CYCLE, QUALITY AND COST OF A VERTICAL FUSELAGE PANEL WHICH WAS CONSTRUCTED BY INNOVATIVE HYDRID THERMOPLASTIC COMPOSITE MATERIALS WITH THE USE OF NEW PRODUCTION PROCESSES OF COMPONENTS

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ABSTRACT

The growing demands for more resilient and lighter constructions in the field of aeronautics led to the development of composite materials. The increased mechanical properties of these materials, combined with their low specific gravity, results in energy savings. Priority for the aeronautical industry is to increase the efficiency of the aircraft (reducing the weight of the aircraft structure while increasing the payload), reducing fuel consumption and harmful emissions for the environment as well as weight, combined with improved material properties. Fiber reinforced polymer matrix composites are widely used in aeronautics. In recent years significant efforts have been made at research level to replace thermosetting matrix composites with thermoplastic matrix composites. In the present work we investigate the environmental footprint through Life Cycle Analysis (LCA), production costs through Life Cycle Cost Analysis (LCA) the quality of the material produced as well as the optimal operating conditions of the autoclave for the production of a panel on the fuselage of an ATR aircraft made by a hybrid material consisting of APC-2 PEEK-carbon with two outer layers of PEI.

ANALYTICAL INVESTIGATION OF THE FRACTURE BEHAVIOR OF BONDED JOINTS IN PRESENCE OF THERMAL STRESSES

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ABSTRACT

The rapid pace of technology development has increased the need for engineering research. One of the problems faced by modern engineering is the need to analyze the fracture behavior of bonded joints. Bonded joints are widely used in the aerospace industry as they have significant advantages. The most important advantage in relation to mechanical connections, such as bolts, is the reduction of the weight of the construction. Bonded joints are used to bond both composite and non-composite materials. Especially in the case of composite materials, due to their manufacturing process, they have residual thermal stresses, which affect their durability. Fracture toughness is measured by the strain energy release rate. The strain energy release rate is a measure for determining the fracture behavior of materials, as it describes the resistance of materials to crack propagation, and consequently to total failure. In the present work, a thorough analysis of two main and extremely recent works of P. Tsokanas & Th. Loutas (2019) and P.S. Valvo et al. (2019), is done. The main purpose of the present work is to introduce the residual thermal stresses in the model of P.S. Valvo et al. (2019) and the final influence that these terms have on the strain energy release rate. The models of these two works will be analyzed and the fundamental relationships that make up each of them will be described. Then, results are obtained for both of these models, with and without the effect of residual thermal stresses, for the double cantilever beam experiment. Three different categories of specimens will be compared, for the same loading value. This comparison is being made in terms of internal forces, strains, displacements and strain energy release rates.

Keywords

Fracture Mechanics, Strain Energy Release Rate, Composite Materials, Residual Thermal Stresses, Bonded joints

INVESTIGATION OF MECHANICAL STRESSES AND PROPERTIES OF CARBON FIBER AND GRAPHENE PARTICLE REINFORCED POLYMERS

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ABSTRACT

Stress distribution around a hole is a crucial part of designing a structure. Nowadays composite materials are preferred because of their designing freedom in conjunction with their specific properties but render the analysis more difficult and detailed by virtue of anisotropy and the many points of where the stress field increases (interlaminar, intralaminar effects, holes, notches, free edges etc.). Specifically, the stacking sequence affects the stress field because of the anisotropic behavior. Apart from the fiber's orientation, the matrix is another contributing factor. In recent years matrices are being reinforced with nano particles that increase their thermomechanical properties. Graphene is a new material that belongs to this class. It is commonly used as an enhancement for the polymeric matrix and as a result, the classic methods for the characterization of material behavior under loading are not accurately demonstrating how the material operates any more. For this reason, the scientific community invested in spectroscopy because it allows for the exact insight in terms of material behavior. Due to graphene's crystallic structure, Raman spectroscopy is a commonly preferred method. The purpose of this master 's thesis is the investigation of the stress field and the determination of the stress concentration factor in a woven laminate with carbon fibers reinforced with graphene enhanced polymer resin, with a hole in its center, loaded under tension. The determination of how stresses affected by the existence of the hole will be derived via Raman spectroscopy experimentally in order to investigate the fibers' behavior, with Finite Elements Method as numerical approach and analytically for the macroscopic level.

Keywords

Composite Materials, Graphene, Raman Spectroscopy, Fracture Mechanics

DIVISION OF DESIGN AND MANUFACTURING (FEBRUARY 2021)

DYNAMIC IDENTIFICATION AND ESTIMATION OF THE LIQUID LEVEL IN AN ELEVATED LIQUID TANK VIA VIBRATION SIGNAL MEASUREMENTS

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ABSTRACT

This study focus on the Dynamic identification and the estimation of the liquid level in an elevated liquid tank via vibration signal measurements. Firstly, a brief explanation of the experimental procedure is made.

In the first section, a parametric analysis of the structure using the stochastic models ARX and VARX for all levels of liquid with available experimental measurements is shown. For the estimation of all models the software that was used is Matlab. Using those two models as a base, two new models were created. The Global-ARX and Global-VARX models are capable of estimating the dynamic characteristics of the structure for all the levels of the liquid, even for levels that don't have an available experimental measurement. The estimation of the innovative FP-VARX model is also made. This model can also estimate the dynamic characteristics of the structure for all the possible levels of liquid with even better accuracy.

In the next section, the models Global-ARX, Global-VARX and FP-VARX are used for the estimation of the level of the liquid using unknown experimental measurements. Those measurements were not used for the estimation of the models. Then, the real value of the level is compared with the estimated value for every signal. The Global-VARX and FP-VARX models are capable of estimating the level of the liquid with decent accuracy, although the Global-ARX isn't capable of identifying the level when the liquid tank is full for some

measurements. The conclusion of the present study is that the FP-VARX model has the best accuracy in comparison with the other two, but is also the most complex one. The estimations of the less complex model Global-VARX were also decent but with less accuracy.

Keywords

Dynamic Identification, FP-VARX, localization, partially-filled water tank, parametric analysis

FAULT DETECTION IN RAIL SUSPENSIONS VIA MULTIPLE MODEL METHODS UNDER VARYING TRACK PROFILE AND THE USE OF VARIOUS SENSOR LOCATIONS

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ABSTRACT

The rapid evolution of railway transports during the recent years has emerged the need for optimized maintenance and timely replacement of degraded suspension components in railway vehicles. Suspension element faults in advanced stage can lead to operation outside the design limits and in more extreme cases to accidents (e.g., derailment). Moving towards the approach of "predictive maintenance" and thanks to nowadays advances in signal processing methods, as well as the wide range of sensors and measuring devices available, automated fault detection consists one of the most crucial technological topics. However, no general solution has been yet deployed to the problem, as the various railway suspension fault detection methods that have been developed either fail to detect incipient faults, or face robustness challenges, thus their performance is negatively affected by the varying operating conditions of the vehicle. In this work, the ability of detecting small magnitude faults in suspension elements of a train under varying track profiles with two Multiple Model (MM) methods is investigated: one method based on the Power Spectral Density Functions (PSD) of acceleration signals obtained from the structure, and another one based on parametric vector autoregressive (VAR) models. A 3-dimensional (3D) train wagon model, developed in the SIMPACK environment, is used for executing simulations and the acquisition of signal from "virtual" acceleration sensors which have been implemented on various locations close to the suspension of the vehicle and record linear accelerations in vertical and lateral direction. The model was constructed with very realistic specifications, very close to those of real trains. Incipient (very small) faults of 10% and 20% magnitude in the primary, secondary suspensions and the lateral damper were simulated. The robust fault detection capability of the two utilized methods is investigated through the MATLAB software. The PSD-based method is proven efficient enough for detecting early primary suspension faults in the vehicle, and appears to outperform the VAR model-based method,

when the Euclidean norm is used in both methods as a distance metric between the training data (of the healthy state) and the inspection data (of an unknown state).

Keywords

Multiple Model, Vibration-based methods, Rail suspensions, Early faults, Condition-based maintenance

FAILURE ANALYSIS FOR SX-DIA AIRCRAFT MAIN LANDING GEAR

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ABSTRACT

The present work investigates the failure of the main landing gear of a BAE Jetstream 41 SX-DIA aircraft during its landing at Rodos Island International Airport "Diagoras" on February 2, 2015. The dynamic and static loads developed in this mechanism during landing are analyzed. The Regulations and Instructions applied in its design are taken into account, as well as the failures and damages that usually lead to plane crashes. The flight data in the day of the accident are examined as they were presented in the respective Hellenic Civil Aviation Authority experts report. The examination of the conditions during the accident and the application of analytical and numerical solutions lead to useful conclusions for the safety design of aircraft landing mechanisms.

Keywords

Aircraft, Landing gear mechanism, Design, Fracture, Fatigue

FAULT DETECTION IN RAILWAY VEHICLE SUSPENSION SYSTEMS UNDER VARYING OPERATING CONDITIONS

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ABSTRACT

The current thesis deals with the vibration-based fault detection in suspension systems of in-service railway vehicles that operate under varying speed and moving on rails of the similar quality (roughness). Vibration signals are measured from three different points on the vehicle which are on the right axle box of the front wheelset, on the right corner at the front side of the car body and at the front right edge of the leading bogie. The modeling of the healthy vehicle partial dynamics under different operational speeds is obtained, in a baseline, training, phase through two Functional Pooled Transmittance Function AutoRegressive with eXogenus input (FP-TF-ARX) models. This modeling corresponds to the formation of a proper subspace through the FP-TF-ARX model parameters, where the vehicle healthy dynamics is represented. Thus, fault detection is achieved using fresh signals obtained from a current unknown vehicle state by testing if they reside within this healthy subspace based on a proper optimization procedure. The vibration signals which are used in the baseline and inspection phase where the fault detection of unknown test cases is attempted, are produced from a detailed and realistic forty-two degrees of freedom railway vehicle that is constructed in Simpack. Numerous Monte Carlo simulations are performed for healthy and faulty components in the primary and secondary suspensions for the assessment of the employed method. The results indicate that the appropriate extraction of information from vibration signals through advanced stochastic methods that employ TFs corresponding to properly selected measurements from the railway vehicle, may lead from very good up to excellent fault detection of even relatively small faults in the vehicle suspension systems.

Keywords

fault detection, varying operational conditions, railway vehicles, simulations, statistical time series methods.

FATIQUE DESIGN OF INTERNAL COMBUSTION ENGINE VALVE SPRINGS

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ABSTRACT

This specific student thesis studies and analyzes a variable timing valve mechanism from an internal combustion engine. First, a detailed analysis of the components that make up a valve mechanism is made and a study of their characteristics. Special emphasis is given to the spring of the valve mechanism, as well as its resistance to fatigue. Thus, the methodology of design and analysis of a helical spring is developed. Furthermore, the technology of variable valve timing is presented as well as its applications from various automotive industries. Afterwards the methodology of cam profile development using basic kinematic curves is analyzed, along with the magnitudes of interest and their characteristics.

At this point two different cam profiles are developed using different kinematic curves in Analytix software. After inserting the VTEC valve mechanism of B16A engine into Catia design software, the valve inlet section for an engine cylinder is isolated and applied the necessary modifications, so that the mechanism can then be transferred to ADAMS software environment, where the mechanism is modeled, in such a way as to approach the real one. During the processing of the mechanism in ADAMS software the desired motion is given at the input of the mechanism and a series of simulations are performed for the two different cam profiles, exporting the desired diagrams. Finally, the results of the simulation are evaluated and ways in which the functional characteristics of the mechanism can be improved are presented.

Then a helical spring is designed in Catia software, the geometry of the spring was designed based on the operating characteristics of VTEC valve mechanism. This geometry was then analyzed in Ansys software to determine the desired results using two different wire materials. Exporting the stresses and deformations that develop in the spring, as well as the peculiarities and eigenfrequencies. Finally, the fatigue strength is determined by calculating the remaining life inside the coils of the spring. Interest is given to the calculation of the remaining life using the Rainflow counting algorithm for the loading history of the mechanism, as in this way the fatigue strength of the spring can be calculated more

accurately. Evaluating the two materials, we come to the most suitable for use into the mechanism.

Finally, reference is made to the literature used in the various points of this work

Keywords

mechanism. valves, cam, spring, fatigue

PREDICTION OF MECHANICAL PROPERTIES OF STRUCTURED MATERIALS WITH CRACK

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ABSTRACT

This Diploma thesis focuses on modeling nanocomposite materials of graphene/PMMA, and aims to determine their mechanical properties. More specifically, the properties that are calculated are the elastic modulus, the shearing modulus and the Poisson's ratio for sandwich type nanocomposite materials. The material's matrix is polymer whereas the reinforcement is graphene. Moreover, the change in the mechanical properties is calculated due to the effect of temperature and the existence of a crack on the matrix. In order to calculate the mechanical properties of the nanocomposite, the model of a unit cell is developed using a finite element analysis program. This unit cell consists of three phases, the matrix, the reinforcement and the interphase, which is located in between them. Initially, calculations are for a perfect unit cell without any crack. Next, the effect of the crack is studied by considering variable parameters as its position alongside the unit cell and its depth. All calculations are taken with the change of temperature. Then, the results presented show the dependence of the mechanical properties of the unit cell depended on the change of the temperature and the parameters of the crack and are compared with results found in the literature which demonstrates its satisfactory accuracy. Finally, the conclusions that emerge from this thesis are presented.

ANALYSIS AND MODELING OF NON-STATIONARY IN-FLIGHT RANDOM VIBRATION SIGNALS

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ABSTRACT

The purpose of this Thesis is the analysis and modeling of non-stationary in-flight vibration signals of an aircraft. Firstly, a detailed description of the experimental procedure performed for obtaining the vibration response signals is given. Such structures present mostly vibration signals with non-stationary characteristics. The modeling of these signals focuses on time varying ARMA (TARMA) and vector time varying ARMA (VTARMA) models with a recursive approximation of their parameters, also known as Recursive ARMA (RARMA). The models investigated in this project, differ in the recursive method of calculating their parameters. The methods used are the Recursive Maximum Likelihood (RML), the Recursive Kalman Filter (KF), and the Recursive Forgetting Factor (RFF). The above methods are applied to the available signals, and then the structure of each model is evaluated and selected, respectively. Then, the structure of each model has to be validated. The reason such models are chosen is their ability to accurately predict time-dependent dynamic characteristics. This is done by changing recursively the model parameters for each time period. Finally, the methods are compared in terms of the efficiency of their estimates, both in time and frequency domain, but also in terms of the computing power they require and their ease of use. Taking into consideration the results of this research, it is observed that two of the models (Recursive Kalman Filter and Recursive Forgetting Factor) manage to model the dynamic characteristics of the aircraft with great accuracy.

Keywords

Non-stationary vibrations, Time-varying ARMA models, Identification of oscillating systems, Spectrum analysis, Time-frequency analysis

VEHICLE ROLLOVER - KINEMATIC AND DYNAMIC ANALYSIS

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ABSTRACT

This dissertation deals in the analysis of overturning accidents of four-wheeled passenger vehicles by applying the principals of dynamics and kinematis. This work distinguishes the phases of vehicle trip, it lists the equations which apply on each phase and the parameters which apply for each phase, like the different coefficients of friction which apply. Rollover accidents are investigated and an algorithm is proposed for the systemic recontrsuction of similar rollover accidents.

Keywords

Passenger Vehicles, rollover, speed, Energy, friction coefficient, rollover algorithm.

A FEASIBILITY STUDY ON THE DETECTION OF CHIMERA-LIKE STATE USING STATISTICAL PATTERN RECOGNITION AND MACHINE LEARNING METHODS TO ELECTROENCEPHALOGRAMS

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ABSTRACT

The object of the present work is the feasibility study for the detection of the chimera state from electroencephalograms. Due to the fact that the available electroencephalograms were not mapped to chimera state or not, they were initially classified using a suitable transmittance function (TF) based index, using electroencephalograms from two areas of the brain and examining their dynamic characteristics. Thus, based on the sharp increase of this index for some electroencephalograms, it was assumed that they correspond to a chimera state while the rest do not, in order to test then the possibility of detecting the chimera phenomenon with pattern recognition and machine learning statistical methods based on electroencephalograms.

The electroencephalograms being processed come from 128 sensors, grouped by 32 into 4 panels, each panel corresponding to a different area of a monkey brain and the collected signals have a sampling frequency of 40 kHz. The investigation of the dynamic characteristics of the signals is carried out in the bandwidth where a significant frequency content up to 50 Hz is observed, which led to the filtering and re-sampling of the signals at 5 kHz since the length of the available signals does not allow further reduction of the sampling frequency. This limitation combined with the small differences observed in the power spectrum (Power Spectral Density, PSD) and the transmission function of the different signals, led to a high difficult problem of separation of states, as well as to high-order parametric models.

The statistical methods used to detect the chimera state are based on the parameters of estimated stochastic Transmittance Function AutoRegressive models with eXogenous input (TF-ARX) and the test results are plotted through ROC (Receiver Operating Curves) and scatter plots. The final comparison of the methods is based on the success rate of diagnosis (True Positive Rate, TPR) for false alarms (False Positive Rate, FPR) of 5%. The results indicate

on the one hand the satisfactory categorization of the signals from the presented methods and on the other hand that the statistical method of pattern recognition presents better results in the diagnosis of the chimera phenomenon compared to those of machine learning, achieving at best a true positive rate (%TPR) equal to 95%.

BELT BENDING SIMULATION BY APPLYING FEM

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ABSTRACT

The purpose of the dissertation is to approach with the method of finite elements of the tension and deformation of a belt on a cylindrical drum (pulley).

The power transmission with flat belts appears in a number of mechanical applications and becomes important for their operation and structure. In belt drive transmissions, mechanical power is transmitted between at least two pulleys connected to the belt and is achieved by developing frictional forces between the pulley and the belt. Belts are used both in material handling systems and in relatively long distance power transmission.

The device consists of a flat belt and a pulley. If we consider that the belt and the pulley are very wide, then this problem becomes flat. The pulley has an outer diameter and the belt is thick. To simplify the problem, assume that the pulley is stationary and almost deformed, while "looking" at a 90° arc. This means that the measure of elasticity of the pulley is much greater than that of the belt. Studies will be done for 3 different values of belt thickness, as well as for different belt materials. The belt accepts bending stresses, due to the bending that occurs through the pulleys.

The belt bending problem will be parametrically simulated with the finite element method via Lusas software. The problem is non-linear. To be able to monitor the response of systems with material or geometric nonlinearity (as in the pulley-belt system) we use a pacing process, either time or load.

In the modeling of the system in the program FEA-LUSAS Modeller, first, we define the geometric model, then the properties of the system and finally the parameters of the non-linear analysis that will be done. The following is the presentation, commentary and study of the results that will result from the analysis of finite elements.

DESIGN AND DYNAMIC ANALYSIS OF RECIPROCATING ENGINE

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ABSTRACT

In this thesis the main types of reciprocating engines, used mainly for automotive propulsion, and power generation are studied, as well as their balancing. The main types of reciprocating engines are described along with the thermodynamic cycle. The dynamic behavior of a single-cylinder reciprocating engine and the loads and stresses generated during operation are analyzed. Finally, using an algorithm for the design of reciprocating engines, the full calculation of an internal combustion engine is performed.

From the kinematic and dynamic analysis of the crankshaft mechanism for a single-cylinder reciprocating engine, the operating loads, the forces produced by the combustion gases, the equivalent masses and the inertia forces of the moving members, the reciprocating forces, the torque on the crankshaft, the loads on the pistons, dampers, and bearings are calculated.

The problem of balancing of the rotating and reciprocating machine parts, the vibrations developed by the inertial forces and the axial balancing applications is analyzed. A systematic algorithm with spreadsheets was developed for the design of an internal combustion engine and the balancing of shafts and reciprocating masses.

Suggestions for extending the design algorithm to other types of engines such as naval engines follow.

Keywords

Reciprocating engines, crank – rod – piston mechanism, Algorithm for the design of reciprocating engines, dynamic analysis, vibration, balancing.

ESTIMATION OF THE REMAINING USEFUL LIFE OF CRITICAL VEHICLE SUSPENSION COMPONENTS BASED ON FUNCTIONAL MODELS AND VIBRATION SIGNALS

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ABSTRACT

This present thesis focuses on the estimation of the remaining useful life of critical vehicle suspension components, and more specifically, the stiffness and damping suspension components of a quarter car model. The suspension model consists of two masses (one sprung and one unsprung), two springs (k_1, k_2) and a damper (c), while a type B road profile according to ISO 8608 is inserted into the system and causes vertical oscillation. The response of the suspension system is given by two acceleration sensors which are placed on the two masses of the suspension, respectively, and fatigue response of mechanical components is approached through fracture-mechanics. The total reduction due to fatigue for k_2 is 29% and for c is 32.8%. The response of the suspension system is given by two acceleration sensors which are placed on the two masses of the suspension, respectively. In the case of a fatigue scenario of Type I stiffness component k_2 is under fatigue, in a Type II damping component c is under fatigue, and in a Type III both k_2 and c are under fatigue. Each fatigue scenario has as an input a different road profile which is constructed so that it changes stochastically without changing the type of road. The estimation of the remaining useful life is done by using functional models and more specifically FP-ARX-TF (Functionally Pooled AutoRegressive with exogenous excitation) stochastic models implemented in output-output form (transmittance) and VFP-ARX-TF. The estimation results in three different estimation models, thus, one for each type of fatigue scenario, from 60% to 96% of the total life cycles corresponding to them, with the estimated value to be the current days of life spent by each component. Finally, it appears that for the prediction of the remaining useful life for signals with a Type I fatigue scenario the average percentage estimation error is 9.895%, for Type II 5.522% and for Type III 5.04% and 6.15% remaining useful life (in days) of spring and damper respectively.

Keywords

Vehicle suspension, remaining useful life, fatigue, functional models, vibration signals, transmittance function

VIBRATION ANALYSIS OF NANOTUBES WITH AN ADDED MASS AND ELASTIC SUPPORT CONDITIONS

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ABSTRACT

Nanomechanics deals with nanoscale materials and devices and is a fast-rising field of science as it can be applied to a variety of structures. This work mainly involves applications of nanotubes in nano-sensors and thus, the research is focused in structural and vibrational analysis calculating frequency change, which is the fundamental idea in the operation of nano-sensors.

Hence, the main goal for the development of nanomechanics is to build reliable computational models for simulating nanomaterials. Therefore, in the present work, the mathematical modelling of nanotubes using mechanical beam models was studied where the beams do not follow classical boundary conditions but rather the case of elastic supports. The models used Krylov − Duncan functions based on Euler and Bernoulli beam theory. Validation of the developed models with numerical results from literature was carried out to confirm the computational work so far.

Subsequently, the Adjustment Mass Method was incorporated into the framework in order to simulate the lumped mass in nanotubes. The study investigated the effect of mass, position and the quantity of lumped mass on natural frequency.

In this research, the case study of clamped-clamped beam was used, while the influence of the parameters (position, size and quantity of mass) were investigated. In this case, the analysis was conducted under the assumption of symmetric vibration.

The computational work was implemented using Matlab and Wolfram Mathematica programming.

Keywords

Nanotube; Nanosensor; Vibration; Krylov − Duncan; Clamped-clamped; Adjustment Mass Method;

DESIGN AND MANUFACTURE OF THE SUSPENSION SYSTEM FOR AN ELECTRIC FORMULA STUDENT RACECAR

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ABSTRACT

Formula Society of Automotive Engineers (FSAE) is a student design competition organized by SAE International. The participants build and compete with a racecar in static and dynamic events amongst other university teams around the world. The goal is to score as many points as possible to win the competition with UoP5eEvo, a redesigned and improved version of UoP5e. This single seater competed in international student competitions Formula Student (FSAE) in the year 2017, representing the Mechanical Engineering department of the University of Patras under the supervision and support of the Laboratory for Manufacturing Systems (LMS).

This thesis covers a proposed method for the complex suspension system design and manufacturing process of an FSAE racecar and the development of a group of data analysis and vehicle dynamics tools in Matlab. Commonly, in an early design stage, the team performs point mass lap simulations, for the design of a top-level concept of the FSAE vehicle via point sensitivity analysis in all dynamic disciplines. The suspension design greatly affects most subsystems of the vehicle and their targets and thus it has to be developed first. Having established the most dominant sensitivities tires must be selected. This is performed by comparing tire data of market available tires, with a custom Matlab tool developed for this purpose. This data is collected via tire testing performed by the Tire Test Consortium (TTC). The next step involves tire modeling using the Pacejka MF5.2 formula in which the coefficients are estimated, again using a Matlab code. After this a tool for producing Milliken Moment Diagrams (MMM) is developed which is used in conjunction with other calculations for setting the suspension kinematics targets. Having established the suspension kinematics targets, a kinematics software is used to determine the pickup points. This is an iterative process that requires an accurate CAD model of the suspension unsprung assembly and chassis space limitations and thus communication with the chassis subteam is critical. The

last step is mechanical design, stress analysis and manufacturing all of which is covered in the proposed thesis.

Keywords

Suspension system, tire data, sensitivity analysis, electric racecar, vehicle dynamics, formula student, fsae

USE OF ARTIFICIAL NEURAL NETWORKS FOR POWER CALCULATION FOR BELT CONVEYORS BASED ON PAST DESIGNS

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ABSTRACT

The present diploma thesis proposes a method for determining the required power of a conveyor carrying bulk load. To solve the problem, the parametric design process is used, which - in combination with the design method based on previous design cases (Case-based Design) - produces a set of design solutions that form a solution base. Then, a set of artificial neural networks is created with different topologies that - using the solution base - are trained, tested and evaluated in terms of the ability to quickly predict the required power of the track. The dissertation is completed with the citation of some case study and conclusions.

Keywords

artificial intelligence, artificial neural networks, parametric design, case based design, conveyors

TRIBOLOGICAL DESIGN OF THE COMPRESSION RING OF INTERNAL COMBUSTION ENGINES USING FULLERENE CONTAINING LUBRICANTS

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ABSTRACT

In order to improve even more the efficiency in automotive engines, it is crucial to fully understand the generation of friction in its components. Finicky simulation and modeling of friction in engine components is, beyond the others, dependent on realistic lubricant rheology and lubricant properties, where especially the latter may as affect on the machine life time as on the environment as well.

Special mention is made of lubricants. Their history is reported as well as the different species. In this case reference is made to the use of lubricants from a tribological point of view. The system of tribology or tribo-system is analyzed and an extensive reference is made to the different types of friction that are encountered. Lubrication greatly affects friction, which is why lubricants are used, and the conditions of friction and lubrication are studied.

Another major chapter of tribology is wear, in all its forms. Obviously the use of lubricants aims to reduce wear as much as possible. There are several types of wear with different characteristics. Many everyday phenomena, such as corrosion, are wear and in this work will make extensive reference to the types of wear.

The rheology of lubricants is a very important chapter and object of study around the world. The fundamental differences between Newtonian and non-Newtonian fluids are analyzed, and the behavior of the fluid in each case is compared. Viscosity is analyzed as a concept, one of the basic characteristics of lubricants. Viscosity is affected by various factors, one of them is temperature which greatly affects the degree of viscosity. The concept of viscosity index and its importance is introduced. As viscosity changes with a possible change in temperature so it is affected by pressure, to a lesser extent of course, and from the shear rate.

Lubricants and their viscosity are reported in various ways, globally accepted according to some certifications. The lubricants used in internal combustion engines, as well as in the various mechanical parts of the car are extensively analyzed. The choice of the most suitable lubricant for each case is very important. There are several criteria that one must consider before making a choice.

In this work, a study is made at the point of contact of the piston mill with the cylinder, and the behavior for different types of oils is studied. The study is done through ANSYS FLUENT. The results are obtained for the duration of a blind cycle and for different crankshaft rotation angles.

Keywords

lubricant, fullerene, tribology, internal combustion engines

DIVISION OF ENERGY, AERONAUTICS AND ENVIRONMENT (FEBRUARY 2021)

CFD SIMULATION OF THE VISCOUS FLOW OF A HORSESHOE VORTEX

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ABSTRACT

In the present dissertation the horseshoe vortex is simulated using computational fluid dynamics (CFD), through the ANSYS FLUENT 16.0 program. First, a reference is made to the advantages of using CFD over experimental procedures. It also analyzes the fundamental quantities and properties of fluids that are essential to understanding the results, as well as the types and states of flows under which a fluid can flow in a conduit or generally anywhere in nature. Also, the most common vortices and the devices in which they are encountered are presented. Then, analyze the mathematical models governing fluids used by ANSYS for a satisfactory approximation of the results. Then, the flow status in a rectangular section pipe is analyzed by inserting an obstacle body (cube) in two dimensions (2D) for a turbulent flow state with inlet speeds of 60, 80 and 100 m / s using the Spalart Allmaras turbulence models, k epsilon and k omega and compare the results of these three models. Additionally, the above arrangement is examined in three dimensions (3D) using the Spalart Allmaras turbulence model and shows the changes in the drag and lift coefficient, velocity vectors and steamlines and the distribution of local turbulence viscosity, pressure and velocity in each of the three components. Finally, conclusions and general remarks are drawn and suggestions are made for further research.

STUDY ON THE EFFECT OF THE VELOCITY OF AN AIR JET IMPINGING ON AN AIRFOIL

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ABSTRACT

One of the most promising procedures for creating lift forces from jet engines is USB (Upper Surface Blowing). In this Process, the orifice from which the fluid exits is placed at the top of the wing and the flow follows the course of the flap, allowing us to apply the Coanda effect in order to design the various vectors that result from the procedure. The Coanda effect, combined with Kutta-Jukowski's axiomtheorem, marks the beginning of research into a less common method of creating a lift, which, however, manages to provide us with lift coefficients of 8-9. In addition, the USB method reduces the noise pollution of the aircraft, since the engine will be placed on the upper part of the aircraft and the wing is between the ground and the latter. Unfortunately, the USB method is still experimental, because the creation of flaps, as well as the jet exhaust can only be done experimentally, since there are several parameters that affect our performance. The creation of each flap should be done in a specific way, in order to fulfill each task that needed be done. NACA type flutters can be used for our experiments, but in order to save time and effort we must create a database to produce a standard USB flight-aircraft design methodology! For now, due to the impracticality of not having a standard design method, we build our various wings in design programs (ANSYS) and follow a simple methodology, choosing stable environmental and design conditions (i.e. atmospheric pressure, constant jet velocity, fixed and specific dimensions- fin ratios, specific flow models, ksst, etc.). The main disadvantage of our method is that in reality, at high altitudes and under reduced pressure, we should take advantage almost exclusively of the vortexes that are created, which encourages the use of conventional lifting methods and not USB. Last but not least, the jet output is not above the entire wing surface, so we have an uneven distribution of forces. Taking into consideration all the above, we will propose a solution and we will use our design in 2D and then we will generalize our solution. In our work, we will analyze a flap of specific dimensions (length 30 cm) and bulge width 1/10 of the length.

COMPUTATIONAL INVESTIGATION OF FLOW INTO A RECTANGULAR SECTION PIPE WITH LVGs

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ABSTRACT

In the modern world of science as well as in the most of rest of the world, saving energy is a key pillar. At heat exchangers the need to reduce energy losses as well as reduce this volume has led to the search for ways to achieve these. A fairly effective way of increasing the rate of heat exchange and reducing the volume of heat exchanger is the development of turbines along the flow, thus the continuous mixing of the layers of fluid. The specific bachelor's thesis is a sequel of the previous student's work which has as a study object the flow within a rectangular conductor cross-section in which on its interior is the mounted a turbine generator pair under different angles. In the following text will be presented a comparative study about the same geometry but the first part will be about a simple line of vortex generators pair whereas in the second it will be a double line of vortex generators pairs placed at the same angles. In this bachelor's thesis the main object of study is the flow and observation of turbine development in each of these different cases depending on the angle incidence and the extraction of conclusions for the functionality of the specific array of vortex generator pairs.

Keywords

vortex generators,vorticity,flow

COMPUTATIONAL ANALYSIS OF AERIAL DROP OF WATER FROM FIREFIGHITING AIRCRAFT IN THREE-DIMENSIONAL SPACE, UNDER SEVERAL REYNOLDS NUMBERS AND ANGLES OF DROP

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ABSTRACT

In this dissertation is researched the drop of water from an aerial firefighting which is still in the stage of preliminary design. After previous thesis, where the drop of water was studied for specific conditions, we have the opportunity to study multiple cases for this drop.

All the theories that have been used for the turbulence model, the multiphase model (Eulerian- Multifluid) and the wall film (Eulerian Wall Film) are represented in this study. Also, we represent the software that we use, the Ansys-Fluent. In which we created the tank of the aircraft fulfilled by water, mesh it with the finite element method and then calculate using k-ε Realizable model the fluid flow in the air. Aircraft speeds are at 16,5m/s and 20m/s and both speeds tested in each angle. The angles that have been used for the tank are 0°, 10°, 15° and 20°. In each case we represent the water that spreads in the ground with the help of Eulerian Wall Film. All in all, there are expounded the results for each case flow and then they are compared with each other. In conclusion, we choose the best case we would like to use for our current aircraft design and we propose future improvements.

Keywords

Ansys-Fluent, Water Drop, Eulerian wall film, Multiphase Model, Aerial Firefighting

COMPUTATIONAL ANALYSIS OF THE FLOW AROUND OF THE FORMULA 1 DRS SYSTEM IN RAIN CONDITIONS

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ABSTRACT

The present dissertation deals with the computational simulation of single-phase air flow and two-phase air-water flow around the rear wing of a Formula 1 car, also known as the Drag Reduction System (DRS), and the study of its aerodynamic behavior. Also for all cases, and with the increase of the angle of attack, the static pressure distributions are studied. The Eppler 420 spoiler was chosen as both the main and the secondary (flap) wing, as suitable for the production of large coefficients of vertical force.

The computer package used is ASNYS Fluent. The simulations were performed for both open and closed DRS, for air speeds of 280 km / h and 320 km / h, and for angles of attack 0˚, ± 3˚, ± 5˚, ± 9˚, 12˚. In the case of biphasic flow, a rainfall density of LWC = 30 g / m³ was selected. All simulations were performed using the Realizable k-e model and in the case of two-phase flow modeling the Discrete Phase Model for discrete phase and Taylor Analogy Breakup for particle splitting were used.

The computational process showed us that, as expected, the closed DRS produces a higher coefficient of vertical force, which increases with increasing angle of attack. In the case of the open there is a decrease as the angle of attack increases. The coefficient of resistance in the closed DRS decreases with increasing angle. Open DRS shows a large reduction in the coefficient of resistance compared to closed, this is also the main goal of the system. The static pressure at the top of the system is higher and more evenly distributed as the angle increases, while where it is maximized, we have the minimum air velocity.

In the study of two-phase air-water flow we have an increase of both the resistance coefficient and the buoyancy coefficient at an absolute value. The droplets were also split during the collision with the film formed on the wings and the formation of a cloud around them.

Keywords

computational fluid-mechanics, double face air-water flow, DragReductionSystem, aerodynamic efficiency

NUMERICAL AND EXPERIMENTAL INVESTIGATION OF AIR-WATER FLOW PASSING THROUGH A T-JUNCTION BRANCH TITLED AT 30^o

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ABSTRACT

In this thesis, the experimental and computational analysis was carried out, through ANSYS Fluent, for the separation of two-phase air-water flow in a T-Junction type separation device with a side pipeline slope 30^o. The analysis essentially consists of two parts, the experimental and the computational and aims to compare these two methods. The result to be compared is the degree of separation of the two-phase flow for twelve pairs of volumetric air-water supplies. In particular, the experimental and computational procedure for three volumetric air and four water supplies was carried out. The air supplies are Qw_1 = 18 L / min, Qw_2 = 30 L/min and Qw_3 = 40 L/min and water supplies are Qw_1 = 8.33 L/min, Qw_2 = 16.7 L/min, Qw_3 = 25 L/min and Qw_4 = 33.3 L/min. An important comparison between the computational and experimental process is also the visualization of the distribution of phases. In addition, through the computational simulation, the pressure drop along the horizontal conductor was studied and compared with the theoretical models (empirical and phenomenological). In empirical, the Homogeneous and the Muller-Steinhagen & Heck model is classified, while in phenomenological, the Beattie&Whalley and Olujic. Also, the vacuum fraction is calculated which is compared with the theoretical model of Premoli and finally the percentage of compaction of the liquid phase in the side conductor of 30o is calculated.

With regard to the experimental part of the work, the present thesis presents and analyzes all the features conceived in the proper elaboration of the experimental process. Initially, photographs of the experimental device are given and all measuring and non-measuring instruments are extensively analyzed. In particular, the construction plans of the experimental instruments and their mode of operation are listed. The way in which the experiment is conducted is then fully analyzed. In particular, the process of starting, alternating between volumetric benefits and ending the experiment is presented. In the first stage, the volumetric supply of air and then water is measured in order to introduce the

two-phase mixture into the ducts. The total air mass flow at the side duct outlet is then measured at the interval of three (3) minutes finding the average of the result for the specified time and dividing it by the mass supply of air entering the facility, the degree of separation is calculated. This result is compared in the last chapter of the work with the corresponding value derived from the computational analysis of ANSYS Fluent.

A series of theoretical knowledge and methods is required for the implementation of computational simulation. Therefore, first of all, computational and theoretical methods for comprehensively understanding the phenomenon are presented. In particular, elements of theory concerning multiphase flows, turbulent flows and T-type separators are mentioned. Then some necessary data are calculated for the computational process such as the height of the first computational cell, the shear stress on the wall of the pipeline and the length of the input pipeline.

One of the objectives of this thesis is to compare results from computational simulation with various theoretical models. In particular, the vacuum fraction is calculated through the empirical model of Premoli and compared with the corresponding value obtained from the computational simulation. Then, the pressure drop is calculated through the theoretical models mentioned above and compared with the corresponding value by the computational process. It is noted that the calculation of the vacuum fraction and the pressure drop in the computational environment of the Fluent result from measurements at specific points of the pipeline through special surfaces transverse to the flow (Surface plans).

In conclusion, in the results obtained through computational analysis, both for the degree of separation and the gap fraction and for the pressure drop, there is no comparison ratio with the corresponding experimental and theoretical values. In particular, the results obtained do not have a constant change in their values depending on the different cases of volumetric air-water supplies. In general, however, although there may be changes in price stability, the results of the computational simulation converge largely on experimental and theoretical values. Therefore, the elaboration of the computational analysis simulates with considerable accuracy the experimental process

Keywords

T-type branching, Experimental & Computational process, Two-phase air-water flow, Degree of separation, Vacuum fraction, Pressure Drop

EXPERIMENTAL STUDY ON VERTICAL BUOYANT JET'S VELOCITY FIELD WITH TURBULATORS

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ABSTRACT

This project concerns the experimental study on the velocity field of a buoyant jet with vortex generators. Specifically, concerns the impact of the vortex generators on the potential core of a free vertical jet flow. Vortex generators are a passive mechanism which is placed on the orifice outlet and they change the evolution of the flow. The experiments included measurements on cross-section traverse the flow in five different altitudes 0.5z/D, 1z/D, 3z/D, 5z/D and 7z/D. The used measuring technique is called P.I.V (Particle Image Velocimetry) and it is a non-intervening measuring method. The exported data concern the statistically mean velocity field and the statistically turbulent velocity field. The three different exit conditions of the flow are:

- round orifice
- round orifice with vortex generators on 45^{o}
- round orifice with vortex generators on 90^{o}

Proceeded measurements export data such as contour diagrams about the statistically mean velocity field for both Vx and Vy, the cross-section flow velocity magnitude, the axial vorticity, the standard deviation of the velocity's turbulent components Vx and Vy, the turbulent kinetic energy and the Reynolds stresses.

In conclusion the results of the cross section contour diagrams are summarized right here.

- The flow, in case it comes through a round orifice without vortex generators is axis symmetric so the exported contour diagrams for the velocity components Vx and Vy but also the exported contour diagrams for the standard deviation of the velocity's turbulent component seem to be alike and rotated to 90 degrees.
- A mixing layer is created in the circumference of the potential core when no vortex generators are attached. The mixing layer intrudes in and deconstructs the potential core.

- The axial vorticity's contour diagram shows when vortex generators are attached, that are generated two vortices and the one contains the other in z/D=0.5 altitude. In altitude z/D=1 the two vortices are merge in one vortex. Vortex generators on 90 degrees seem to cause more intense vorticity.
- The results concerning the statistically turbulent velocity field show that when vortex generators are attached they cause turbulence that is modifying the mixing layer. In other words the existence of vortex generators is responsible for the mixing intensification between the jet flow and the ambient fluid.

CORNER FLOW IN A RECTANGULAR CROSS-SECTION DUCT - THE EFFECT OF WIDTH

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ABSTRACT

The flow of air in ducts is a common practice with various applications such as the transfer of air inside buildings for the purpose of cooling, heating, air exchange (especially in very tall buildings which is usually the only way in this regard), maintaining suitable conditions for working in areas with high environmental load, regulating the level of air purity in cases where there are special requirements for its quality (preparation of electronics, microbiological laboratories, preparation of drugs), but also in specific processes as part of mechanisms (eg intake manifold ducts in internal combustion engines).

The design of the ducts, apart from the purely mechanical part that concerns the materials and their properties (weight, strength, etc.) includes in an important part the understanding and the investigation of the air flow in the ducts and the parts of the air transfer system so that the flow has the desired characteristics.

The present dissertation examines the theoretical background of the study of air flow in ducts focusing on its characteristics and in particular on the secondary flows that occur in a duct of rectangular cross section. In this context and with the help of computational fluid dynamics, the effect of the change in the cross-sectional width of a rectangular straight duct on the flow of air within it and on the formation of secondary flows is examined.

In general, the model created for computational fluid dynamics and the results obtained from the relevant simulations lead to the following conclusions:

- The model confirmed what is stated in the theory related to the formation of secondary flows at the corners of the rectangular cross section of the pipeline.
- The fluid (air) starts at a uniform speed at the inlet of the duct and tends to show a decrease which is more noticeable near the outlet of the duct, in the corner areas.

Correspondingly, the velocities on the cross-sectional axes tend to increase in the areas around the corners of the cross-section, especially in areas close to the exit, which indicates the turbulent flow in these areas.

Consistent with the relevant theory of secondary flows, it is presented at the angles and for the velocities of the cross-sectional axes or their grouping in pairs at high and low on opposite sides of the cross-section.

The increase in width generally increases the phenomena as shown by the relevant diagrams of turbulent kinetic energy, as the field (area) that it increases becomes larger as the ratio of width/depth of the section increases.

Keywords

Computational fluid dynamics, pipeline flow, viscous flow, secondary flows

COMPUTATIONAL AND EXPERIMENTAL INVESTIGATION OF TWO-PHASE FLOW DIVIDING AT A 45^o INCLINED T-JUNCTION BRANCH

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ABSTRACT

The purpose of this project is the calculation and the optimization of important parameters of two-phase flows in a simple T-junction setup. Important terms such as the void fraction, phase separation and the pressure drop are understood and investigated theoretically, computationally and experimentally.

The theoretical analysis aims to use empirical models for the calculation of the pressure drop in a wide variety of two-phase flows, with various volumetric intakes of air and water. The reliability and flexibility of the Homogenous model, the Friedel model, the Beggs-Brill model as well as the precision of the Baker flow chart for horizontal flows in predicting flow patterns, are thoroughly examined.

The computational investigation begins with the construction of the examined geometry in 3D in the environment of ANSYS Fluent, and continues with the creation of a computational nexus of finite elements. After that, the insertion of flow parameters and the execution of simulations for the same volumetric intakes that were previously analysed theoretically is carried out. This research is concluded by producing results regarding the pressure drop, the average velocity of the mixture, the percentage of liquid take-off in the side arm of the T-junction as well as the phase separation percentage.

Afterwards, an experiment is conducted to better approximate the previously simulated procedure. The setup of the experiment is depicted and explained. The experiment is thoroughly described and eventually, the examined flow parameters are measured and recorded.

Finally, an interpretation of the theoretical, computational and experimental results and a comparison between them is actualised. The aim of this process is the discovery of the most

precise method used in approaching two-phase flows, as well as the better understanding of this complicated phenomenon.

FINANCIAL AND TECHNICAL STUDY OF RENEWABLE AND FINITE SOURCES OF ENERGY

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ABSTRACT

This diploma thesis reviews the economic and technical aspects of renewable and conventional energy sources.

Initially, the available energy sources worldwide are listed and categorized into renewable and conventional. Then, the individual costs for energy production, both short-term and long-term, are investigated. These include the costs of installing the power plant, raw materials, maintenance, emissions of dangerous gases for the environment, the health of workers and especially in the event of an accident.

Furthermore, the cost of energy production of the individual sources is compared. To achieve the comparison, the levelized cost of electricity is introduced, which measures the total cost of energy production per unit of energy. It was observed that in 2017 the cost of electricity generated using renewable sources was often comparable to that of fossil fuels.

In addition, the range of use of each source was investigated, by comparing the different sources according to the production costs, both in Greece and in the EU. Indicatively, it was observed that between 2005 and 2017, the share of renewable sources in electricity generation in the EU doubled, from around 15% to almost 31%.

Finally, conclusions and suggestions for the future are presented.

NUMERICAL SOLUTION OF THE FLOW IN A 3D LID DRIVEN CAVITY

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ABSTRACT

This diploma thesis investigates the laminar, incompressible and steady state flow in a 3D lid driven cavity. Initially, the theory of fluid mechanics is introduced, as well as the equations of fluid dynamics which arise from the conservation laws of classical physics. All sufficient data associated with any given physical situation are included, required to produce a mathematically well-formulated CFD (Computational Fluid Dynamics) problem and the basic aspects of discretization. The partial differential equations have been discretized with the method of finite differences. At the first stage, the Central Differences (CD) and Upwind scheme are applied to simple partial differential equations such as the one-dimensional parabolic heat diffusion equation and the one-dimensional hyperbolic advection equation. The two-dimensional nonlinear system of Burger's equations is resolved in MATLAB environment using the above schemes, the obtained results are compared between the central differences and the Upwind discretization method, whereas the independence of the numerical solution from the grid is being studied and concludes that the central differences are more effective than the Upwind scheme as the grid becomes sparser. Then, the pressure term is introduced and two methods of calculation for the pressure field are described· IPOT and IPOT RHIE & CHOW (RC). With the incompressible Navier-Stokes equations having emerged, the geometry with the initial and boundary conditions of the flow in a 3D lid driven cavity is expressed. The comparison between the IPOT and IPOT-RC method led to the rejection of IPOT due to unnatural pressure oscillations. The computational code is created in MATLAB environment. The central differences are used for the Navier-Stokes equations and the results for the velocity field are presented and concern four Reynolds numbers, namely 10, 100, 400, 800. At the end, future extensions of the diploma thesis are suggested.

COMPUTATIONAL STUDY OF THE THERMAL EFFICIENCY OF A TROMBE WALL WITH AN EMBEDDED PHASE CHANGE MATERIAL

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ABSTRACT

This diploma thesis is about the computational study of the thermal efficiency of a passive solar system used in the bioclimatic design of buildings. More specifically, a variation of the classic Trombe wall is analyzed, which includes, in addition to the glazing and the thermal storage wall, an embedded phase change material (Glass-Water Trombe Wall). In particular, the phase change material that has been added, is in the form of a water wall because due to the high conductivity of this material, large amounts of heat can be transferred to the interior of the building quite quickly.

After simulating the wall, a comparison is made between it and the other 2 categories in terms of thermal efficiency of the conventional Trombe wall, with that of the Water-Trombe Wall and the Glass-Water Trombe Wall, in order to find out which is the most efficient of the 3. To make a correct comparison, the simulations were performed under the same and constant conditions.

ANSYS computer program Fluent was used to solve the problem. The simulation took into account the solar radiation where the Discrete Ordinates model is used, while the SST k-ω and the Boussinesq hypothesis were also used as the turbulence model.

COMPUTATIONAL STUDY OF NACA4412 AIRFOIL PERFORMANCE IN A 2D MULTIPHASE FLOW OF AIR-WATER AND APPLICATION TO A WIND TURBINE WING

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ABSTRACT

This diploma thesis refers to the study of the effect of rainfall on the aerodynamic characteristics of the airfoil NACA 4412. For this purpose, we used the computational package ANSYS Fluent for Reynolds number Re = $1x10^6$ and Liquid Water Content, LWC = 30g / m^3. Firstly, a reference is made to renewable energy sources, especially to wind energy, and the need of using them to meet the energy requirements of our planet. Then basic concepts of aerodynamics are listed below and wind turbines are mentioned as machines that utilize wind energy. At the same time, airfoils, as a basic part of a wind turbine, are discussed here, and their operation principles are demonstrated. Next, a reference is made to the multiphase flows and the two-phase air-water flow that will concern us is described too. For a clear understanding of this study, we describe the way in which computational fluid dynamics is used to analyze and record the behavior of an airfoil under specific conditions. Thus, the realizable k-e turbulence model with the corresponding Euler-Lagrange, Euler-Euler multiphase flow models, discrete phase model and droplet break-up model are presented below. Finally, the results of the study and relevant detailed conclusions are reported.

STUDY OF ANALYTICAL SOLUTIONS FOR THE DIFFRACTED SIGNAL AROUND RIGID WEDGES

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ABSTRACT

The present diploma thesis is a study of the analytical solutions of the diffracted acoustic signal around a semi-infinite acoustically rigid wedge of angle 2Ω in the time domain. In particular, the Directive Line Source Model (DLSM) is examined and compared with the exact analytical solution of Biot and Tolstoy for the diffraction of spherically spreading waves around a wedge. This comparison shows that the error of the model depends on three parameters, which are the wedge angle, the period of the incident signal and the region around the wedge in which the receiver is placed. Furthermore, in order to compensate for that error a modification of the initial model is proposed. The Modified Directive Line Source Model (MDLSM) is extracted from the exact analytical solution of Biot and Tolstoy and is introduced in a form that retains the simple mathematical form of the former model, while showing higher accuracy for every wedge angle, period of incident signal and region of the receiver. Moreover, it is proven that the modified model maintains the advantages provided by DLSM, with a wider region of validity. For instance, it provides a diffraction number that describes the evolution of the signal and a generator curve that embodies/generates all the impulse responses of the diffracted field. In the study of the initial model it was shown that the generator curve and the diffraction number are applied in the case of the half plane, whereas the study of MDLSM proves that it is possible to apply the same concepts for every wedge with angle 2Ω and every source receiver configuration. Finally, the MDLSM is extended to plane and cylindrically spreading waves and it is compared with the corresponding exact solutions.

Keywords

Diffraction, Wedge, Analytical Solutions, DLSM

COMPUTATIONAL INVESTIGATION OF LNG FLOW INSIDE A PRECOOLED CRYOGENIC PIPE DURING A BUNKERING PROCEDURE ON A SHIP

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ABSTRACT

The subject of this diploma thesis is the study of temperature changes of a ship's cryogenic pipe, during Liquefied Natural Gas (LNG) bunkering procedures. The extent to which the flow of the various fluids used to prepare the pipeline for refueling affects its temperature, has been investigated using the methods of Computational Fluid Dynamics.

LNG is stored under atmospheric pressure at -162^{o}C. Its immediate channeling through the supply system of the ship, which is at room temperature, will cause its instantaneous evaporation and consequently the rapid increase of the system's pressure. In addition, it may cause thermal stress shocks to the system's components due to the sudden change in temperature. In order to avoid the above consequences and to ensure the safe supply of LNG, a series of procedures that precede mass loading of the fuel and compose the subject of this thesis, are carried out.

During the first stage, the introduction of inert gas (Nitrogen) at a temperature of -45^{o}C is simulated, in order to purge the system from the air that occupies its space. Afterwards, warm natural gas flows at a temperature of -80^{o}C in the inerted pipeline, in order to eliminate nitrogen and to maintain the composition of stored natural gas according to the specifications. After the completion of all the above processes, the pre-cooling process begins. At this stage we study the procedure of cooling down the pipeline to a temperature close to that of LNG, using three different velocity profiles ranging from 0,006m/s to 0,5m/s, 1m/s and 1,5m/s respectively.

The pipeline was designed according to the FW - Fernwärme Technik standards. It consists of a pipe-in-pipe system, with multilayer insulation of rigid polyurethane foam and vacuum, a technology that has a leading role in the construction of LNG storage and transport systems. Fluent code of Ansys 2020 R2 software was used for the design of the geometry and the construction of the computational grid, as well as for modeling the flows and the results

extraction. Primary aim of those simulations is the development of the expertise around the construction of optimal LNG vessel supply systems, through the understanding of various flow effects on them.

Keywords

Cryogenic Pipe, Liquefied Natural Gas, Inerting, Gassing Up, Cooling Down

SIMULATION OF THE VAPORIZATION RATE OF N-HEPTANE TURBULENT SPRAY, INSIDE THE PATRIAL PREMIXING CAVITY, IN A PRIMARY HOT AIR FLOW OF DISK - PREMIXER BURNER ARRAY

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ABSTRACT

Vaporization of liquid fuels and the search for suitable ways to explain the phenomenon and the appropriate geometries where the process can take place, is a subject that even nowadays occupies the scientific community. It is crucial to control vaporization rate as it is a factor that contributes a lot in the characteristics of the flame and the combustion that follows. It is proven that the vaporization rate of droplets and the rate of penetration of the oxidizing gas into a spray of fuel, has a strong influence on the kind of combustion that will occur.

A liquid spray occurs when an amount of a liquid fuel (or an amount of any liquid) is getting dispersed by using a spay injection system. In this work an attempt was made to investigate and devise a series of steps for modeling the evaporation of a liquid fuel spray. The proposed methodology can also be generalized for the process of preparing any simulation and for any computational fluid dynamics program. However, for this work the program Fluent of Ansys was used. So, for this software some basic equations that govern its models are mentioned.

Within the context of this work, two different arrangements were used to simulate the evaporation of a liquid fuel spay. One of them was a simple square duct arrangement and the other one was a disc – premixer burner array. In the first case, ethanol is being sprayed in a short distance from the hot air inlet plane and in a transverse direction relatively to the air's direction. As the air flow sweeps the spray along, it disperses it and increases evaporation rates. The viscous model that was used was the Realizable k-ε, while for the simulation of the discrete phase, the DPM model (Discrete Phase Model) of Fluent was chosen, which is an Euler - Lagrange type model. The results are compared with those obtained from a similar simulation from a bibliographic work. More specifically, the discrete

phase temperature and the reduction of the mean diameter of the droplets along the duct are compared. The relatively simple arrangement of the first case, is essentially an introduction to more complex arrangements, like the one of the second case. In this case, n-heptane is sprayed into the small cavity of the disc – premixer burner array and in a direction opposite to that of the hot inlet air. This option in combination with the disks of the arrangement, create vortices and turbulent flow which benefit fuel - oxidant mixing and dispersion of the spray and leads to faster evaporation. For the modeling of the turbulent flow and discrete phase, the Realizable k-ε and DPM models were selected respectively once again. Finally, the velocity and temperature of the discrete and continuous phase along the geometry are presented in contours and graphs, as well as a graph of the mean diameter of the droplets and a contour of the mean mass fraction of n-heptane are introduced.

Keywords

Spray evaporation, Realizable k-ε model, Ethanol and n-Heptane evaporation, Disk – premixer burner array, Square duct arrangement.

COMPUTATIONAL STUDY OF FLOW INSIDE CAVITY

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ABSTRACT

The current thesis aims for the computational solution of laminar and incompressible flow of a Newtonian fluid. Initially the thesis focuses on solving the problem in two dimensions and then it expands to the third dimension. The geometry of the problem is a square cavity in two dimensions and a cubic cavity in three dimensions. The upper wall of the geometry has a velocity witch is oriented towards right and therefore the fluid that is tangent to the upper wall has the same velocity. Specifically for the solution of the problem, four different codes were developed via Matlab software, two of witch focus on a two dimensional solution and the rest focus on a three dimensional solution. The method used for the solution is called IPOT (Impicit Potential) and to counter the abnormalities that occur when this method is applied , the Rhie-Chow scheme is also introduced. Last but not least, contours for specific values of Reynolds Number are presented as well as comparing diagrams of the horizontal velocity depending on the vertical dimension.

Keywords

Cavity flow, computational fluid mechanics, IPOT, Rhie Chow, 2D, 3D

COMPUTATIONAL SIMULATION OF FIRE IN A SMALL APARTMENT

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ABSTRACT

The scope of this thesis is to familiarize the user with computational fluid dynamics (CFD) software, which eventually will be used in a model. Specifically, the Fire Dynamics Simulator (FDS) software for the computation and Pyrosim for the design and simulation of the fire model, which will be a fire in a small apartment. Firstly, statistical data are shown which provide the socio-economic consequences of the fires, the causes and solutions to the problem. Moving forward, the theory of CFD programs is analyzed. For example, the governing equations of a problem, which are the principles of conservation of mass, energy and momentum. Also, the equations Navier-Stokes, which constitute the most important equations used by CFD software, in order to describe a problem. The theory of turbulence is also cited, as this is regarded the major problem to the numerical solution of a fluid problem. Moreover, the methods used to analyze turbulent flows, Direct Numerical Solution (DNS) and Large Eddy Simulation (LES) and turbulent models that are used by CFD software to simulate a flow. Some tutorials were performed with Pyrosim, in order to understand the possibilities of this software. The tutorials that were performed ranged from simple ones, such as the simulation of air flow and the simulation of a fire inside a room, to more intricate ones, like importing a complex geometry model, setting an extinguishing mechanism, or the creation of fluid motion by opening a door. Next, as the first part of theory and tutorials has finished, the model of the apartment will be designed. All the parameters are going to be defined, such as the materials of the apartment, the surfaces, the mesh and the outputs that are desired. Then, a few scenarios are going to be put to the test, in order to get different results for the better comprehension of the fire phenomena.

Finally, these results are going to be compared in order to distinguish the differences between the scenarios and what cause these fluctuations to the results

DIVISION OF MANAGEMENT AND ORGANIZATION STUDIES (FEBRUARY 2021)

SUPPLIERS' ENVIROMENTAL EVALUATION PROCESSES IN THE GREEK MARKET

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ABSTRACT

In recent years, mainly due to the globalization and decentralization of companies, needs have arisen for rational management of raw materials and final products. Even in smaller markets, such as the Greek market, these needs are increasing, either due to climate change, or the increasing energy costs of production, transportation, etc.

Primary aim of this graduate thesis is the best possible understanding of the environmental behavior of suppliers operating in the Greek market.

For this purpose, a survey was conducted based on an online questionnaire in seven hundred and forty-nine (749) companies of the following sectors: Industry, Craft, Processing and Recycling, Food and Housing, Construction, Import - Export and General Trade operating in Greece.

During the analysis, we will find that the general picture of the environmental behavior of companies in the Greek market is quite satisfactory. Most companies in the Greek market are quite environmentally aware, both internally and in their requirements from their suppliers and the State. Unfortunately, there are many who have not yet decided whether the environmental supply chain and its evaluation are useful, both in their internal operations and in general. About one tenth of those, denies or opposes processes and behaviors that improve its environmental image. However, there is considerable room for improvement in the future. With more effort, proper management of environmental criteria

and rules, as well as sustainable solution of the special problems Greek market suffers, the path to environmental awareness and processes, seems auspicious.

Keywords

“Environment” “Evaluation” “Supplier” “Environmental Behavior” “Greek Market”

PREDICTION OF FAILURES RELATED TO THE COMPRESSED AIR PRODUCTION SYSTEM (APS) IN SCANIA VEHICLES, USING MACHINE LEARNING TECHIQUES TO MINIMIZE THE TOTAL INSPECTION COST

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ABSTRACT

This study presents the Air Pressure System in Scania vehicles and how the overall control costs can be predicted and minimized using machine learning techniques. A compressed air tank is a pressurized tank that contains compressed air. Compressed air tanks are used in the braking system and other similar systems that require the use of compressed air. The APS system controls the air pressure in the compressed air system of the vehicle which includes components belonging to the air supply circuit.

Prediction of failures and the total cost of maintenance and inspections is extremely important and is currently used in many sectors such as aerospace, shipping and the rail industry. Utilizing these predictions, it is possible to increase safety and at the same time reduce direct and indirect maintenance costs.

In order to have the best and most accurate predictions, machine learning is used which is computational methods that use prediction algorithms. The data they use is information that is already available for analysis, and based on this, machine learning techniques can predict side effects, provide early warnings, and suggest preventative actions regarding problems or deviations from the original goals. In general, machine learning is linked to computer science but also to statistics, probability and optimization.

Keywords

Scania vehicles, APS, Prediction of failure and costs, Machine Learning

IMPLEMENTING A HYBRID RECOMMENDER SYSTEM THROUGH THE EXPLOITATION OF SENTIMENT ANALYSIS TECHNIQUES ON ONLINE USERS' REVIEWS

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ABSTRACT

Internet's ceaseless development has instigated major changes over the last decades, both in the way people get informed and communicate and the public's consumer habits. Electronic commerce accounts for a modern alternative to purchasing, however, the vast mass of available information in online shopping can make for a complicated process. Recommender Systems are called to solve these challenges by locating products or services according to each user's interests. In this thesis, we consider the theoretical basis of Recommender Systems, as well as the methods used in electronic commerce in order to facilitate users' browsing experience by proposing products and services that match their needs. We introduce applications and algorithms of Machine Learning and analyse Recommender Systems' combinations with Machine Learning algorithms that have been created in order to generate more efficient suggestions. Later on, we develop a Recommender System that deploys a data base with products from Amazon and implements suggestions according to the Model-based Collaborative Filtering System model, based on the products that are being sold and the users' reviews. Afterwards, we implement the same Recommender System model, combined with Natural Language Processing. Finally, we inspect the results from both models and evaluate them based on efficiency.

Keywords

Recommender System – Machine Learning – Model-based Collaborative Filtering System Model – Natural Language Processing

DEVELOPMENT OF A PLATFORM TO SUPPORT URBAN LOGISTICS THROUGH CROWDSOURCING METHODS

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ABSTRACT

In recent years, the rise of both online food ordering and e-commerce has created an increased need for omnichannel distribution response to last mile distributions. Some companies experiment with using the sharing economy business model to optimize distribution strategies using crowdsourcing. A business based on crowdsourcing platform only is unable to fulfill the entire range of deliveries reliably without the operation of a dedicated fleet of vehicles. Therefore, the main goal of this research is to develop a commercially viable business model that combines "Crowdsourced Logistics" (CSL) and an internal fleet of distributors to fulfill last mile & food delivery. The research, which adopts a research design strategy, is based on Osterwalder and Pigneur's Business Model Canvas (2010) as a theoretical framework to guide the empirical study using qualitative research methods. In this research we will first study the theoretical background of crowdsourcing and business model canvas. Then we will analyze each building block of the crowdsourcing company and we are going to integrate into its Business Model Canvas. Finally, android software applications will be developed that will achieve the communication between shopkeepers and distributors as well as the control of the order process until their completion. In addition, a presentation website of the company under study will be developed.

In more detail, the structure of the dissertation first follows an overview of the methods and begins with a review of the current literature on crowdsourcing and business strategy planning.

The company under study will offer value through internal distributors and through crowdfunding, so it is important to analyze the theoretical background of crowdfunding and crowdfunding in general. So in Chapter 2 a study of the existing literature on crowdfunding as a business model and I focus on crowdfunding distributions through a platform.

In Chapter 3, the literature review begins by examining business strategy, planning, and innovation, and provides a description of business planning with an in-depth critique of current theories and literature. Next, I present various business modeling tools that are available to technology start-ups. At the end of the chapter, such a tool is implemented for WeDelivery, the company under study.

The theoretical background of the canvas business model is analyzed in the next chapter, although it is also a tool of strategic management and this is why it was necessary to make an extensive analysis of the canvas. Therefore Chapter 4 concerns the Business canvas and the theory behind it. Each section is separated by the structural corresponding structural element of the canvas which is analyzed in detail.

In the 5th chapter I proceed to the application of the canvas business model for WeDelivery based on the data collected. The modules were separated this time not by building blocks but by building blocks as shown below: Infrastructure (Key Partners, Key Resources, Key Activities), Business Proposal (Value Proposal), Customer (Customer Relationships, Networks, target markets), Profitability (Revenue Flows, Cost Structure). Finally, the business canvas for the company is completed. The dissertation concludes with the conclusions of the results and with suggestions for future research or business activity.

In the 6th chapter begins the development of the platform (2 applications) and the online page of WeDelivery. This chapter is divided into sections that include the analysis of user requirements followed by the relevant analysis diagrams of the platform, the tools used to implement it, the detailed presentation of its pages with the actions that users can perform as well and the presentation of the online page from which those interested can be informed about the sections in which they can cooperate with WeDelivery.

DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMEHANICS (JUNE 2021)

STRUCTURAL ANALYSIS OF A COMPOSITE STRUTT WITH METAL FITTINGS FOR SPACE STRUCTURES. THE USE OF MICROPINNING TECHNOLOGY FOR THE JOINING OF CFRPS WITH THE METAL AND CONNECTORS

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ABSTRACT

The micro pin 3D reinforcement, is a brand-new field of research in the section of the composite materials joints, mainly coming up from the aviation industry, providing great advantages in the mechanical properties of the joint (such as lightweight connection, increased strength and significant improvement in damage tolerance etc.) compared with previous technologies. The benefits of this method are tremendous however there is a lack of usage of this technic in real applications outside the laboratory. Inspired by that this thesis wants to emerge the benefits of this technology by applying it in space structures and compare it with previous methods. Therefore, two FE models where created in ABAQUS for structural analysis of a CFRP space strut with aluminum fittings and for the joint of those two with two individual methods: the first was with adhesive bonding and two adhesives where used, ARALDITE AV138M1 and ARALDITE 2015 and the second with the micro pin technology. For the modeling of the micro pin layer in the structure, cohesive elements where used with certain properties taken from previous studies that where created for the same purpose. After that the influence of the height of the m-pins in the joint is studied and all the results are presented and compared to each other.

Keywords

composite joints, micro pins, cohesive elements, finite elements, space structures

STATIC DESIGN AND OPTIMIZATION OF AIRCRFAFT WING STRUCTURES WITH COMPOSITE MATERIALS

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ABSTRACT

On this thesis, several aircraft wing components are designed for finding an improved geometry and material system using optimization algorithms. At first, the develop-ment of wing components will be studied and how composite materials contributed to that in the last decades. Because of this, the advantages, properties and applications of composite materials will be mentioned. However, special attention will be given to a specific type of composite material, the one with carbon matrix. Closing the first part of this thesis, which is the theoretical background, the classic laminate plate theory is being understood since it is used at the analysis to a great extent and a whole chapter refers to the optimization field for engineering and industry.

Regarding the part of analysis, the structural part that surrounds the main wing frame, that is the stiffened skin or else stiffened panel will be examined thoroughly. Several modeling techniques with finite elements, such as equivalent plate will be surveyed as well as adhesive modeling technique will be developed. The glue bonded joints con-stitute a significant survey topic, since their wide use in aeronautics, so the next com-ponent that will be analyzed extensively is a bonded doubler that actually it is a con-junction between two plates, in which the second has smaller dimensions. It is used for reinforcement on damaged skin components or for antenna adhesion on the air-plane fuselage. So, the connection between flange and web can be analyzed with this method, so that the optimum lamina stack sequence around the adhesive can be esti-mated.

Finally, a very important design parameter is the damage tolerance. It's the final and most significant piece of the process that is added to the total stiffened panel analysis and makes it complete. Specifically, the damage that will be investigated is an open hole that is used on the airframe and skin for many reasons, such as bolted joints, cut-outs and weight reduction. The optimum stack lay-up is found for minimizing the stress concentration factor around hole.

Keywords

Stiffened Panel, Composite Materials, Optimization, Bonded Joints, Damage Toler-ance

INFLUENCE OF EXPOSED TO CORROSION LEGTH OF REINFORCING BARS ON THEIR SEISMIC RESISTANCE

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ABSTRACT

Steel corrosion constitutes the main cause of durability reduction in reinforced concrete constructions. Particularly in Greece, where a high percentage of constructions are located in coastal areas, corrosion-based issues greatly arise due to aggressive chloride action (XS category based on EN 206). It is established that the mechanical performance of steel reinforcement is significantly diminished, as corrosion causes a loss of the reinforcement's profile and deterioration of its mechanical properties, mainly in terms of ductility. To improve the passivation of steel reinforcement against corrosion, EN 206 suggests the use of higher quality concrete and minimum thickness of concrete coverage, which limit, but don't prevent concrete cracking, which in turn is linked to the penetration and permeation rate of these aggressive, corrosive factors. So the limited concrete cracking, compared to older constructions, favors the creation of small, exposed surfaces on the corroded steel reinforcement, a fact that has been proven to greatly affect the rate and level of reinforcement corrosion. Taking the above into account, in the present experimental study the effects of the exposed corrosion length of steel reinforcement is placed under examination. Specifically, 96 specimens of steel bars B500c, with nominal diameter of 12 mm were used. They were broken into two groups, in order for the effects of exposure to corrosion length to be examined. One group featured a small exposed length of 1 cm and the other featured a large exposed length of 10 cm. For the needs of this study and in order for the corrosive agent's effects to be examined in a short amount of time, 84 tests of accelerated corrosion via electrical current were administered, for durations of 150 and 300 hours, respectively. From analyzing the experimental results, the effect of steel's exposure length to corrosive environments is significant, since an intense distinction in corrosion damage is exhibited, both in terms of percentage mass loss as well as the morphology of the pitting corrosion.

In addition, taking into account the fatigue effects that are introduced to the steel reinforcement due to intense seismic activity, this study examined the seismic response of

steel bars through low-cyclic, fatigue testing. The main parameters examined were the free fatigue length, equal to 6Φ (72 mm) and 8Φ (96 mm) respectively, as well as the enforced deformation range, equal to ±0.75%, ±1.0% and ±1.25%. At the same time, given the need to improve on the construction steel reinforcement's anti-corrosive protection, in this study every corroded specimen had also been subjected to a shot peening process, to examine the impact of shot peening on corrosion damage as well as the steel reinforcement's mechanical performance. The shot peening process featured two stages, first a blast of Olivine particles, followed by glass bead particles. As shown by the extracted fatigue data, shot peening the steel bar specimens exhibits a beneficial effect in the reinforcement's mechanical performance, mainly in low ranges of cyclic deformation, improving the material's life duration. On the contrary, during greater deformation tests, the positive effect of shot peening is limited due to the appearance of buckling.

Keywords

Steel reinforcement, corrosion, fatigue, anticorrosive protection, shot blasting, sandblasting

DESIGN OF A MARS MICROROVER EXPLORATION CONCEPT

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ABSTRACT

Mars is one of the most important targets of space exploration and a major candidate for the creation of a human colony in the future. In fact, only in the year 2020, 3 space missions were launched from different countries with destination the red planet. Its ocean-filled past and evidence of modern water in liquid form are an encouraging sign of possible existence of life. One of the most important means of exploration are autonomous research vehicles, which enable scientists to study Mars closely and give answers to its greatest mysteries. Ideas and bold designs of autonomous research vehicles must be encouraged, as the future of humanity in these inhospitable parts of space can only begin with their distant exploration and better understanding. In this spirit, a microrover type vehicle is designed, aiming to search for water and collect samples. Finally, the importance of microrovers in future missions that will set the stage for the human exploration of Mars is highlighted.

Keywords

autonomous, exploration, rovers, design, Mars

INVESTIGATION OF THE EFFECT OF GRAPHENE NANOSPIECES ON THE DAMAGE TOLERANCE OF FIBROUS COMPOSITE MATERIALS UNDER STATIC LOADING

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ABSTRACT

In the last decades, fibrous composite materials have proven to be the answer in the advanced industries' search for materials with superior mechanical properties, combined with minimized weight. Graphene, one of the current century's greatest discoveries, was quickly realized to be of immense value in this search. The inclusion of various types of graphene nanoparticles in composite structures yielded not only astounding mechanical properties, but also unprecedented improvements in the electrical, chemical and optical properties of such materials.

In the present thesis, the effect of graphene nanoplatelets (GNPs) in the fracture response of fibrous composite specimens is investigated. More specifically, nano-enhanced laminates were compared to their neat counterparts on their interlaminar fracture toughness results in Mode I and Mode II testing, under static loading. In the case of nanoenhanced specimens, two material systems were created with nanoparticles of different dimensional features, in order to further assess the effect of sizing in the overall enhancement.

The specimens for both modes originated from a single laminated CFRP plate in each case, the manufacturing of which entailed the use of an automated pre-impregnation contraption, lamination and consolidation by means of an autoclave. For the nano-enhanced epoxy matrix, the required dispersion of the GNPs was achieved by following the method of three-roll milling, that utilizes a calender configuration.

Results indicated a similar fracture response in both modes, as the nano-enhanced material system with the smaller GNPs exhibited improvement of the interlaminar fracture toughness values, by 19% for Mode I and 5% for Mode II, compared to the neat matrix system. On the contrary, the second nano-enhanced material system's results showed deterioration of the

same values, 27% and 37% respectively, providing thus a strong case on the matter of the nanoparticles' dimensions effect on their capability to enhance composite material structures.

Keywords

composites, nano-enhanced laminates, graphene nanoplatelets, fracture

THERMAL BEHAVIOUR AND FAILURES ANALYSIS OF CONTAINER MADE OF COMPOSITE MATERIALS UNDER EMERGENCY DECOMPRESSION CONDITIONS

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ABSTRACT

Aircraft containers are remarkably useful for cargo transportation purposes. Under normal operational conditions a pressure of 7 kPa is developed, whereas, in emergency situations (rapid decompression) 14kPa overpressure at the interior of the containers is developed. It is also essential to secure their operation in the case of fire and this can be achieved with the use of a fire detection system which at a temperature of 120^{o}C activates the extinguishing system.

The aim of this thesis is: (1) to analyze through a finite element method the thermomechanical behaviour of an air container made of composite materials subject to decompression under both room and elevated temperature and (2) to inspect its structural integrity and (3) to design the container to withstand the loads that various thermomechanical circumstances impose. The analysis was performed with use of the material properties at 25^{o}C and 120^{o}C (thermal expansion coefficients included). For structural integrity to be achieved, the container should present no initial failures at ΔP=7kPa and no detrimental failures at ΔP=14kPa. The structural integrity of the composite frame has been assessed through Hashin and max stress failure criteria. For the aluminum brackets the maximum von Mises stress was compared to the yield limit and the ultimate strength. The main design was performed at room temperature, in which case all the requirements were met and improvements were made to endure at 120^{o}C, in which case failures occurred, due to the degraded materials properties and the thermal stresses that were developed.

Keywords

Analysis, Design, Container decompression, Composite materials, Thermomechanical behaviour, Fire, Finite elements, Failure criteria

A STRAIN-RATE DEPENDENT MICROMECHANICAL FINITE ELEMENT MODEL FOR HIGH-VELOCITY IMPACTS ON LAMINATED COMPOSITE PLATE

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ABSTRACT

The aim of the current thesis is the development of a multi-scale micromechanics-based strain-rate dependent FE micromechanical model for the simulation of high velocity impacts on a laminated composite plate IMS-65/RTM-6. The micromechanics analysis is based on the composite material model of Chamis. The inclusion of micromechanics enables the synthesis of composite properties using constituent material models and input properties at the fiber/matrix level. Strain-rate effects of the matrix are considered in the micromechanics. According to the Gerlach model, simple variation of the Weibull distribution formulation has been adopted for the modulus and a linear approximation for the strength of the matrix. For the damage initiation in the composite, the max stress criterion was implemented. For the damage evolution, predefined degradation factors for the mechanical properties of the fibres and matrix were assigned. The resultant degraded composite properties are calculated using the micromechanics. Cohesive contact properties between two plies with appropriate mixed-mode damage laws were implemented to simulate delamination. The micromechanical model was implemented in the FE code (ABAQUS/Explicit) through a user-define material subroutine (VUMAT).

A series of woven carbon/epoxy plate specimens impacted by steel ball impactors of high velocities and energies reaching and/or exceeding the ballistic limit (m=110 g, v=60-100 m/s, E=200-500 J) are investigated and multi-scale progressive failure explicit dynamic FEA analyses are performed to assess impact response and predict progressive intraply damage and interlaminar fracture evolution. Ultimately, correlations with high-velocity impact tests and post-impact NDE validate the capability of the multi-scale FEA model to determine the structural integrity of the impacted composite structures in terms of: (1) type of failure (delamination, matrix cracking, etc.); (2) damage footprint (pattern and size); (3) penetration energy (ballistic limit).

Keywords

Strain Rate, Micromechanics Chamis, High Velocity Impact, Composites, Ballistic Limit, FE Model

DIVISION OF DESIGN AND MANUFACTURING (JUNE 2021)

DESIGN AND DEVELOPMENT OF PRODUCT - SERVICE SYSTEM BASED ON AUGMENTED REALITY FOR MACHINE MAINTENANCE

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ABSTRACT

Maintenance is a demanding set of tasks performed on industrial equipment. Technicians are obliged to carry printed manuals, in order to perform all the necessary corrective actions. Moreover, there are cases where the technician needs to communicate with an engineer or even call specialized personnel in order to accomplish complex maintenance tasks. Technological advances in mobile technologies and mixed reality, have enabled engineers over the world to produce useful applications for providing all the needed instructions and communication with the use of any smart device, just by registering 3D content on the real environment. Augmented Reality is a cutting-edge digital technology facilitating engineers in reducing the cognitive load of technicians. Further to that, with the utilization of AR the threshold for minimum special skills and/or training is also reduced. Taking into consideration the advances in Information and Communication Technologies (ICT), expert engineers are capable of establishing sufficient communication channels with the shopfloor technicians, in an attempt to provide to provide remote guidance. As a result, the total maintenance time of industrial equipment can be further reduced and simplified. The purpose of this research work is the design and development of an AR based remote and smart maintenance framework for Engineered to Order (ETO) equipment. The framework can be realized as a mobile AR application, which is provided to the clients from the OEM as a Service, thus creating a Product Service System (PSS).

Keywords:

Augmented reality, Product-Service System (PSS), maintenance, Engineered-to-Order (ETO)

ACCIDENT RECONSTRUCTION OF PASSENGER VEHICLES FRONTAL COLLISION

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ABSTRACT

In the present dissertation, an expert report was investigated regarding the frontal collision of two passenger vehicles and the deadly injury of the one co-driver, so that the conditions that led to the accident can be explained. Optical and geographical data recorders are used for the reconstruction as long as the technical characteristics of each car. For the final reconstruction scientific methods will be used, available at the global bibliography for a mechanical engineer. From the analysis of the preceding methodology, a systematic algorithm for the reconstruction of similar accidents can be created and developed.

Keywords

Accident reconstruction, momentum equilibrium, vehicle, collision, speed, deformation

FATIQUE FAILURE PREDICTION ON ROLLING BEARING USING FINITE ELEMENT SIMULATION

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ABSTRACT

This thesis deals with the concept of Rolling Element Bearing Failure due to the fatigue of materials. Although there are several modes of failure that occur to rolling bearings, the failure due to fatigue is the one that the research community is mostly interested in, because of the fact that it is an inevitable threat to the Rolling Bearing life. To predict the number of cycles until failure, an in – depth knowledge of the stress condition during the operation of the machine part is essential. If the stress history data, and the data of material response to dynamic loads are acquired, a deterministic prediction of the remaining useful life of the part can be carried out. On this work, computer simulation tools are used, implementing the Finite Element Method. A 3D Rolling Bearing model is generated and solved using ANSYS Mechanical 17.1 software.

The thesis is organized in six (6) Chapters. The first Chapter introduces the basic concepts of the fatigue phenomenon, and its mechanisms of compromising the structural stability of machines. On the second chapter, the mathematical models that form the basis of fatigue failure prediction, are presented. Next on chapter 3, the modes of rolling bearing failure are discussed. The Rolling Contact Fatigue (RFC) is specifically referred to, being the most significant mechanism that conducts fatigue wear in rolling bearings. Proceeding, Chapter 4 introduces the development of the Finite Element model in ANSYS that aims to simulate the operating conditions of the specific roller bearing type NJ203. This chapter describes every step that took place in the procedure and then presents the extracted results. Finally, on Chapter 5, the stress results generated on the previous chapter, and the theoretical intelligence on RFC are used combined in order to predict the fatigue failure of the model. Chapter 6 contains conclusive remarks and suggestions about further investigation of the phenomenon, that could be attempted on future works.

Keywords

Fatigue Life prediction, Rolling contact fatigue, Rolling Bearing, Finite Element Method, Hertzian Stresses.

ASSESSMENT OF NOVEL DEEP LEARNING METHODS FOR SEA VESSEL CONDITION MONITORING

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ABSTRACT

In the past decade, in the context of a rapidly changing and fiercely competitive global economy along with continuous efforts against climate change, maritime and marine engineering endeavors towards rendering ships more efficient and environmentally friendly are of vital essence. In this framework, the concept of condition monitoring and its modernization utilizing the latest digital technologies and implementing data-driven analyses is gaining more popularity within the marine industry. This study proposes the use of 2 types of convolutional neural networks (CNN), to recognize patterns that indicate early signs of defective behavior in the operational state of the vessel, benefiting from the capability of these models to represent features at high levels of abstraction without requiring to mine the features on which they shall be trained, which in numerous situations of condition monitoring is a challenging task requiring a lot of domain expertise. Specifically, the two methodologies examined in the present study are based on a 2D CNN, whose inputs are contour images extracted by the dataset, and on a 1D CNN with the time series being fed directly to it, in both cases, the dataset undergoes a preprocessing procedure. A parametric inquiry is presented in an attempt to deduce the parameters of the networks that ensure the best performance in the task of timely detecting defective patterns. Comparisons between the two proposed methodologies and benchmark classifiers are carried out to determine the strengths and weakness of the proposed methodology. The results provide an insightful picture of the applicability of CNN models in performing condition monitoring in ships, demonstrating the remarkable acquired in both study cases outperforming the benchmark classifiers.

Keywords

Deep Learning, Condition Monitoring, Maritime, Convolutional Neural Network (CNN), Fault Detection

CAR-PEDESTRIAN COLLISION ACCIDENT IN URBAN AREA

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ABSTRACT

This dissertation studies the reconstruction of traffic accidents of loss of control of a car and the fatal injuries to pedestrians on the sidewalk. A state of the art of accidents involving cars and pedestrians collisions is presented here, along with the factors leading to similar traffic accidents. A systematic review of a collision, the description of the vehicle involved, and details of the accident scene follow. A spreadsheet is developed for the calculation of the vehicle's speeds before and after the collision. The method is useful for a systematic approach in forensic engineering in similar accidents.

Keywords

Car-pedestrian accident reconstruction, vehicle-pedestrians collision accident analysis, reconstruction methods, Forensic Engineering

INVESTIGATION OF A ROAD ACCIDENT INVOLVING THE FRONT COLLISION OF A PASSENGER CAR AND A TRUCK

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ABSTRACT

In the present diploma thesis, it is presented the expertise for the traffic accident that happened on 3/12/2010 and around 09.15, in CH. 2,000 of the Provincial Road of Alepochori-Megara, of a truck with a passenger car, which resulted in the fatal injury of the driver of the car. There are bibliographic reports on road accidents, such as how poor car maintenance and overestimation of driving skills contribute to causing such accidents. The following is a description of the vehicles involved in the accident, recording of the scene of the accident, photos of the vehicles and their location before and after the collision. The factors that contributed to the cause of the accident are investigated, such as the speed of the vehicles, the condition in which they were and the natural obstacles that forced the drivers to deviate from their course.

Keywords

accident, passenger vehicle, truck, expertise, conditions

JOURNAL BEARINGS' DESIGN UNDER THE INFLUENCE OF CAVITATION AND GROOVES

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ABSTRACT

Journal bearings have been at the heart of research more and more these past years, and their applications embrace several areas which serve human needs, such as industry, shipping, manufacturing, transportation and more. The present diploma thesis, is trying to give in short and in an understandable way to a wider audience, the theoretical background around hydrodynamic lubrication, the effect of a modification of the geometry of a journal bearing under the creation of grooves at its internal wall, and the phenomenon of cavitation. The thesis presents the modeling of journal bearings with grooves, for different rates of grooves' depth, trying to simulate real life models. Moreover, the selection of the liquid is based on which liquid could give the most realistic operating conditions of bearing – shaft system. This project provides the reader with analysis using computational fluid dynamics (CFD), through a computer package, with the allocation of pressure in liquid's film, with the flow of liquid's particles under the rotational velocity of the shaft, as well as the existence or not of cavitation and the way this phenomenon is taking place on the internal wall of the bearing. This process helps in understanding and draw conclusions from solving a problem which concerns realistic situations, especially in the field of shipping.

Keywords

Journal Bearings, Hydrodynamic, Grooves, Cavitation, Pressure

RECONSTRUCTION OF TRAFFIC ACCIDENT PEDESTRIAN HIT BY PASSENGER CAR

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ABSTRACT

Main purpose of this dissertation is the analysis, examination and reconstruction of a car accident involving a pedestrian being dragged by a private car that caused the injury of the pedestrian. Extensive reference will be made to the basic principles of road accident analysis which will include a historical background of road accidents, the types and causes of a road accident as well as the fundamental principles governing pedestrian collisions that are necessary for their study. This will be followed by a complete reconstruction of the accident and a detailed analysis from both theoretical and numerical points of view and will describe and represent the scene of the accident, the vehicle involved and the conditions prevailing at the given time. Finally, the vehicle speeds before and after the collision, the pedestrian trajectory after the collision will be calculated and the possibility of perceiving the danger for the driver and the pedestrian will be assessed. In closing, we will draw critical conclusions, identify the causes of the accident and make suggestions to avoid similar incidents in the future.

Keywords

Car accident, pedestrian's injury, accident reconstruction, vehicle's speeds, Conclusions

GENERATION OF MANUFACTURING PROCESS KNOWLEDGE FOR PROCESS OPTIMIZATION: A CASE STUDY ON MILLING

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ABSTRACT

Industry 4.0, also called the fourth industrial revolution, is aiming to push the digital transformation of the manufacturing sector. The usage of sensors in the machines, which are interconnected with one another, as well as with other levels of the product lifecycle, such as design and operating life of the product will be introduced in a wide audience. Therefore, technologies that provide the ability to manage this amplitude of data and process them are key elements of this era. As a result, the automated generation of manufacturing process knowledge is highly pursued. To this end, structured approaches to design and develop robust and high-performance knowledge generation systems are required. This work presents an approach based on the DIKW pyramid, where the application of each level of the pyramid is mapped into the manufacturing process context, in order to define the requirements for the knowledge generation system. Physics-based modelling of the process is utilized to enable the identification of the required transformations to climb the DIKW pyramid. The proposed approach is validated in a case study on chatter detection in milling. An acceleration sensor is integrated in the milling machine and Variational Mode Decomposition is utilized to decompose the acceleration signal and keep the component that holds chatter rich information. Features that are sensitive to the phenomenon of chatter are extracted from the signal, in order to capture the transient nature of the phenomenon, compared to the steady-state, stable process, as well as the energy shift from the tooth passing frequencies towards the structural modes of the machine. A Support Vector Machine classifier is trained and utilized towards chatter detection, enabling high classification accuracy and excellent detection speed, which can facilitate the implementation of the knowledge generation system towards real-time monitoring and control of chatter during the milling process.

Keywords

Milling, Chatter Detection, Milling modelling, Machine Learning, Knowledge generation

SELECTION, PARAMETRIC DESIGN AND OPTIMIZATION OF CONVEYOR BELT DRIVE UNITS

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ABSTRACT

The conveyor belt is a globally used transport device in a variety of material handling applications in any form (bulky, compact, in powder form, etc. materials). The power supply required to drive the conveyor belt, is provided by one or more drive units attached to it, which in most applications use electricity to power them.

This thesis focuses on attempting to standardize the process of calculating the total traction force and total power required of three (3) different conveyor belt drive unit configurations, the first involving a single drive at the tip, the second a twin drive at the tip (Tandem layout) and the third an intermediate drive via friction belt. The purpose of this process is the final selection of one of the three (3) alternative design configurations based on the total traction force and the total power required of the drive unit, as well as the other design parameters that the interested party will define according to their problem.

Next, the problem is considered as a parametric design problem and an attempt is made to multiparametrically optimize the three mentioned drive unit layouts, which examine three different parameters. The total required power of the drive unit, the winding angle of the belt around the drive drum and the coefficient of friction between the belt and the drive drum of each of the above drive units.

The optimization process is implemented through the MATLAB software and the already existing libraries of genetic algorithms that it has.

Keywords

Conveyor belt, drive unit, optimization, parametric design, genetic algorithms

DIVISION OF ENERGY, AERONAUTICS AND ENVIRONMENT (JUNE 2021)

NUMERICAL INVESTIGATION FOR THE DETERMINATION OF CRITICAL REYNOLDS NUMBER VALUE AND THE POSITION OF TRANSITION FROM LAMINAR TO TURBULENT FLOW REGIME INSIDE A U-TUBE

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ABSTRACT

In the current diploma thesis, a numerical investigation was conducted for the transition from laminar to turbulent flow inside a curved tube of U shape. The goal is to determine the value of critical Reynolds number, which is different from a straight pipe, and how this value changes based on the position inside the U-tube. In addition, it is necessary for the accomplishment of the aforementioned goal the full understanding of the complex flow characteristics and phenomenon inside a U-tube, which are different from a straight pipe and also to understand the role that the curvature of the tube plays on this phenomenon.

The investigation was conducted for three different geometries of U-tubes, with curvature ratios $\gamma = 0.1$, $\gamma = 0.05$, $\gamma = 0.025$. The numerical investigation was conducted with ANSYS Fluent, using three different model setups. One for laminar flow, one for transition flow and one for turbulent flow.

The current research was based on four different criteria for four quantities, which can indicate or show whether the flow is laminar or turbulent. These quantities are: 1) $dp/d\theta$ the axial pressure gradient in the direction of the tube, 2) the turbulent viscosity μ_t , 3) the wall

shear stress τ_w, 4) Intermittency, a quantity which represents the possibility that a point of the fluid is in laminar or turbulent flow.

Based on the results of the investigation the curvature of the tube leads to the increase of the value of Re_{ctrit}. In addition, the transition does not happen instantly like in a straight pipe, but within a range of values, which expands as the curvature ratio increases.

The transition to turbulence comes earlier in the outer side of the tube, as the fluid particles with higher velocity are leaded there due to the centrifugal forces.

The occurrence of secondary flow and the creation of Dean cells is happening both in laminar and turbulent flow due to the centrifugal forces on the fluid particles.

Keywords

Curved tube, Transition, Laminar and Turbulent flow, Critical Reynolds number, numerical investigation

COMPUTATIONAL AND EXPERIMENTAL INVESTIGATION OF TWO-PHASE AIR-WATER FLOW IN A 60^o TITLED BRANCH OF A T-JUNCTION TYPE SEPARATOR WITH CIRCULAR CROSS-SECTION PIPELINE

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ABSTRACT

This diploma thesis presents the computational and experimental investigation of a T-junction separator with a 60^o separation angle. The lead enjoyed by this type of separators for gas-liquid two-phase flows, compared to other type of separators base on gravitational and/or centrifugal forces, makes their in-depth analysis and, by extension, their optimization a very interesting research field. Since multiphase flows are generally distinguished by their complex description, the investigation of the separation of two-phase flows undeniably introduces additional parameters that affect the phenomenon and further make its approach more difficult.

In particular, the parameters most extensively presented in this text that affect the separation of a two-phase flow are the growing flow regime, the speed of each phase separately, the void fraction of the mixture, the total pressure and the pressure gradient. At the same time, the separation performance and the water carryover are an indicator of a comparison between cases of separation, highlighting the best and most efficient solution on a case-by-case basis. The scientific community has turned its attention to the correlation of the effectiveness of separation with these parameters, a project quite difficult due to the inability of a universally applied theoretical model to give accurate results in a wide variety of applications.

This technical report presents and compares the results of the separation performance between computational and experimental investigation, concluding that smaller volumetric water supplies achieve the most efficient separation performance, this does not mean that greater water supplies lead to discouraging effects, simultaneously the air supply affects in the same way the separation performance but much weaker. In addition, the pressure

gradient of the two-phase flow in the pipeline shall be calculated using, (a) the homogeneous model, (b) the Beggs-Brill model and (c) the Olujic model, and compare it with the results of pressure gradient of the case-by-case computational simulations where it appears that the Olujic model is more converging on them. Similarly, the void fraction is calculating using, (a) the homogeneous model, (b) the Premoli model and (c) the Beggs-Brill model, and compared with the results of the case-by-case computational simulations showing that the Premoli model is more converging on them.

Supplementally, the water carryover, the speed of the mixture before and after the branch and the pressure gradient measured in the area where the branch is inserted are listed, sizes derived from the numerical solutions of the cases of flow problems through the ANSYS Fluent software. In addition, visualization of the distribution of phases in the pipeline is presented during the experimental process using photographic shots and during computational simulation with the tools offered by the Fluent software, while finally compared with each other in terms of the developing flow pattern. In fact, there is a correlation between computational and experimental investigation, since in both cases a stratified or wavy-stratified flow regime develops in the horizontal main pipeline, contrary to the predicted flow regime resulting from the theoretical approach with the help of Baker's flow regime map, which is due to the generality of theoretical flow regime maps.

In conclusion, this diploma thesis includes information on the experimental pipeline layout in which the experiments are carried out, as well as the technical characteristics and construction designs of the individual components and measuring instruments used. Additionally, the experimental process and the way in which it is carried out for the series of experiments carried out for combinations of five different volumetric air supplies with four different volumetric water supplies are presented. Finally, the construction of geometry and computational mesh, the models and algorithms selected and more generally the procedure used to carry out numerical solutions with the help of the commercial software ANSYS Fluent are summarized and of course contain the necessary theoretical background that generally governs fluid flows and in particular the two-phase flow that are also the subject of this diploma thesis.

Keywords

T-junction, Phase separation, Air-water two-phase flow, Experimental investigation, Computational fluid dynamics

APPLICATION OF THE FINITE VOLUMES METHOD FOR THE NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATION IN THE PYTHON PROGRAMMING LANGUAGE

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ABSTRACT

The subject of this undergraduate thesis is the study of the flow equation in an initial stage, in the Python programming language. More accurately, the comparison of an uniformed and a non-uniformed mesh is attempted, in order to highlight the advantage of each. The non-linear Burger equation, which is one step behind the Navier-Stokes equation is then applied that differs from the Burger equation in the fact that it takes into account the pressure. A curved mesh is then applied as well as its combination with the non-uniform mesh. Finally, von Neumann boundary conditions are applied which act as insulation in the simulation and Diriclet boundary conditions which refers to known functions at the edges.

The findings of this study relate primarily to the finite volume method in the fact that it has no increased difficulty in programming from cartesian to semi annular geometries, as well as the preference of the Upwind method in problems where technical oscillations are created if the FTCS method is used. On the other side it's preferred to use the FTCS method in problems where artificial diffusion is created if the Upwind method is used.

Keywords

non-uniform mesh, stretched mesh, Burger, semi-circular mesh, von Neumann boundary conditions, finite volumes, Python

REDUCTION PROCEDURE OF DETAILED MULTISTEP CHEMICAL-KINETIC MECHANISMS OF HEPTANCE AND UTILIZATION IN LAMINAR AND TURBULENT FLAMES

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ABSTRACT

In large scale turbulent flame simulations, the exploitation of detailed chemistry and transport models often necessitates expensive memory and CPU requirements. To maintain the practicality and flexibility of such simulations the combustion chemistry is commonly represented by reduced reaction mechanisms. The present study presents the development of such a reduced short kinetic scheme, for the high temperature oxidation of n-heptane, suitable for application in complex turbulent flame simulations. Through a combination of DRG and FSSA methodologies a skeletal 65-species kinetic model was formally reduced to a 25-species derivative suitable, for atmospheric, lean to stoichiometric conditions. Further removal of appropriate reactions and species was facilitated using Reaction Path Flux Analysis, yielding a short chemical scheme of 25 species and 69 reactions. Particular attention was given to avoid the addition of lumped reactions and artificial kinetic rates expressed as non-linear algebraic combinations of excluded elementary steps. In addition, most of the original radical reaction pathways were duly preserved and an adequate number of intermediate lighter-chain hydrocarbon species was represented in the reduced scheme to ensure a proper breakdown and oxidation of the main hydrocarbon. A series of 0-D, 1-D propagating and counterflowing premixed flames and axisymmetric coflowing laminar jet flames, were computed throughout the iterative validation procedure. Complementary computations with the 65-species base scheme, as well as available experimental data were exploited for the assessment of the optimization effort. The comparisons demonstrated that the derived scheme produced a satisfactory agreement with these data over the investigated parameter space.

Keywords

reduced combustion chemistry, n-heptane oxidation, laminar flames, chemical reaction schemes.

COMPUTATIONAL STUDY OF AN AIRFOIL OF A THREE-BLADED WIND TURBINE OPERATING UNDER HAILSTORM CONDITIONS

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ABSTRACT

This thesis aims to present a computational study of hailstorm conditions over a SG 6050 airfoil at Reynolds number Re=10^6 and various rainfall conditions. Introductory reference is made to the global need for the use of renewable energy sources, the role of wind energy in this effort as well as the European regulation that has been created in recent decades and aims to cover a percentage of energy production from Green sources. The next chapter refers to the wind turbines, their classification according to their principle of operation as well as the way of calculating the power factor. The third chapter presents the basic characteristics of the airfoils as well as the special characteristics of the airfoil under study. In addition, the basic aerodynamics regarding the flow of fluids around airfoils is mentioned with reference to the aerodynamic quantities, the boundary layer, the flow resistance as well as the detachment phenomenon. The fourth chapter deals with multiphase flows and the modeling of water droplets and hail as will be used for the computational study. The fifth chapter deals with computational fluid dynamics. The Navier-Stokes equations are presented and the way to solve flow problems with the Ansys Fluent package is analyzed. The next chapter describes the procedure followed for the computational simulation of the flow under study. The turbulence model used (Realizable k-e) as well as the ANSYS Fluent 16.0 software model used for multi-phase flow modeling (Discrete Face Model – DPM) are reported below. The seventh chapter presents the results obtained in the form of diagrams and visualized media available in the Ansys Fluent package, first for single-phase air flow and then for multi-phase air-water-hail flow. Finally, the conclusions of the study are presented.

Keywords

SG 6050, Hail, Water, Multi-phase flow, Computational Fluid Dynamics

COMPUTATIONAL INVESTIGATION OF THE EFFECT ON THE FLOW AND THERMAL FIELD IN A RECTANGULAR TUBE OF A FLAT TILE TYPE VORTEX GENERATOR WITH HOLE DIFFERENT VALUES OF HOLE DIAMETER AND ANGLE OF ATTACK OF THE TILE

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ABSTRACT

The subject of the present diploma thesis is to investigate the effect of a flat tile type vortex generator with hole in the flow and thermal field of a heated rectangular tube from which air passes. The investigation of the effect of the tile is made for different hole diameter values, angles of attack and Reynolds numbers of air at inlet. The aim of the study is to enhance the heat transfer, while achieving the lower possible pressure drop.

The computational analysis has been completed entirely by using Ansys-Fluent program. The procedure was followed consisted of the design of the geometries of the problem, the creation of their meshes, the adjustment of the parameters and the determination of the boundary conditions, leading to the final solution. The viscous model used is k-ε Realizable, with the energy model was activated. The simulations were performed for a constant temperature on the inner surfaces of the tube equal to 650 Kelvin and for air temperature at inlet 273 Kelvin. At first, the different hole diameter values (0,2,4,6,8 mm) were investigated. The optimal diameter was selected, examined and compared with an empty tube of the same dimensions for different Reynolds numbers of air at inlet (5,10,15,20,25 k). Consequently, the tile with the optimal diameter chosen it was investigated to the different angles of attack (0,25,45,65,80 degrees). Then the results were exported and compared and the tile with the angle presented the best results was picked. Following, the tile that picked previously investigated and compared with and empty tube of the same dimensions for different Reynolds numbers of air at inlet (5,10,15,20,25 k). For each simulation performed, the average temperature at the outlet of the tube, the average Nusselt number and the

Darcy friction factor (pressure drop coefficient) were calculated and the diagrams of the above quantities were constructed as a function of each parameter.

Finally, the conclusions that emerged from the results of the computational analysis were analyzed and some ideas were suggested for further research.

Keywords

Ansys-Fluent, Vortex Generator, Heat transfer, Pressure Drop, Reynolds

COMPUTATIONAL AERODYNAMIC STUDY OF TWO PHASE FLOW OVER A MULTIPLE ROLE UNMANNED AERIAL VEHICLE IN SEVERAL REYNOLDS NUMBERS AND TURBULENCE MODELS AND COMPARISON WITH EXPERIMENTAL WIND TUNNEL RESULTS

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ABSTRACT

Nowadays, the rapid development of technology and consequently of computers have allowed the development of a new generation of Computational Fluid Dynamics (CFD) codes that are much easier and user friendly in terms of mathematical modeling, numerical techniques and presentation of the results. This helped a lot to increase the accuracy of the results but also reduced time and costs. The aim of this dissertation is the computational aerodynamic study of two-phase air water flow around a multi-role unmanned aircraft in different Reynolds numbers and turbulence models and comparison with the results of an experimental study in a wind tunnel. In this study, two models are manufactured, one that has the normal dimensions of the aircraft and the second that is scaled to 10% of the normal. In the computational part we study both the normal aircraft and the sub-scale in two-phase flow in the turbulence models k-ω SST and Spalart - Allmaras respectively, for different Reynolds numbers. Finally, for the experimental process we study the scale aircraft in the wind tunnel, printed by 3D-Printer with the aim of extracting results for the aerodynamic sizes and comparing them with the computer result to prove that a scale aircraft can satisfactorily approach a normal-sized aircraft by giving sufficient accuracy to the results and the necessary convergence.

Keywords

CFD, Unmanned Aerial Vehicle, Computation Aerodynamic, Experimental, scale, k-ω SST, Spalart - Allmaras

NUMERICAL STUDY OF STREAMWISE ELEMENT WITH WINGS FOR VORTICITY GENERATION IN TURBULENT FLOW

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ABSTRACT

The present study numerically investigates the magnitude and allocation of the streamwise vorticity induced by a streamwise element with wings in a rectangular duct with turbulent flow.

The study was achieved through computational fluid mechanics, and specifically with the use of the ANYS FLUENT computational code. All simulations were carried out for a Reynolds number of 10000.

A parametric analysis of the fitting of different wings to the geometry is conducted, aiming to find the solution maximizing the vorticity generation, and its conservation, while also supervising the induced pressure loss of the flow, since it has been proven that vorticity can increase heat transfer and mixing in the flowing fluid.

Initially, theoretical knowledge of vorticity and the vortices created by the insertion of streamwise elements in the flow is presented, and their role in augmenting heat transfer is shown, by citing both theoretical knowledge and various studies already conducted on the matter.

Twelve different geometries are analyzed and the results for each case are presented and compared, in order to obtain the optimal solution. Having found said solution, further credibility is given to it by improving the quality of the solution and the grid. Finally, the best grid for this particular study is selected and discussion is made on using it in future studies for saving on computational time, while maintaining credibility of the solution.

Keywords

Vorticity, vortex generators, pressure loss, CFD numerical simulations

2D HYDRODYNAMIC BLADE ANALYSIS OF TIDAL DARRIEUS TURBINE

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ABSTRACT

The present diploma thesis addresses the two-dimensional hydrodynamic blade analysis of a vertical axis Darrieus turbine with the aim of maximizing the performance. The current events of climate change have led to the implementation of renewable energy sources, with an ultimate purpose for the production to be based primarily on clean energy. Taking into account the above, the main aim is the evolution and innovation of these sources, with the use of tidal water turbine continuously earning its place into the energy production. Especially the last few years Darrieus type water turbines have interested researchers due to their small size and great efficiency on lower current (stream) speeds.

In the present thesis the analysis consists of stages from the design of the blade to the hydrodynamic analysis and simulations. The first chapter of the thesis involves not only the blade geometry design, but also the enclosure geometry design, which is analyzed further for the best results. The enclosure analysis is aiming to minimize the size (area) up to the point that does not affect the experiment results and, at the same time, utilizing efficiently the processing power.

The next phase focuses on mesh refinement and improvement, which is the most important factor for the results accuracy. The mesh analysis consists of two main parts; the cell skewness and mesh density (division number). Next step involves defining the correct constraints and initial values such as current flow, rotational speed of the model and fluid density into the computational model.

Continuing to the experiments chapter, all the different types of airfoils are being implemented into the model for further analysis and comparisons. The main comparison factors which take place are foil thickness analysis, foil curvature analysis and turbine blade number analysis. In addition to the airfoil analysis, comparing charts are being drawn for a better understanding of the above results with ultimate aim choosing the best and more

efficient airfoil. The final chapter of the thesis refers to future experiment propositions and planning regarding

Keywords

Darrieus H type, foil blade analysis, Tidal Turbine, mesh analysis, torque coefficient, tip speed ratio.

COMPUTATIONAL INVESTIGATION OF PNEUMATIC CONVEYING OF SOLID PARTICLES ALONG HORIZONTAL AND VERTICAL PIPES

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ABSTRACT

Pneumatic conveying is widespread in many industrial applications and the proper design of such a system is a matter of major importance for quality assurance, energy savings and consequently costs.

In the present Thesis, the model of separate two- phase flow is first introduced and the general assumptions according to which it is used are defined. The general equations of motion and power for a single volume element in a sloping pipe, the solid transport substance and the gaseous carrier are then formulated. Conditions of incomressible dilute pneumatic conveying are then considered and the magnitude of the free fall velocity of the solid particles is introduced.

A standard vertical as well as horizontal pneumatic installation device is then defined. According to the theoretical background of the one-dimensional two-phase flow, the facilities will be modeled and analytical equations of the magnitutes of interest will be extracted. Then the main parameters that will result from the modeling of the problem will be investigated and depending on the pressure drop and the required power, operation diagrams will emerge for each case.

The main conclusions are drawn and the optimal combinations of parameters that must be combined to achieve the pneumatic conveying at the lowest possible financial cost are highlighted.

Keywords

two-phase flow, pneumatic conveying, vertical pipe, horizontal pipe, computational investigation, power, pressure losses

SIMULATION OF THE TURBULENT FLOW AND MIXING FIELDS DOWNSTREAM OF DIFFERENT BLUFF BODY GEOMETRIES IN A NOVEL PREMIXER BURNER ARRAY, UNDER INLET MIXTURE STRATIFICATION

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ABSTRACT

The creation of innovative combustors and the improvement of the already existing ones is the subject of many laboratory experiments and also the focus of the combustion community. These researches are aiming to make the burners more efficient and more eco-friendly. Although in laboratory scale tests there is a deviation between the results and the values of technical systems, they have provided important information for the advance of computational and experimental approaches.

In the present work, an attempt was made to investigate the turbulent flow field and the mixing characteristics in a pre-mixer burner array under the effect of different bluff body geometries. The bluff body used in this study consists of three concentric disks and the way that they are connected forms two cavities. These cavities create recirculation zones which contribute to pre-mixing of the air with the fuel, which enters form the second disc and after mixing with air it reaches the stabilizing area as a stratified mixture.

Four different geometries of bluff bodies were created and studied. Two of the bluff bodies were conical shaped and they were designed with diameters of 25 and 36 millimeter each, the other two bodies were designed as discs with the same diameters as the conical. In the simulations, inlet air temperature was set at value of 300K, and the fuel flow was at the blow off limit. All the simulations were performed using the Ansys Fluent software. LES (Large Eddy Simulation) model of the Fluent software was used to compute the turbulence values. The results are presenting the velocity fields and the concentration of the fuel downstream of the bluff body and at the annular gap between the bluff body and the central tube.

Keywords

Turbulent Mixing Field, Bluff Bodies, Large Eddy Simulations, Propane stratification

OPTIMAL DISTRIBUTION OF ELECTRIC VEHICLE CHARGING STATIONS IN URBAN MAST AND HIGHWAYS

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ABSTRACT

This diploma thesis focuses on the formation of an algorithm that calculates the total amount and the best distribution of EV charging stations for the cases of a city and a road network.

The aim of the present thesis is the design of a method, that is able to calculate the necessary amount of charging stations and propose their proper distribution in a city or a road network, based on its characteristics and peculiarities. It's a two-case problem that needs different perspective and approach for the quantity calculation and the distribution design.

First of all, an introduction on the concept of electromobility is made with a short analysis of the characteristics of the Electric Car and the electrochemical batteries that are used. Then there is a reference made for the types and the characteristics of the EV chargers and the prevailing law that describes the various charging processes.

Next, we have the main part of this thesis, that is the development of the calculation methods. Firstly, for the cities' case, there is a step-by-step explanation of their characteristics and the variables that we take account for our process. Then we have the road network's case, in which the road categories and peculiarities are taken into account and their dealing is analyzed. Since the above method has being described, its programming form is being described with the form of flowcharts and their logic is being described piece-by-piece.

The next part of this thesis is about the application of the above program. The application is about three case studies that are being made. It's about the cities of Patras and Chania and about the Main Greek road network. Each case is being analyzed and the right methods are being applied. Each case is commented after its analysis.

Finally, in the rest of the work, final conclusions are made on the topic that was developed. Some obvious difficulties and disadvantages of the methodologies are described, which appeared during their implementation and suggestions are made as to how they can be improved in the future. Also, at the final chapter a commentary on the estimated costs for the purchase of the estimated number of chargers in the case of Patras is made, as an indicative pricing.

Keywords

Electric Cars – Charging Stations – Quantity and Distribution Calculation – Methods Development - Computing Software Development

FLOW CHARACTERISTICS OF DOUBLE PIPE WITH CIRCULAR AND TRIANGULAR CROSS SECTION WITH AND WITHOUT FINS

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ABSTRACT

This paper studies the characteristics of airflow inside a double pipe of circular and triangular cross-section. Specifically, the area of the fluid that moves between the two pipes is studied.

The study is divided into two stages. In the first stage, fluid-flow simulations are performed on double pipe of circular and equilateral triangular cross-section without the presence of fins in order to find the optimal dimensions for each cross-section. In the second stage, after the optimal cross-section has been found, continuous fins are placed on the outer surface of the inner double-pipe along the double pipe and simulations are performed in order to find the optimal height of the fins.

The ANSYS Fluent program is used for flow calculations and for the simulations. The process of formulating the solution, performing the calculations and extracting the results is presented in detail. From the results obtained, graphs and charts of speed, vorticity, turbulent kinetic energy and turbulence intensity are also included. The present study aims to find the cross-section of a double pipe with the best possible flow characteristics.

Finally, the observations and comments are presented, based on the results of the simulations, as well as the conclusions and suggestions for the continuation of the study.

Keywords

Air flow, flow characteristics, double pipe, circular cross section, equilateral triangular cross section

COMPUTATIONAL AERODYNAMIC STUDY OF SINGLE PHASE FLOW OVER A MULTIPLE-ROLE UNMANNED AERIAL VEHICLE IN SEVERAL REYNOLDS NUMBERS AND TURBULENCE MODELS AND COMPARISON WITH EXPERIMENTAL WIND TUNNEL RESULTS

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ABSTRACT

Nowadays, CFD algorithms form an integral part of fluid dynamics. The complexity and unsolvability of the Navier-Stokes equations favored the development of computational algorithms. The technological revolution of the last decade and the enhancement of computer performance assisted scientists to predict the behavior of fluids with increasing accuracy. However, the correlation between computational (CFD) and experimental fluid dynamics (EFD) is crucial for the behavior prediction of aerodynamic bodies. This thesis objective is to develop a method that approaches commercial CFD codes and their link with EFD in a more efficient way, using a downscaled model. More specifically, we investigate the single phase flow over ethERAs, a Multiple – Role UAV developed in the Fluid Mechanics Laboratory, based in University of Patras. Moreover, CFD calculations were executed with the usage of Spalart-Allmaras and K-omega SST turbulence models. More accurately, for the comparison, we created two models. The first model represents the real dimensions of the UAV, while the second one is scaled to 10% of the real size. The experimental model was constructed in accordance with the downscaled model, using 3D printing technology and tested in subsonic wind tunnel. The results from the Experimental and Computational Fluid dynamics showed a very good convergence. This can lead to the conclusion that a rapid and low-cost study for the estimation of the aerodynamic performance of objects with high accuracy is feasible with the suggested method.

Keywords

Unmanned Air Vehicle, Computational Fluid Dynamics, Experimental Fluid Dynamics, Ansys, Spalart - Allmaras, K-ω SST, Downscaled Model, Wind-Tunnel, 3D printing

COMPUTATIONAL INVESTIGATION OF AIR-WATER TWO-PHASE FLOW IN A PIPE WITH A T-JUNCTION SEPARATOR

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ABSTRACT

The objective of the current diploma thesis was the investigation of the separation efficiency in a two – phase flow flowing through a pipeline system with a single vertical – oriented T – junction branch forming a 30^{o} angle with the horizontal plane. Furthermore, the liquid phase carryover rate in the inclined part of the junction was investigated along with the pressure drop in the junction area. Finally, the pressure drop at the horizontal part prior to the junction was calculated and compared with the results from the theoretical models. Initially, due to the complexity of phase separation phenomena and the pressure drop for the two – phase flow, relevant greek and international bibliography was studied. Then the flow pattern was calculated according to the flow conditions along with the void fraction and the shear stress. Also, important components for the design of the mesh were calculated, the height of the first computational element and the length of the inlet pipe. Afterwards, the geometry was designed in the software of Rhinoceros 3D which was imported in the Ansys Mesh for the mesh design. Subsequently, the problem was set in the Ansys Fluent environment and the simulation took place. There were three (3) pairs of volumetric flow rates investigated and specially for the air flows the rates were: a) 18 $^{L}/_{min}$, b) 30 $^{L}/_{min}$, c) 40 $^{L}/_{min}$ where as for the water flows: a) 8.33 $^{L}/_{min}$, b) 25 $^{L}/_{min}$ and c) 33.33 $^{L}/_{min}$.

The designed model consisted of two different inlets, one into another, where the outer diameter was 40 mm and the inner 20 mm. In – between them, the water was flowing and into the smaller one the air. After 200 mm, the length of these two inlets, the two liquids were mixed being inserted into the horizontal pipe, diameter of 20 mm and length of 700 mm. Subsequently, the two – phase mixture was separated meeting the T – junction of 30^{o} where the outlet pipes length were equal to 300 mm. The whole length of the designed model was 1200 mm and its height 245 mm. The results of the computational investigation were different with respect to the theoretical ones, whereas the measured quantities varied significantly with the variation of the volumetric flow pairs. Finally, significant deviation of

the pressure gradient was observed between the Homogenous and Lockhart – Martinelli models with respect to Beggs – Brill one, which however was more accurate with respect to the computational results.

Keywords

T – junction, Two phase air – water flow, Phase Separation, Ansys Fluent, Pressure drop

COMPUTATIONAL INVESTIGATION OF OIL-NATURAL GAS TWO-PHASE FLOW IN A PIPE WITH A T-JUNCTION SEPARATOR

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ABSTRACT

The objective of the current diploma thesis was the three-dimensional computational investigation of Oil – Natural Gas two phase flow and more specifically, the change in separation efficiency depending on volumetric flow rates of those two (2) fuels inside a pipeline system with a single T – junction branch, forming a 45° angle with the horizontal plane. Furthermore, the liquid phase carryover rate, which is Oil in this case, in the inclined part of the junction was investigated along with the velocity and pressure drop in the junction area.

To achieve a computational simulation with correct results, initially, a literature to the phase separation phenomenon and pressure drop phenomenon was selected and studied, as these phenomena and the parameters that affect them are characterized by complexity, therefore, a theoretical background is needed to control computational results. In addition, a theoretical background was acquired on the Computational Fluid Dynamics (CFD). As the problem will be solved on the computer and not experimentally, it should be possible for the user to switch from the differential equation specified in the continuum (e.g. on the real numbers axis), to the computer, where the space is no longer continuous but discrete. In order to select appropriate mathematical models and arithmetic schemes for the implementation of the computational simulation of this problem, as well as to make the appropriate definition of the computational domain and the appropriate Post - Processing with a view to the results that will be correct, treatise has been carried out on the field of the Computational Fluid Dynamics.

The construction of geometry in this problem has been carried out in the Rhinoceros software or as commonly referred to (Rhino 3D), which is a commercial application of 3D CAD modelling and subsequently the commercial software ANSYS v.16 was used. Specifically, the geometry was introduced into the environment of Ansys Meshing, for the construction

of the computational grid, and then through the Fluent code, the problem was set and the simulation took place. There were three (3) pairs of volumetric flow rates investigated and specially for the Oil flows the rates were a) 8.33 $^{L}/_{min}$, b) 25 $^{L}/_{min}$ and c) 33.33 $^{L}/_{min}$, whereas for the Natural Gas flows: a) 18 $^{L}/_{min}$, b) 30 $^{L}/_{min}$ and c) 40 $^{L}/_{min}$. The design model consisted of two different types of funnel, one in the other, where the outer one had an input diameter of 40 mm and an output diameter of 20 mm, while the inner one had an input diameter of 20 mm and an output diameter of 10 mm. In - between them the Oil was flowing and into the smaller one the Natural Gas was. After 200 mm, the length of these two funnels - inlets, the two fluids, were mixed being inserted into the horizontal pipe, diameter of 20 mm and length of 700 mm. Subsequently, the two – phase mixture was separated meeting the T – junction of 45° where the outlet pipes length were equal to 300 mm. The total facility length is 1200 mm.

The aim is to develop the appropriate technical knowledge: a) for the modeling of pipelines, which are used in applications of two - phase flow Oil – Natural Gas, with a view to achieving a high degree of separation and a low rate of liquid phase carryover and b) as soon as for simulating of two - phase flow in these facilities.

Keywords

T-junction, Two phase Oil – Natural Gas flow, Phase Separation, Computational Fluid Dynamics

AERODYNAMIC ANALYSIS OF A SMALL HORIZONTAL AXIS WIND TURBINE ROTOR

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ABSTRACT

During the construction of a wind turbine, our main interest lies in the calculation of its' efficiency. Thus, the present diploma thesis is organized into four main sections.

Within the first section we describe the development of a simple and easy to use application that determines the geometrical characteristics of a blade using specific functions that are based on BEMT theory. More specifically it uses an iterative algorithm to closely estimate the power of the given blade.

In the second section we conduct an extensive two dimensional study of the aerodynamic behavior of the NREL's S834 airfoil using the ANSYS Fluent computational package and compare the results against actual experimental wind tunnel data.

In the third section we exhibit the construction of a blade that incorporates the airfoil that was studied in the previous section and calculate the aerodynamic efficiency, using the BEMT method. In the fourth section we study the three dimensional behavior and efficiency of the aforementioned blade making use of the ANSYS Fluent computational package.

Finally we present the results, comparisons and conclusions extracted from the simulations.

Keywords

Wind energy, Wind turbines, Computational Fluid Dynamics, NREL's S834, Blade Element Momentum Theory

PHOTOVOLTAIC SYSTEM INSTALLATION IN BUILDING STRUCTURES: TECHNICAL-FINANCIAL FEASIBILITY STUDIES

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ABSTRACT

Existing buildings in the urban fabric are usually old constructions without provisions for their energy efficiency and rationalization of energy consumption of both thermal and electrical. As a result, in addition to being significant energy consumers, they are also pollutants in general, especially in relation to greenhouse gases, due to increased energy consumption.

This problem has various solutions, from the renovation of the building to improve its energy consumption using green methods of shading, air conditioning and lighting, to the installation of power plants in an effort to make the building energy efficient.

The present work examines in this light an emblematic building of the city of Patras, the archaeological museum, where minimal interventions have taken place to reduce energy consumption. In short, the building as it exists is only a consumer. However, the work examines the possibility of autonomy of the building energy by installing a photovoltaic system of energy production on its roof.

The results show that with this installation, even with conservative calculations, the building can indeed cover to a large extent or completely its energy needs.

Keywords

Building energy efficiency, photovoltaics, urban fabric, building energy autonomy

COMPUTATIONAL MODELLING OF TWO-PHASE AIR-WATER FLOW IN PRESSURE DROP INSTRUMENTS FOR FLOW MEASUREMENTS (NOZZLE AND VENTURI TUBE) BY APPLYING THE CFD CODE FLUENT

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ABSTRACT

The aim of this diploma thesis is the computational investigation of air-water two-phase flow in choke flow measuring instruments (nozzle and Venturi tube).

Nozzles and venturi tubes are devices for measuring the flow rate of fluids. With the orifice, they are in the category of differential pressure transducers (or choke flow instruments). Their basic principle of operation is based on the pressure drop they create, as they force the flowing fluid to pass through a constricted section. It should be noted that a significant amount of pressure drop remains unrecoverable, since the pressure after the instrument is always lower than that before it.

For the computational analysis of the air-water two-phase flow through the choke flow devices mentioned above, the commercial software package FLUENT 6.3.26 was used. For the creation of the mesh the pre-processing program Gambit 2.4.6 was utilized. The computational results processing was accomplished by Microsoft Office Excel 2007.

The meshes used for the simulations are structured in their biggest part and unstructured close to the nozzle. Two different models were created for each choke flow device. In the first model, the change in diameter is from 100mm to 50mm while in the second from 100mm to 70mm. The mesh of the first model for the nozzle consists of 5200 cells while the second from 3750 cells. For the Venturi tube both models consist of 10800 cells.

The air-water two-phase flow was simulated in Fluent software package and various cases were examined. Firstly, the initial conditions of the flow were defined, and three different flow velocities (5, 10 and 15m/s) were studied. For each case, every possible air-water

volume fraction was examined (0.1 to 0.9 to the nearest decimal place) and three different turbulence models were applied (Eulerian k-e, Mixture k-e and Spalart-Allmaras).

From the results it was observed that the differences between the air-water mixing rates are very small, for the same velocity inlet of the mixture. There is a sharp increase in velocity at the entrance of the choke flow devices, as it was expected. After the nozzle exit, at the cross-section with the small constriction (5cm) it appears that the velocity at the considered length of the flow field remains constant without decreasing to the level of the initial value, while at the cross-section with the large constriction (7cm) it decreases and remains constant at values slightly higher than the initial value. Respectively, in the Venturi tube, the velocity at the cross-section with the small constriction (5cm) decreases as the air-water mixture moves away from the Venturi tube outlet and remains constant at values slightly higher than the initial, while at the cross-section with the large constriction (7cm), the velocity decreases as the mixture moves away from the outlet of the Venturi tube and remains constant and equal to the initial value.

Moreover, a deviation of the values was observed between the turbulence models Eulerian, k-e and Mixture, k-e of the order of 3.99% for the section "10-5” and 0.34% for the section "10-7" in the nozzle, while in the Venturi tube the deviation was about 1.21% and 0.28% respectively. From the simulation it was observed that the turbulence model Mixture Spalart-Allmaras was not possible to apply due to the reverse flow that existed in the choke flow devices. The reverse flows were observed on the flow outlets of the instruments and in a greater degree in the nozzle, due to its geometry.

Summarizing, in this diploma thesis the topic is introduced at first and then follows the theory of fluid flows (laminar and turbulent), and analysis of the turbulence models that were used, the two-phase flow and the choke flow devices. The description of grid creation and simulation in Fluent follows next. Finally, the computational results are presented and discussed in detail.

Keywords

Computational investigation, Two-phase Flow, Pressure drop instruments, Nozzle, Venturi tube

STUDY OF HUMAN CLASS SPACECRAFT GUIDANCE FRO MARS ENTRY DECENT AND LANDING

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ABSTRACT

The aim of this paper is to study the problem of entry decent and landing of a human class spacecraft on Mars. Mars has unique characteristics among the planets of our solar system in attempting to land spacecrafts both unmanned and manned. The main problem lies in the peculiarity of its atmospheric characteristics. Atmospheric surface density is 1% that of Earth thus prohibiting atmospheric deceleration and control methods that are currently in use. New methods have been proposed to address the problem. The newest and the one that will be studied in this paper is the supersonic retro propulsion deceleration method. With a brief reference to the scientific research and data that exist, the study will result in the calculation of valid trajectories for entry descent and landing, the required fuel mass fractions and the reentry heating due to the atmosphere in order to safely decelerate and land the human class spacecraft on the surface of the planet.

Keywords

Simulation, MATLAB, Landing, Supersonic, Retro, Propulsion

NUMERICAL ANALYSIS OF SINGLE AND TWO-PHASE FLOW ON THE DRIVAER FASTBACK MODEL AERODYNAMICS

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ABSTRACT

Subject of the current diploma thesis is the computational study of the DrivAer Fastback model in single-phase flow of air and two-phase flow of air and water. The purpose is the analysis of the aerodynamic phenomena of the flow around a conventional car, in indicative operational velocities, 16m/s and 38.89 m/s, and under influence of heavy rain. After processing in ANSYS Spaceclaim the geometry given, by the Technical University of Münich (TUM), and the construction of the computational domain and the bodies of influence of the mesh, a high quality Poly-Hexcore mesh was constructed in ANSYS Fluent Meshing R19.2. It is the application of the new Mosaic Meshing technology, by ANSYS Inc., which manages to reduce the number of cells in the mesh, while keeping the accuracy high. The grid independence study was conducted with the GCI method, by the construction of 3 meshes of, 4.8, 10.5 and 21.6 million cells, where convergence was found by the mesh with the 10.5 million cells, which was finally chosen. The simulations were performed in ANSYS Fluent R19.2, where after tests, modeling using k-ε Realizable turbulence model, with Scalable wall functions and 2^{nd} order SimpleC algorithm was chosen, while for the two-phase flow the Lagrange approach was used by the discrete phase modeling (DPM). The results of the single-phase flow were compared with the, available in the bibliography, experimental ones and were found to be approximated with good accuracy, especially for the drag coefficient. The flow and vortices were visualized and presented in the corresponding diagrams. On the other hand, the water structures that were observed in the rain modeling, are characteristic in the bibliography, and consist of the formation of a thin water film at the front and side surfaces of the car and the recirculation area in its wake. These influence negatively the operation, aesthetics and safety of the car. Finally, the conclusions are presented and the margins for future expansion of the study are showcased, for the numerical modeling and the geometric design for optimization of the aerodynamic behavior of the DrivAer model.

Keywords

DrivAer, aerodynamics, computational fluid dynamics (CFD), two-phase flow, Poly-Hexcore

EXPERIMENTAL MEASUREMENTS IN A SMALL TURBOJET ENGINE

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ABSTRACT

Small gas turbines are used in various applications such as the main propulsion system in UAVs, manned, experimental and RC aircrafts, APUs, as long as in cogeneration and power generation. The fact that their basic characteristics and principle of operation correspond to that of large gas turbines used in major commercial applications, adds further value to their study.

Basic information used to determine the behavior of such gas turbine engines are its performance parameters. In this context, this thesis deals with the study of a small turbojet engine and measurements of its basic performance parameters such as thrust, fuel consumption, rotational speed (rpm), specific fuel consumption (SFC) and exhaust gas temperature (EGT).

For this reason, an indoor test stand is used. The equipment required for the engine's operation is described, as well as how it is configured to form the test facility. In addition, the use of a data acquisition system including the suitable sensors, hardware and software is studied the suitable sensors, hardware and software is studied.

Results represent plots of the basic performance parameters comparing to operating level and engine rpm.

Keywords

Turbojet, Performance, Test Stand, Data Acquisition

DIVISION OF MANAGEMENT AND ORGANIZATION STUDIES (JUNE 2021)

PREDICTING ITEMS' RECOMMENDATIONS IN E-MARKET'S THROUGH THE EXPLOITATION OF NATURAL LANGUAGE PROCESSING AND MACHINE LEARNING TECHNIQUES

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ABSTRACT

The rapid development of technology and at the same time of the internet, in recent years, has brought about remarkable changes in the way of communication, information and of course in the field of product marketing. E-commerce, nowadays, is the dominant way of shopping, however, the large volume of information in e-shopping, highlights the complexity of the process. The specific "problem" is called to deal with the Recommender Systems, identifying products or services according to the interests of each user-client.

In this Thesis, we approach the topic of recommendations-proposals from a different- than the established- point of view, using Natural Language Processing (NLP). We present applications and algorithms of Machine Learning, analyze methods and techniques of natural language processing and make a review on the use of the latter in the field of recommendations. In addition, we introduce the term sentiment analysis and present the results that result when combined with natural language processing.

Finally, using the Python programming language, we process reviews for mobile phones made by Amazon.com customers. Our goal is to apply natural language processing

techniques, machine learning algorithms and sentiment analysis to the texts of mobile reviews, to identify which words are most important in the product recommendation.

Keywords

Natural Language Processing, Machine Learning, Recommender Systems, Sentiment Analysis

CREATING A RECOMMENDER SYSTEM USING DATA MINING TECHNIQUES FOR THE ASSIGNMENT OF EMERGENCY CONSTRUCTION WORK BY THE LOCAL GOVERNMENT

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ABSTRACT

This thesis analyzes how a recommender system can be used in order to predict the end result of a construction project, which will allow the local government to automatically assign a contractor to emergency construction works and save up on time. For this, we used data from past natural hazards, showing how much it affected the lives of citizens, data from past contractor and construction information, as well as, the timetable of the current methodology of construction work assignment. Furthermore, we tested various classification algorithms and decided to design the system with the Random Forest algorithm, which gave us hypothetical predictions based on past construction projects. The results showed that the recommender system produced trustworthy predictions and by utilizing them we could have from two to six times faster emergency construction work assignments.

Keywords

recommender systems, urgent construction work, random forest, clustering, prediction

DEVELOPMENT OF A HYBRID GRAPH-BASED RECOMMENDATION SYSTEM WITH THE UTILIZATION OF GRAPH-OF-DOCS REPRESENTATION AND GRAPH NEURAL NETWORKS

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ABSTRACT

The present dissertation aims to inform the reader about the science of artificial intelligence and its subdivisions, the basic models of recommendation systems as well as a beginning in artificial neural networks and artificial graph neural networks. Finally, the attempt to create a hybrid system of recommendations using artificial graph neural networks is analyzed. To build this hybrid system of recommendations, a graph is first constructed that receives review data from the users of "Amazon" website for the products that they purchase. This graph contains most of the information offered by the given data such as users, items they have purchased and reviews they have given for those items. This graph, which consists of nodes and edges of the given data is then fed with features for each different type of node and edge, such as embeddings for each word of each review using the "Word2Vec" algorithm, edge weight such as the score given by the user for the product for the edge that connects the user with the product, etc. the graph is then analyzed via graph neural networks and the desired predicted results are obtained. Here, three different types of graph neural network algorithms are analyzed, each of which accepts a different structure of the originally constructed graph. Finally, the results of these algorithms are presented and suggestions for the evolution of the subject are given.

Keywords

Artificial intelligence, machine learning, recommendation systems, graph neural networks, python

DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS (SEPTEMBER 2021)

RESPONSE OF ELASTIC, PIEZOELECTRIC AND FLEXOELECTRIC BEAMS THROUGH HIGHER ORDER ELASTICITY THEORIES

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ABSTRACT

The dimensions of many mechanical and electromechanical systems and structures are comparable to those of their material microstructure. In these cases, the microstructure affects the mechanical or electromechanical behavior. The Classical Elasticity Theory or the Classical Electroelasticity Theory fails to correctly determine the mechanical or electromechanical behavior of a material, respectively, when there is the effect of microstructure. For this reason, Gradient Elasticity Theories and Gradient Electroelasticity Theories have been developed, also referred to as enhanced elasticity theories. Gradient Elasticity Theories introduce the strain gradient, in the expression of the elastic strain energy. Gradient Electroelasticity Theories introduce the strain gradient and the electric field gradient, in the expression of the electroelastic enthalpy. In the present work, bending models, of gradient elastic and gradient electroelastic Bernoulli-Euler beams, are analyzed. The size of microstructure "characteristic length" is introduced, in constitutive equations.

As it concerns the gradient elastic beams, the response with respect to the deflection and axial strain is examined for the cases of cantilever beam bending, three points bending and pure bending. Furthermore, the bending of a beam from sandwich composite material is

analyzed. In all cases, gradient elastic beam presents a lower response than the classical elastic beam.

Piezoelectric beam is the most common classical electroelastic beam. The beam that exhibits fully gradient electroelastic behavior is called "flexoelectric". The beams that are analyzed in the work, although they exhibit gradient electroelastic behavior, they do not have all the flexoelectric characteristics. The cases of cantilever beam bending and pure bending are analyzed. The gradient electroelastic beam presents a lower response than the classical electroelastic (piezoelectric) beam.

It has been supported that the response of a Bernoulli-Euler beam subjected to bending, also depends on the transverse cross section area. However, there is a serious objection that this theory is incorrect because it violates some conditions concerning the top and the base of the transverse cross section. This work shares the view that the theory supporting the effect of cross-sectional area is incorrect. However, this theory is presented for the case of the gradient elastic beam as well as the reason why it is not correct. An indicative problem of gradient elastic beam bending is also given, with the results that would be valid if this theory were correct. It appears that the beam response is even lower, but increases as the beam thickness increases.

Keywords

Gradient Elasticity, Gradient Electroelasticity, flexoelectricity, bending, Bernoull-Euler beam, strain, strain gradient, electric field, electric field gradient.

MESH ANTENNA STRUCTURAL DESIGN FOR SMALL SATELLITES

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ABSTRACT

Over the last years, advancements in space exploration require satellite antennas with greater diameters than before. Considering the limitations from rocket launch to satellite orbit, the stowed size of the antenna must be compact enough to fit the limited space. To overcome these challenges, the deployable antenna concept is used. Among different antenna designs, mesh reflectors have lately been gaining more attention and new designs or improvements of current ones are being studied. Even though mesh reflectors are great for larger diameters and apertures, little research has been conducted for smaller diameters.

This thesis briefly presents the basic working principle of antennas along with parameters that will be used during the following research. Common satellite antennas are introduced, the need of deployable structures is presented, and the deployable mesh antenna is described. After the initial classification of deployable mesh antennas, the survey focuses on the peripheral ring truss concept which is analyzed in greater detail.

Based on the survey conducted, a 1.6m ring truss is studied. Beginning with the preliminary design, geometric features and cable network are generated while the final geometry is calculated through FEA. A CAD model of the ring truss is designed in detail and it is kinematically evaluated. Finally, the designed ring truss is compared to similar antennas and its compatibility with the CubeSat project is verified.

Keywords

mesh reflectors, deployable satellite antenna, ring truss, hoop truss, finite element analysis

FATIGUE DAMAGE IDENTIFICATION IN COMPOSITE SPECIMENS USING RANDOM VIBRATION SIGNALS

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ABSTRACT

Composite materials, due to their high special mechanical properties, have found increasing use in recent decades in lightweight structures and especially in aerospace applications. For the more efficient maintenance of aerospace structures and the design of new advanced structures with an even higher percentage of composite materials, it is very important to develop and implement structural health monitoring systems (SHM) in real time. These systems include the components of damage detection, diagnosis-prognosis and the correlation of damage with the remaining mechanical properties of the structural parts.

The aim of the present work is to detect the fatigue damage with a tested method and the damage classification in classes corresponding to those of the disrupted fatigue.

The proposed experimental procedure consists of the following components:

• Carrying out disruptive mechanical fatigue tests on laminated specimens for the controlled development of fatigue damage.

• Detection of fatigue damage in laminated specimens using acoustic ultrasound (C-scan). The data from the secondary control with C-scan were used to set up and verify the primary evaluation method.

• Stimulation of the laminated specimens with white noise and analysis of vibration. Stirring with white noise allows simultaneous stimulation with all frequencies and the acquisition of as much data as possible about the dynamic characteristics of the specimens. The received response was in the form of oscillation velocity and was measured with a laser device.

• Fault detection on laminated specimens.

• Fault classification on laminated specimens in stages corresponding to those of the disrupted fatigue.

To increase the validity of the procedure, ten specimens were used and repeated experiments were performed.

Experimental results have shown that the proposed procedure can lead to the unsupervised detection of fatigue damage as well as to the supervised classification to fatigue stages.

The key innovative elements of the work are the development of the device (type of excitation and measurement of oscillation) and the analysis of the response data.

Keywords

Composite materials, Fatigue, Vibration Test, Time Series Analysis, White Noise

SCAFFOLD DESIGN AND OSTEOPOROSIS SIMULATION VIA FDM 3D PRINTING TECHNOLOGIES

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ABSTRACT

Trabecular bone micro-architecture is crucial for the mechanical behavior of bones. Osteoporosis or bone resorption is a skeletal disease that leads to microstructural deterioration and bone strength loss while increasing the risk for bone fracture. One of the greatest limitations in assessing the effects of osteoporosis is that they do not exist two identical trabecular structures. 3D printing is a technology that can be utilized to surmount this problem.

This thesis examines various hypotheses regarding the ability of the used FDM 3D printer to fabricate precisely 3D printed trabecular bone replicas as a useful tool in evaluating the mechanical properties of trabecular bone samples with the same architecture but with different BV/TV. Concurrently through CAD and 3D printing scaffolds with assorted patterns and shapes for bone tissue engineering applications were produced and tested in order to examine the optimal mechanical properties for referred scaffolds.

The experiments carried out proved that the mechanical properties of osteoporotic trabecular bone replicas were reduced linearly with density and that the produced models were precisely and accurately printed. Also, between cubic and cylindrical bone tissue engineering scaffolds the shape appeared to not affect their mechanical properties while the complexity of their pattern enhances their structural modulus and strength.

3D printed bone replicas can prove a valuable tool in quantifying the effects on the mechanical properties of osteoporotic trabecular bones and aid in the successful fracture risk analysis.

Keywords

3D Printing, Scaffolds, Osteoporosis, Tissue Engineering, Polylactic Acid

FATIGUE DAMAGE STATE IDENTIFICATION IN UD-GFRP THROUGH THE USE OF A STIFFNESS DEGRADATION MODEL, DISPERSION CURVES AND MACHINE LEARNING

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ABSTRACT

This thesis is concerned with the fatigue damage accumulation stage identification in unidirectional GFRP. In the past, it has been proposed and experimentally proved by many researchers, that FRP materials under fatigue loading, go through three damage accumulation stages before failure, that are associated with their stiffness degradation and are discussed further later in the thesis. Specifically, it has been established, that the relation between residual stiffness and dimensionless load cycles can be approximated by a power law fitted in experimental data.

The purpose of this thesis, given the previously mentioned behaviour of FRP materials under fatigue loading, is the proposal of a non-destructive method that will take advantage of the stiffness degradation to detect the fatigue damage accumulation stage.

Taking advantage of the fact that elastic wave velocity inside an anisotropic material is a function of the material's properties, a model has been constructed, that detects guided waves phase velocity variation, due to stiffness degradation. Due to the small thickness of the laminate, dispersion appears as waves propagate through the material, i.e. phase velocity depends on the frequency, and more modes appear as frequency increases.

Using the Spectral Collocation Method we obtain the material's dispersion curves and we then search for a specific mode that meets certain conditions so that it would be appropriate for the non-destructive method. This has been found to be the S0 mode. Subsequently, we perform a sensitivity analysis to identify the properties that the S0 mode phase velocity depends upon.

After the identification, we use Machine Learning to obtain an approximate relation that correlates the S0 mode phase velocity and those properties. Finally, we show that if the S0

mode phase velocity is experimentally measured and this approximate relation is solved for stiffness, it can be used to calculate the residual stiffness.

As a result, using the calculated residual stiffness and the previously mentioned power law, one can identify the fatigue damage accumulation stage.

Keywords

Residual Stiffness, Fatigue, Dispersion Curves, Machine Learning, Damage Accumulation

STUDY OF MATERIAL DAMPING IN FIBER REINFORCED COMPOSITES MODIFIED WITH NANOPARTICLES. EXPERIMENTAL INVESTIGATION AND NUMERICAL MODELLING: APPLICATION TO SELF-DEPLOYABLE STRUCTURE

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ABSTRACT

In the present thesis, a fully developed research is conducted for the determination of material damping in glass fiber reinforced composites modified with various types of nanoparticles. The research consists of two main parts, the experimental determination of material damping and the confirmation of the experiment through modeling in the programme "Abaqus / CAE".

First of all, material damping is determined experimentally in 5 materials which are: Unmodified GFRP, GFRP modified with 0.5% CNTs, GFRP modified with 1% CNTs, GFRP modified with 0.5% nSiC and GFRP modified with 1% nSiC. The construction and operation of the entire experimental set-up is described, as well as the components that the set-up is consist of, and the introduced errors and limitations of the experiment are reported. The results are analyzed and comparisons are made to obtain reliable results.

The second part of this thesis concerns two analyzes that were performed to confirm the validity of the experiment. The specimens tested during the experiment are modeled in the "Abaqus / CAE" program in order to calculate the theoretical values of eigenfrequencies. The resulting data is entered in the "MATLAB" program and the theoretical calculation of material damping is conducted. The results showed that the deviation between theoretical and experimental values are negligible and are justified by the errors of the experiment. Thus, the experimental procedure is valid and reliable.

Finally, the material with the largest value of material damping was applied to the panel development mechanism of a CubeSat. This analysis, performed in the "Solidworks"

program, serves as an example of applying the material with the best energy dissipation capacity to a structure in which the oscillations must be suppressed quickly.

In conclusion, the experiment proved to be reliable and accurate as the modeling through "Abaqus/CAE" confirmed its results. The application of the optimal material to a panel development mechanism is one of the many applications in which a construction must be made of a material with excellent damping capacity that can suppress oscillations and prevent a possible failure.

Keywords

Material Damping, GFRPs, Free Vibration Analysis, Modelling, Panel Development Mechanism Design

DESIGN, ANALYSIS, OPTIMIZATION OF GRID STIFFENED STRUCTURE FOR AEROSPACE APPLICATIONS

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ABSTRACT

This dissertation is referred to the design of a grid stiffened lattice structure for aeronautic applications. The design, analysis, and optimization of the reinforced structure is studied, in terms of its ability to carry certain loads in a way that no buckling phenomena are developed. The most efficient way of designing such a structure is presented, so that it can carry the applied loads, while having a minimum mass. The response of this structure is calculated, with respect to the development of buckling phenomena.

The dissertation consists of five (5) chapters. In the first chapter a general introduction is made to the lattice structures, the basic applications for which these structures are used and the manufacturing methods of grid stiffened lattice structures. The most common types off grids are described. Information is given concerning the geometry, the technical characteristics, and the materials, that are used for their construction. Furthermore, information is given for the relevant scientific research in the fields of the design optimization for aerospace applications. Sampling and polynomial interpolation methods are described to predict the response off the surrogate model. In the second chapter the optimization problem is defined. Information is given, concerning the model and its geometrical characteristics. The main methodology, which was followed during the parametric design of the structure is described and the applied loads are calculated. In the third chapter information is given concerning the discretization, the finite elements that were used, and then materials of the shell and the grid of the structure. Additionally, the method which was followed for the buckling analysis in the mass calculation of the structure is described. In the fourth chapter the optimization process is described. Information is given about the design of experiments, the approximation of the response of the surrogate model, and the optimization algorithm that was used to find the optimal solution. In the fifth chapter the results are presented, and certain comments are made. Conclusions, concerning

the overall response of the surrogate model are made, and suggestions for further research are discussed.

Keywords

aerospace, grid stiffened structures, composite materials, optimization, surrogate model

STRUCTURAL ANALYSIS, DESIGN, SCALE CONSTRUCTION AND MATERIAL MECHANICHAL PROPERTIES DERIVATION OF A SMALL-SCALE TETHERED HYBRID AIRSHIP

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ABSTRACT

The rise of lighter than air systems in the international literature, as well as their use by various entities in recent years has given new life to an otherwise forgotten type of aircraft, the aerostat. In the course of this thesis, we will focus on the design of a small-scale hybrid aerostat that will compete with similarly small unmanned systems with the main goal of maximizing the payload and the duration of its mission. This goal will be achieved when and if only a structural analysis of the aerostat components is performed at the same time under the specified environmental conditions. The structural analysis will be accompanied by a research on the properties of the gas chamber construction materials but also the selection of the payload and the structures that will support it. Also, the flight mechanics that are expected to be observed by the aerostat will be presented although less extensively. Finally, the completion of this thesis is proof that the proposed hybrid balloon is capable of being manufactured with commercially available methods and materials.

Keywords

Lighter Than Air systems, Finite Element Model, Hybrid Aerostat, Semi-Rigid Structure, Strength Experiments

CORROSION DAMAGE OF STEEL REINFORCEMENT WITH SELECTIVE COATING THROUGH WIRE FRAME

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ABSTRACT

It is known that the corrosion of steel reinforcement is recognized as a main degradation factor of the durability and performance of reinforced concrete structures. In this light, several direct or indirect anti-corrosive methods are adopted worldwide in order to delay the onset of corrosive phenomena. Based on these, in the present experimental work, the influence of the cleaning process through shot-blasting (with corundum particles) and the coating of structural steel B500c (with 15% aluminum and 85% zinc alloy) on corrosion damage and mechanical behavior in low cycle fatigue tests is studied.

For the needs of the laboratory study, a total of 34 steel rebars, with 10 mm nominal diameter and each with a total length of 200 mm, were used, which were divided into three subgroups: a) 16 bare reference rebars (without coating), b) 9 rebars partially coated with All5Zn85 in the areas between their ribs and c) 9 rebars fully coated with Al15Zn85. The coating process with a thickness of 10 μm, which was used was the Wire Flame Spray process, while proceded the shot-blasting with corundum (Al_2O_3) particles. To simulate the corrosive environmental conditions of XS1, by ΚΤΣ 2016, accelerated corrosion experiments were performed with the salt spray method for exposure times of 60 and 90 days, while in the case of bare specimens there was and additional time of 120 days. Upon completion of laboratory corrosion and cleaning of speciments (using a mechanical brush and their immersion in hydrochloric acid solution), mechanical tests of low cycle fatigue with an imposed strain range ±2.5% were conducted. From the results of the experimental study it appears that the cleaning process though shot-blasting with corundum particles, contributes to the mechanical behavior, as it compresses and smoothes the outer textured surface of the rebars, increasing their fatigue life. Furthermore, the full coating of the rebars with Al15Zn85 adequately protects the steel against corrosion, while in the case of the partially coated speciments a grearer mass loss was recorded compared to the bare reference rebars.

Keywords

Steel reinforcement, Anti-Corrosive protection, Shot-blasting, Coating, Fatigue

SIMULATION OF THE MECHANICAL BEHAVIOR OR SELF-HEALING COMPOSITE MATERIALS

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ABSTRACT

In recent years, the high performance and design flexibility of the composite materials has led to their rapid spread in the field of Aeronautics and Space, Automotive, Marine etc. At the same time, the growing technological demands have created the need for advanced material properties or even an extended lifespan. In this context, and inspired from the healing mechanisms of living beings, the scientific community has focused on the evolution of composite materials, which mimic nature by incorporating self-healing microcapsules in the matrix of the material. This new class of materials is called self-healing materials.

These materials have the ability to heal autonomously possible damages, such as microcracks of the matrix, without external interventions. In the present work, the self-healing materials with embedded encapsulated healing agents into polymer matrix containing dispersed catalysts are studied. When a crack occurs, the crack ruptures the embedded microcapsules, releasing the healing agent into the crack plane. Then, the healing agent contacts the catalyst, which is dispersed into the matrix, triggering polymerization that bonds the crack faces closed.

In this work, initially Chapters 1 and 2 refer to the state of the art of composite materials and in particular textile composites (woven fabrics) and furthermore to multifunctional materials. Following, in Chapter 3, the main self-healing techniques developed to date are mentioned, with an emphasis on the self-healing mechanism with microcapsules in Chapter 4. In addition, most relevant studies have been included.

As for the diploma thesis methodology, a multiple scale model simulating the effect of significant parameters of the microcapsules on the mechanical behaviour of the polymeric matrix was modeled. Specifically, the effect of the diameter and volume content of the microcapsules was studied, first on the elastic and then on the mechanical properties of the composite material. In this context, a representative unit cell of a polymeric matrix with microcapsules was first created and then a representative unit cell of a textile composite

with a plain weave fabric of carbon fibres as reinforcement and the polymeric matrix with microcapsules of the previous scale. In addition, the material was modeled on the macroscopic scale by utilizing the mechanical properties of the microscopic scale and afterwards through the 3-point bending test the interlaminar shear strength was calculated for each parameter. Conclusions were drawn and compared with existing experimental results.

Finally, some future goals that could improve and evolve the self-healing mechanism with microcapsules were proposed.

Keywords

Microcapsules, self-healing, fabric of composite material, Digimat, Ansys

STEP SCARFED REPAIR OF COMPOSITE STRUCTURES USING ELLIPTICAL PATCHES

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ABSTRACT

Composite materials constitute a category of materials with a vast range of applications, since they consist of two or more different materials, hence having the ability of creating structures with the desirable properties. The incredibly wide use of composite materials in many constructions in modern times, dominated by the applications in aviation and aerospace, have made the need for repair of these structures' imperative, in the points of non-allowable damage, without replacement of the pieces, since their cost is excessive.

The development of many repair methologies of composites, especially in high safety structures, is an outcome of the necessity to recover the material's properties in the optimal degree, so that the good operation and the safety of the construction are secured for a reasonable period. The structural repair of a composite material depends on many parameters, which must be taken into consideration in the calculations, and this is the reason why the development of optimal methods is particularty difficult.

The present thesis analyses a repairing composite plate with a central crack, in the finite element analysis program, Abaqus. The plate is subjected to a compressive load for several elliptical patches, for the purpose of drawing conclusions as regards the strength of the repaired plates, as well as the undamaged material removal of the composite plate. Scope is the selection of the optimal repair patch, which recovers as much strength as possible for the repaired plate compared to the initial undamaged plate, and at the same time removes as less undamaged material as possible from the repairing plate for the importation of the patch. In combination with these significant factors, the delamination status caused by each patch just before the plate's failure is inspected, as well as the matrix's and the fibers' failure of each plate according to the Hashin failure criterion.

Keywords

Composite materials, repair, elliptical patches

CORROSION IMPACT ON STEEL REINFORCING BARS (B500c) UNDER SEISMIC LOADS

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ABSTRACT

For the porpose of this dissertation an experimental research was carried out regarding the effect of corrosion on B500C steel reinforcement and its seismic response. Based on recent studies that have been conducted through the world, corrosion damage differs in accordance with the exposed corrosion length. In the present research 84 bar specimens (with a diameter of 16mm) and a short length (20mm) to corrosion were examined. With the objective of expanding the current knowledge which is limited up to 400 hours of corrosion exposure, accelerated corrosion experiments up to 1000 hours were conducted with a current density of 1mA/cm^2. Specifically, the corrosion times that were tested (XSI environmental exposure) were: 250, 400, 500, 600, 800, 1000 hours. After the completion of the accelerated corrosion, the dynamic response of the corroded rebars was examined through low cycle fatigue mechanical tests at constant strain amplitudes of ±1.0%, ±2.5%, and ±4.0%, simulating fixed blocks of seismic actions. The results of the mechanical tests indicated the significant influence of corrosion on the seismic response of steel in low strain amplitudes, less than ±2.0%, in which its service life is crucially reduced. In the occasion of ±1.0%, it is noteworthy that the number of loading cycles until failure (for a corrosion level 16.1%) recorded at intense degradation of 62.8% compared to the reference speciments. On the contrary, in larger strain amplitudes, the appearance of buckling phenomena dominates the material damage and determines its failure.

Keywords

Corrosion of Steel Reinforcement, Seismic Loading, Fatigue Life of Corroded Rebar

STATIC RESPONSE OF CELLULAR PLATES AND BEAMS VIA ENHANCED ELASTIC THEORIES

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ABSTRACT

The Classical Theory of Elasticity is based on the idea that the material of the element we are studying is homogeneous. However, most materials have microstructures that affect the properties of materials when their dimensions are comparable to the scale of the microstructures. In such cases a deviation has been observed in the response of the analytical models compared to that of the experimental / computational ones. The Strain Gradient Elasticity theory is employed to bridge this gap with the use of higher derivatives of elastic deformations, micropolar and couple stress theories.

In the present Thesis, the response to bending of Bernoulli - Euler and Timoshenko beams is studied using the Strain Gradient Elasticity theory of a single parameter (g). In particular, the problems of the cantilever beam and the pure bending are solved. The response is compared with the results of the analytical model according to the Classical theory of Elasticity and the dependence of the solution of each problem on the value of the parameter g is studied. Additionally, the response of perforated plates is studied numerically, and the results are correlated with the analytical solutions of Gradient Elastic Beams in order to determine the values of the characteristic length g.

The study shows that as the value of g increases, and therefore as the weight of the Gradient Elastic components in the analytical solution of the beam increases, the latter becomes more rigid: the transverse displacement decreases in cases down to less than 10% of the classical solution.

It is, also, proved that plates with periodically distributed cavities on their surface exhibit a gradient elastic behavior. In particular, variations in the number and radius of the circular holes in the slabs, as well as whether the cavities intersect the boundary surfaces of the plates significantly affect the displacement values. This phenomenon is called size effect. The effect of the same quantities (number and size of holes) on the value of g is, also, examined.

Finally, the ability of a simple Gradient elastic model to simplify the analysis of an engineering problem with micro-structure is studied.

Keywords

Classical Elasticity, Strain Gradient Elasticity, Non-homogeneity, Microstructure, Increased Stiffness, Bernoulli – Euler beam, Timoshenko beam, Characteristic length, Size effect, Boundary Element Method

DEVELOPMENT OF COMPOSITE MATERIALS MODIFIED WITH BISMALEIMIDE POLYMER CONTAINING CARBON NANO-PATRICLES. INVESTIGATION OF FRACTURE TOUGHNESS PROPERTIES AND HEALING CAPABILITY

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ABSTRACT

In the present thesis, an investigation was conducted on the fracture toughness properties and the Self-Healing (SH) capability of a Carbon Fiber Reinforced Polymer (CFRP), which was modified with interleaves of a self-healable Bis-Maleimide (BMI) polymer – based on the reversible Diels-Alder (DA) reaction – that contained carbon nanoparticles. The formation and distribution of BMI interleaves (SH Agent - SHA) on the CFRP plies was performed locally before curing, only in interlaminar regions of interest, by the Solution Electrospinning Process (SEP). Namely, reference (unmodified) and BMI-modified CFRPs – either without or with one of two nanoparticle types, viz. Multi-Walled Carbon Nanotubes (MWCNTs) and Graphene Nanoplatelets (GNPs) – were fabricated and tested under Three-Point Bending (3PB) and Mode I Delamination Fracture conditions. The experiments showed that the SHA-modification had only a small negative effect on the flexural mechanical properties of the CFRPs and their interlaminar fracture toughness properties were enhanced, mostly due to the fiber bridging phenomenon (caused by the presence of SHA), with the BMI & GNP-modified case exhibiting the best toughening performance. Subsequently, a healing process took place, but the repetition of Mode I fracture tests indicated that low recovery of mechanical and fracture properties was achieved. Based on the first Mode I Fracture experiments, Finite Element Models (FEM) were developed, including Cohesive Zone Models (CZM) with Multilinear Cohesive Laws to account for the Interlaminar Mode I Fracture response of the specimens. The suitable CZM parameters were in agreement with the experimental conclusions, regarding the superiority of the BMI & GNP-modified CFRP and the principal role of fiber bridging to the toughening effect. Although the numerical models offered a good approach around the maximum load of the fracture response, they displayed some deviation from the experiments in the propagation part of the force – displacement curves. This was mainly attributed to the insufficient approximation of the stress field

around the delamination crack by the utilized plane strain finite elements and secondarily to the inability of the models to describe possible degradation of the CFRP properties around the crack of the DCB specimen. In the end of the thesis, suggestions are made for development of the implemented SH strategy (to achieve healing) and improvement of the numerical models (to reduce deviation from the experiments).

Keywords

Composites, Self-healing, Electrospinning, Fiber Bridging, Cohesive Zone Model

ROBUST DESIGN AND RELIABILITY ASSESSMENT OF COMPOSITES FOR DELAMINATION

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ABSTRACT

The diploma thesis is related to finding innovative and robust ways of analyzing the reliability of composites that have undergone delaminations. The thesis is divided into 8 sections. First, there is a brief introduction to the advantages of stochastic design and its realism over the deterministic one. The second section introduces stochastic structural analysis and mentions the Monte Carlo simulation that will be used for our analysis. Then in the third section an introduction to composites materials is made, while in the fourth section the composite mechanics are mentioned and the first mathematical bases for the implementation of CLT code are introduced. The fifth section lists the methods of delamination analysis and describes in more detail the CTE method which will be used in this thesis. The sixth section explains the micromechanical models and selects the most suitable one where in our case it is the Bridging model. Then in the 7th chapter reference is made to machine learning, its types and models that are widely used with more emphasis given to neural networks which can give impressive results. In the 8th chapter the reliability problem that we must analyze is introduced among with the input data of the problem and finally the results of the probability of failure are presented. Finally, in the chapter 9 the deep learning neural network is designed, enabling the instantaneous estimation of the probability of failure for the specific system that is being studied and therefore opening the road for innovative engineering applications.

Keywords

stochastic reliability analysis, Monte Carlo simulation, delamination, micromechanic models, deep neural network machine learning

LOW VELOCITY IMPACT AND COMPRESSION AFTER IMPACT OF CARBON FIBER/EPOXY COMPOSITES MODIFIED WITH DIELS-ALDER BASED HEALING AGENT AND GRAPHITE NANOPARTICLES

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ABSTRACT

Laminated Carbon Fiber Reinforced Plastics (CFRPs) are prone to delaminations and microcracks during service life. According to relative literature, this type of materials exhibits low fracture toughness properties when exposed to impact events, thus promoting micro-cracks and delaminations. Prompt defect detection and repair of it into a composite structure, is the key point that often is impossible to be occurred especially into invisible areas deep inside the composite structure.

Self-healing (SH) materials, are promising since autonomously repair potential defects into a composite structure at early stages, thus reducing the spread of failure and extend the time limit of use. In addition, after healing process usually restoration of the mechanical properties is achieved up to a great extent, while SH technology contributes to the reduction of waste. SH materials are inspired by biological systems (e.g., automatic repair of damaged tissues). SH systems are integrated into composites by various ways, without affecting the architecture of them and consequently its mechanical properties. SH for intrinsic systems is activated by some external stimulus (i.e., temperature and/or pressure). Depending on the incorporated system type SH technology is divided into two main categories (a) intrinsic and (b) extrinsic type.

In the current work Diels-alder (DA) based SH agent (bis-maleimide) was incorporated into CFRPs having an aim to enable it with SH functionality. DA reaction mechanism provides reversibility upon heating. Based on that, DA based polymers support multiple SH cycles without usually their mechanical properties to be affected. Here, SH agent was incorporated locally by the technique of electrospinning process on a specific surface of the pre-preg plies prior autoclaving process. Reference and modified CFRPs with SH agent (nanomodified or not with Graphene nanoplatelets, GNPs) having the following stacking sequence [45/0/-

45/90]2S were prepared. Fifteen (15) specimens for each category were manufactured and tested under low velocity impact (LVI) and compression tests before, after LVI and after the healing process. The main objective was to compare the response of all specimen types subjected to impact phenomena, and then to evaluate their residual mechanical properties through compression tests prior and after healing process.

Based on compression tests prior LVI, no significant degradation effects were observed due to the SH agent presence. After LVI and following the healing process, the damaged area was fully or partly repaired while the residual compressive properties were enhanced based on compression after impact tests. The presence of nanoparticles made the composite to have lower resistance to damage when exposed to LVI (higher damage area) as a result the reduction of the residual compressive properties as expected. However, the high damage area recovery (up to 100%) after healing process is a promising effect for composites' residual mechanical properties improvement.

Keywords

Composite materials, Self-healing materials, Electrospinning, Bis-Maleimides, Graphite Nanoparticles, GNPs, Low Velocity Impact, Compression After Impact

EXPERIMENTAL STUDY OF THE EFFECT OF TEMPERATURE ON THE DYNAMIC DAMPING OF COMPOSITE MATERIALS

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ABSTRACT

The use of composite materials in order to advance and facilitate daily life, is becoming more and more frequent. Polymer composites and their properties are specifically interesting. Thus, in this thesis, we study the dynamic damping and elastic properties of epoxy resin materials reinforced by oriented glass fibers and carbon fiber weaves, in combination with the effect of the ambient temperature in which they are charged.

First, the theoretical background is presented, regarding the type of materials we examine and the properties related to their stiffness and dynamic damping, as well as how they are affected by environmental factors, such as their operating temperature. In addition, we describe the experimental setup and the construction through which the experiments are performed in order to determine the damping coefficients by approaching the desirable conditions. Additionally, the thermal analysis of the chamber is presented.

The damping and the elastic properties are mainly centered around the first oscillation frequency of the specimens, due to its particular importance in terms of the operation of a structure. During the experiments we study the response of the specimens from the test materials in the temperatures of 25^{o}C, 40^{o}C, 60^{o}C and 80^{o}C. In addition, it is described how the excitation of a certain frequency range, and the signal which we receive from similar sensors, placed in the specimens, leads to the detection of the first eigenfrequency and the damping ratio. Also, with these and the use of programs of reverse engineering models, their elastic properties and damping coefficients are calculated.

These findings show the changes in dynamic damping at different temperatures as well as the way that they affect their elastic properties and dynamic damping on these materials. In addition, it seems that the temperature rise increases the damping and the coupling of the flexural-torsional stiffness of the materials, resulting in the presence of torsion in the flexural

mode, while higher damping values occur in carbon fiber specimens instead of the glass fiber ones.

Finally, observations are made both for the experimental processes and we make suggestions that could improve the accuracy of the clarity of the results.

Keywords

composite materials, dynamic damping, elastic properties, temperatures, damping coefficients

NUMERICAL SIMULATION OF FATIGUE DAMAGE DETECTION IN COMPOSITE LAMINATES BY MODELING OF STOCHASTIC VIBRATION SIGNALS

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ABSTRACT

The object of this Thesis is the numerical simulation of the response of specimens from laminated composite materials with fatigue damage, subjected to random vibration through white noise. The analysis was performed using the Ansys 15.0 finite element computer package. The model, that is developed, represents an experimental process, which was implemented in common by the Laboratories of Technology and Strength of Materials and Stochastic Signals and Automation, in which intermittent fatigue tests were combined with C-Scan acoustic ultrasonic and white noise tests.

The dimensions of the specimens are 250 mm x 25 mm x 3.78 mm and their stratification is $[\pm45/90/0_2/90/\pm45/0/90]_S$. 24 specimens were modelled, one healthy and 23 with damage. The boundary conditions of the model are simple suspension of the specimen. The white noise was modeled by introducing a normalized sequence of numbers adapted to the free vibration eigenfrequency range.

Fatigue damage was modelled based on the analysis of C-Scan images and the degradation of the appropriate elastic properties of the layers in specific groups of elements in the model. The faults differ in geometry, size and type. The damages modeled are extensive uterine failure and delamination.

The results, that are obtained, are PSD (Power Spectral Density) diagrams, from which the natural frequencies of specimens come from and with which they vibrate. The peaks of these diagrams are the eigenfrequencies and any change in them is associated with a damage. Before the model is used for comparison, the numerical model of the healthy specimen was verified with the experimental results from the healthy specimen, respectively. From this comparison it emerged that the maximum deviation between the eigenfrequency values was 7%. Then the comparisons of the numerical model of the healthy specimen with the individual faults were made. In order to achieve a comparison in the

same range of values, it was necessary to reduce the experimental value step from 0.5 Hz to 1 Hz and to log the values.

From the numerical results there is a change in the vibration responses even in the presence of a small fault. In this way the increased sensitivity of the method is confirmed. In cases where there is an accumulation of faults, there is a decrease in natural frequencies. Extensive uterine failure (degradation in the transverse direction) has also been shown to lead to an equivalent change in vibration responses with delamination in the vertical direction. The second is considered the most common form of failure in laminate composite materials, while the first one is simply referred to as a possible failure. Finally, denser discretization showed a significant effect on the damaged models.

Keywords

Composite Materials, Delamination, Finite Elements Analysis (FEA), White Gaussian Noise, PSD Diagram

DESIGN OF AN AUTONOMOUS SMALL PARAFOIL SYSTEM, GUIDANCE, NAVIGATION AND CONTROL

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ABSTRACT

The scope of this thesis is the modelling of a six-degree of freedom parafoil/payload system and the design of the guidance and control algorithms for a controlled landing. The modelling is done based on a payload compatible with the European CanSat requirements. The parafoil system is optimized and simulated in MATLAB/Simulink environment. The guidance system consists of a waypoint path planning algorithm creating a straight and an S-shaped path for the system to follow. Model Predictive Control is chosen to produce a good path-following accuracy even in the presence of wind. Conclusions and future recommendations are presented at the end of this thesis.

Keywords

Parafoil, Payload, Aerodynamics, Guidance, Control

DIVISION OF DESIGN AND MANUFACTURING (SEPTEMBER 2021)

AUTOMATED TASK ALLOCATION COMPETENCY - BASED MODEL

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ABSTRACT

Industry 4.0 has created several challenges for the human element in the working environment. With the Industry 5.0 emerging, the workforce receives an even more necessary role, of integrating the technology to the everyday operations of a production unit and ensure that the adoption of novel solutions is successful, while on the same time change their role, from performing tasks to innovating and solving complex problems. Taking into consideration that the human operator shift their focus to more creative and strategic jobs, the task allocation process will face new challenges and technological advancements should provide solutions for them. Now, jobs are assigned to people based on the supervisor's intuition and judgement, wasting important time from defining the task till finding the most qualified employee for the specific job, and lacking documentation of the decision-making process. Although, competencies have been discussed thoroughly over the past few years, there is still room for improvement in measuring and comparing different competencies of human operators, engineers, technicians, and using the results to manage human capital. To uncover the potential of the task allocation, process the competencies will be used as decision-making criteria, aiming to achieve the best possible performance, through an automated system to assist the project manager find the optimal division of tasks to the available human resources, based on their competencies. The proposed framework can be applied both on a project and on a production line because it can be performed with real-time data and task allocation methodologies are the same for them, with the only difference being the task duration. In order to validate the applicability of the proposed framework and

the generated algorithm, a case study derived from a maritime company has been examined, with the objective to allocate in the optimal way seafarers to vessels and maintain a balanced competency level among the fleet.

Keywords

Competencies, Competence Gap, Task allocation, Scheduling, Process optimization

RECONSTRUCTION OF ELECTRIC SHOCK ACCIDENT

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ABSTRACT

The current survey deals with the reconstruction of a real electric shock accident. Initially, the circumstances and location of the accident are examined. Then, the characteristics of the low-voltage network of the area, where the accident occurred, are studied. More specifically, the design and maintenance of the network, the outdoor substation, the concrete pillars, and the strength of the power line are analyzed. Afterwards, the conditions of the low-voltage conductor's cutting-off and its consequences are calculated. The cases of errors during the cutting-off as well as the conditions of the fire are examined. To reconstruct the accident, it is necessary to understand the electric shock, which takes place through the use of available material. Finally, the accident is reconstructed, and the main conclusions are formulated.

Keywords

Electric Shock, Power line strength, Accident reconstruction, Fire, Low voltage network

DEVELOPMENT OF A TACTILE SENSOR FOR ROBOTIC GRIPPER AND SYSTEM SOFTWARE FOR THE FABRIC TYPES IDENTIFICATION BY RUBBING

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ABSTRACT

Fabrics compose a category of materials, whose production and manipulation cannot get easily automated, because of some special features that these materials possess, such as yielding, flexibility, sensitivity and also variety. Scope of the present thesis is the design and the fabrication of an optoelectronic tactile sensor, which could be possibly used in applications involving fabric-type recognition through touch.

In the beginning, a reference to the features of fabric materials is made, and in general to features of surfaces according to Tribology science. A reference is also made to different types of tactile sensors. Next, a review of literature is presented, including results from research related to the human hand and its motion during the manipulation of a fabric, along with the tribological properties of the human fingertip. In addition to the previous, some applications of robotic fabric manipulation are commented, paying more attention to the types of the sensors used and to the methods with which the data is processed later.

The main part includes the designing steps of the tactile sensor. The thinking process and the criteria, based on which the final design was selected, are analyzed, and the fabrication process is described. In the end, the fabricated tactile sensor is used to take some measurements while rubbing different surfaces. The results show that the sensor presents high sensitivity and response and therefore, it could be mounted on a robotic gripper and used in applications that include fabric classification through touch.

Keywords

Tactile sensors, Fabric materials, Surface recognition

DETERMINATION OF RULES AND BUILDING OF AN EXPERT SYSTEM FOR FEASIBILITY EVALUATION OF WIND PARKS

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ABSTRACT

Wind energy is proving to be a very promising source of renewable energy, complementing or replacing conventional energy systems to meet global energy requirements. It is currently one of the fastest growing renewable energy sources in the world, while in Greece investments in facilities are increasing.

However, the utilization of modern wind turbines depends to a large extent, in addition to their technical specifications, on the selection of the appropriate installation location which is a key challenge as it must meet both the operating requirements and the requirements arising from laws and regulations. In many cases, the satisfaction of these criteria leads to incompatible situations, where e.g. one point is excellent in terms of the operation of the park but is located within a protected environmental area or near a settlement. As a result, the problem to be solved is complex and multifactorial. This complexity, therefore, has led to the widespread use of computational intelligence techniques. However, even this use of these tools is a challenge for the design engineer.

This dissertation presents the rules and proposes the creation of a system based on vague logic for the evaluation and selection of the appropriate location of wind farms. The process of evaluating such a position involves the use of a series of criteria whose critical values are determined by the legal framework of each country (including Greece). The mentioned criteria are used for the construction of vague sets and consequently based on them the vague rules are created for a system for drawing conclusions using the fuzzy Inference System that will undertake the evaluation (quantitative) of the examined positions. The developed system is then tested in two cases to verify its proper operation.

Keywords

Wind farms, Fuzzy logic, Fuzzy Inference System, Wind turbines, RES

TRIBOLOGICAL DESIGN OF ELLIPTICAL JOURNAL BEARINGS

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ABSTRACT

The journal bearings are crucial machine elements which are widely used in the industrial market and the main applications of these are found in the crankshafts, centrifugal pumps and other type of machines (navigational). The geometrical center of the shaft, which comprises the moving part of the system is presenting an eccentricity relatively to the geometrical center of the bearing. As a result, the oil film is taking the profile of a wedge which is formed between the journal and the inner surface of the bearing making it withstand the vertical load which is asked by the weight of the journal and the external forces. The vertical load can be faced by the hydrodynamic pressure produced in the converging part of the bearing. However the cylindrical journal bearings are facing instability problems in circumstances which is observed low vertical load, high number of speed and high diameter of journal. Under these circumstances it is quite possible an sub-sychronous vibration that is responsible for destructive consequences in the system causing failure and severe rates of wear in the journal. The sub – synchronous vibration is actually a resonance that happens in frequency smaller than the crucial of the system. The development of technology and the continuing experimental analysis of non-circular geometries leads to the manufacturing of elliptical geometry of the inner surface of the bearing in order to eliminate the problem of instability and sub-sychronous vibration. This work is firstly explaining the theory of the elliptical journal bearings and how nowadays are crucial in many applications and secondly is dealing with numerical analysis which is applied to the software Ansys Fluent. The geometrical model of the analysis is the oil film and this work studies the themohydrodynamic behavior of under the change of the vertical load and angular speed. Significant results are deduced referred to the pressure distribution, temperature of the inner surface of the bearing and the volume fraction of the gas phase. It is assumed constant temperature in the surface of the journal and zero heat flux in the inner surface of the bearing. The gas phase in the numerical analysis plays crucial role because it shows the density of the bubbles and characterizes the phenomenon of cavitation. The results of the numerical analysis are compared with these of other published studies and are certified. The

reference points for this work are the published experimental study of A. Singla , A. Chauhan with title « Evaluation of oil film Pressure and Temperature of an Elliptical Journal Bearing – An experimental study » and the published work by Maria-Eleni Kyrkou with title « Thermohydronamic Analysis of journal bearings ,lubricating with industrial and environmentally friendly oils.

Keywords

Thermohydronamic Analysis , Cavitation , Adiabatic Bearing , Pressure Distribution , Change of Angular Speed

APPLICATION OF GENETIC ALGORITHMS FOR AESTHETIC OPTIMIZATION OF PRODUCT SURFACE ANALOGIES

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ABSTRACT

The present diploma thesis aims to the study and development of a systematic evaluation method for aesthetic optimization of product analogies. The proposed method is based on the optimization of performance variables using genetic algorithms and is applied on the field of Aesthetic Design. Three major sub-problems are considered: a. the 2-dimensional aesthetic optimization (the maximum possible compliance of the analogies of a surface with the aesthetic rule of the Golden Ratio), b. the 3-dimensional aesthetic optimization (the maximum possible parallel compliance of the analogies of three surfaces of a product with the aesthetic rule of the Golden Ratio) and c. the multi-criteria optimization (the requirement of the 3-dimensional aesthetic optimization as defined above, gets expanded in order to include the maximization of stiffness and minimization of the mass of the product to be designed). The evaluation of the Genetic Algorithm method is performed by comparing its computational efficiency with the cost of analytical (exhaustive) solution.

Two applications of both methods for each sub-problem, are being analyzed as case studies. This analysis results in the conclusion that Genetic Algorithms can benefit the design process by decreasing the time required for finding solutions and by giving useful design suggestions.

Keywords

Aesthetic Design, Genetic Algorithm, Optimization, Analogies, Golden Ratio

FAULT DIAGNOSIS ON ROTATING SYSTEMS WITH THE USAGE OF BIG DATA ANALYSIS

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ABSTRACT

One of the most important issues that engineers have always been concerned of is the study of oscillations and the stability of a structure. Rotating systems and especially shafts exist in a wide range of applications, such as motors, turbines, compressors, pumps and more. In these systems an uncontrolled oscillation can lead to resonance, which may result in devastating consequences for the machine, but also for human safety. So, it has been made clear that it is important to analyze the behavior of rotating systems, in many situations, so to predict an error and especially avoid an accident. In this study, we developed a fault diagnosis algorithm on roller bearings. For this reason, we used experimental data, from an experiment that had been conducted by NSF I/UCR Center for Intelligent Maintenance Systems (IMS – www.imscenter.net), which we used to train a model in MATLAB. This model can diagnose a fault in roller bearings with the usage of the SVM method.

Keywords

SVM, EMD, Big Data Analytics, Fault diagnosis, Roller bearings, Rotating systems.

ACCIDENT RECONSTRUCTION OF COLLISION BETWEEN PASSENGER VEHICLE AND MOTORBIKE

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ABSTRACT

Fatal road accidents involving motorcycles are being stabilized at high levels in Greece, despite the general downtrend of the total traffic accidents that take place annually. This demonstrates the need for specialized analysts and experts in the field of motorcycle engineering and accident reconstruction. This need is also underlined by the fact that the complexity of motorcycle mechanics is such that it diversifies the branch of its criminalistics in a large extent e.g. from the study of the corresponding of the passenger vehicle accident reconstruction.

In the context of this work, the study of a traffic accident between a motorcycle and a passenger car will be made, from the point of view of the mechanical engineer. That is, utilizing the existing methodological tools, such as energy and dynamic conservation methods, I will carry out a reconstruction of a car accident that occurred in Andravida, Ilia in February 2017, and whose expert report on behalf of the Hellenic Traffic Police was made by my supervisor, Thomas Chondros.

Specifically, based on the collected data and observations, an attempt will be made to determine the point of collision, to estimate the collision speed of the vehicles and the ejection speed of the passenger in order to reconstruct the accident and to draw the final conclusions and findings regarding the circumstances, causes and fault of the accident.

Based on the above, an attempt will be made to provide a framework of methods and proposals that aim at improving the driving safety of the motorcyclist but also facilitating the work of the expert of the respective traffic accidents.

Keywords

Accident Reconstruction, Passenger Vehicle – Motorcycle Collision, Traffic Accident's Expert Report, Equations of Motion, Conservation of Momentum

OPTIMIZATION OF WAVELET BASES OF EMG SIGNAL FOR APPLICATION IN DESIGN AND DYNAMICS OF MACHINES & MECHANISMS

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ABSTRACT

In the following thesis an investigation is carried out towards the direction of obtaining optimal Wavelet bases, in a sparsity sense for signals commonly found in biomedical engineering applications. Most of the inspiration that lead to this work was drawn from studying Ilizarov equipment and the possible scenario of incorporating clever signal processing into properly adjusting the parameters of the device through adequate actuators. Our world is packed with data that are in nature immensely complicated, containing rich, hidden structure. For these reasons the extraction of useful information is oftentimes a lasting and exhausting process. Mallat aptly describes this, as trying to find a needle in a stack of hay. It is thus of great usefulness to identify Dictionaries of sets of Vectors that lead to meaningful and intuitive decompositions of the signal. Additionally, digging deep into the structural elements of biomedical data can give intuitive feedback on how mammals use their muscle and bone compositions for ergonomic, efficient locomotive tasks. This information can then be used to push the limits of machine design and automatic control even further.

Keywords

Biomedical Signals, Wavelets, Sparsity, Machine Learning, Design of Machines and Mechanisms

FAULT DIAGNOSIS AND PROGNOSIS OF A ROTOR BEARING SYSTEM ULTILISING DIGITAL TWIN CONCEPT

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ABSTRACT

In modern times, industries consider the field of maintenance as one of the main activities and it is necessary to develop methods for better maintenance planning. In Industry 4.0 traditional methods for fault detection have been sidelined and we focus on the concept of predictive maintenance. Predictive maintenance will lead the industries in the new era with main goal the cost reduction and the integrated control of the production. Predictive maintenance's benefit is that takes into account the current state of the machines and the maintenance planning is more accurate than the traditional methods. In the current thesis we study this perspective utilizing neural network concept. These smart systems have the ability to learn characteristics of complex systems and give results faster than traditional methods. In our case we consider the neural network as the digital twin of the system which give us the estimation of the real condition of the fault in a rotor bearing system.

Keywords

Fault diagnosis, journal bearing, rotor vibrations, neural network, digital twin

DIVISION OF ENERGY, AERONAUTICS AND ENVERONMENT (SEPTEMBER 2021)

COMPUTATIONAL AERODYNAMIC STUDY AND OPTIMIZATION OF PARAMETRICALLY DESIGNED WINGLETS FOR A MULTIROLE UNMANNED AERIAL VEHICLE, IN SINGLE AND MULTIPHASE FLOW AND COMPARISON WITH EXPERIMENTAL WIND TUNNEL RESULTS

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ABSTRACT

Increasing the range of aircraft and reducing fuel costs are essential in the aeronautics sector. According to the international literature, this can be achieved with special devices at the ends of the wings, the so-called winglets, since they manage to reduce the induced drag. Aim of the present research is to find the optimal winglet for the wing of the UAV ethERAs, and to study if the flight over wildfire affects the aerodynamic performance. Optimal is defined as the one with the highest aerodynamic efficiency or lift-to-drag ratio. The programs CATIA V5 and Spaceclaim were used for the parametric design of the winglets, while the Poly-Hexcore method of the ANSYS Mosaic Meshing technology was used for the construction of the computational mesh. The CFD simulations were performed using the turbulence model SST k-ω and the program ANSYS Fluent. The flight through smoke was simulated as a two-phase flow of air and anthracite particles, using the Euler-Lagrange method and the DPM model. For the validation of the results, experiments were conducted using a wind tunnel and a 3D printed scale model of the wing with the optimal winglet. For safety reasons, the two-phase flow was simulated as an air-sand particle flow. The results show that four of the five winglets that were designed, have a positive effect on the

aerodynamic efficiency of the wing, as they manage to reduce the size of the wingtip vortex. The so-called “Blended” winglet offers the highest efficiency, which is 8.92% higher than that of the “Simple” wing without a winglet, for the usual flying conditions (20 m/s, 0°). It also performs better than “Simple”, for every velocity and angle of attack that was studied. The CFD simulations are in accordance with the experimental results, despite some slight deviations, and the two-phase flow seems to reduce the aerodynamic efficiency. We conclude that CFD simulations are a powerful tool to draw faster and cheaper conclusions, the flight over wildfires reduces the aerodynamic efficiency, and the “Blended” winglet is the optimal choice for the UAV ethERAs.

Keywords

CFD, ANSYS Fluent, Poly-Hexcore, SST k-ω, CATIA V5, UAV, winglet, Eppler 420

STUDY OF SOUND DIFFRACTION BY FINITE LENGTH EDGES IN THE FREQUENCY DOMAIN

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ABSTRACT

The present thesis aims to present curves and empirical formulas that predict the diffraction field around a finite length edge for faster calculation. Employment of empirical formulas reduces the computational time by orders of magnitude compared to employment of existing analytical solutions. A newly found analytical solution, Nikolaou P. (2020), is employed and investigated. It is found that the diffraction field depends on three variables: The diffraction time, the diffraction delay time, and the frequency of the source. The diffraction time is the time that it takes for the sound to travel from the source to a point on the edge and then to the receiver. The diffraction delay time is the additional time it takes for the sound to travel from the source to the receiver after diffracting on the edge compared to the direct distance between source and receiver. A formula is derived that predicts the first and the last critical diffraction time, or alternatively the starting and ending point of a finite length edge, which produces a diffraction field that is equal to the diffraction field from an infinitely long edge. Corresponding nomographs are presented. Finally, it is shown that the SPL difference between the diffraction fields of finite and infinite length edges depends on two universal parameters Corresponding nomographs are also presented.

Keywords

Diffraction field, diffraction time, diffraction delay time, nomographs, finite length edge.

FLASH SPRAY COOLING OF POWER ELECTRONICS

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ABSTRACT

In our current technological age, power electronics play a catalytic factor in the management and processing of electricity. The specifications of electronic devices are increasing while the energy requirements are multiplying. The most critical obstacle that the scientific community must face is the extraction of excess heat generated by these devices and causes efficiency reduction or even their failure. Today, various heat dissipation methods are used such as heat pipes and heat sinks. However, their performance is limited to the heat dissipation of conventional electronic systems, such as the cooling of a processor or a graphics card. Thus, when it comes to complex electronic systems with high energy requirements, the need arises for a more efficient heat dissipation technology. Spray cooling is a pioneering technology that offers high cooling capacity and significantly lower operating temperatures, reaching heat transfer coefficients of 300 kW/m^2k. It is a closed system that implements a specialized refrigeration cycle where the evaporator is replaced by a chamber in which the phenomenon of spray cooling takes place. Inside the chamber the R410A used as a refrigerant, experiences a sharp and violent drop in pressure through a nozzle and strikes the hot surface releasing excess heat. The effectiveness of this method lies in the fact that it exploits multiple heat mechanisms such as free convection, phase change of refrigerant and boiling heat transfer. In this work, an extensive study is made on the elements that enhance the cooling efficiency of spray cooling. The exponential increase of the heat transfer coefficient is offered by the adaptation of specially shaped macro-structured surfaces of greater roughness with pyramid-shaped fins resulting the maximization of total wetted area. The nozzle diameter of 0.56 mm and the spray - hot surface distance of 25 mm also showed remarkable results, reaching critical heat flux values of up to 264 W / cm^2. The vision of this work is the technological maturation of the spray cooling method in order to be the next step in the performance of high-quality electronic systems.

Keywords

Macro-structured surface, Nozzle diameter, Spray distance, Heat transfer coefficient (HTC), Critical heat flow (CHF).

COMPUTATIONAL INVESTIGATION OF HEMODYNAMIC FLOW IN HUMAN AORTA

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ABSTRACT

The analysis and assessment of blood flow and its related hemodynamic parameters are indicated to be quite useful for the diagnosis, treatment, even the prevention of multiple diseases. In silico approach of the study of these blood flow characteristics through computational fluid dynamics is being widely used in recent years.

The study that was made in order to create a numerical model and run a simulation of a three dimensional fluid flow inside a realistic geometry of a human aorta is presented in this thesis. For the needs of the current study methods of acquiring geometry data were investigated. Focus was made on part of the stereolithography model utilized, more specifically on the ascending aorta, aortic arch and the thoracic part of the descending aorta. The tool that was employed for geometry processing, mesh generation, definition of the problem and the initial algorithm trials for flow simulation is the open source software for computational fluid dynamics OpenFOAM. Computational flow solution in the complex geometry was attempted using icoFoam, pisoFoam and simpleFoam solvers for a time-invariant input condition, as the aim was to observe and calculate the hemodynamic parameters of velocity and wall shear stresses during the ventricular ejection phase of the cardiac cycle. The adjustments to the default settings of various parameters and the behavior of said solvers were recorded in detail. Calculation of wss was achieved with simpleFoam and their distribution confirms the existence of a critical area for atherosclerosis due to low wall shear stresses in parts of the aortic arch.

The computational trials of the present work demonstrate the difficulty of the problem in terms of: creation of proper numerical model, selection of an appropriate algorithm, selection of compatible boundary conditions, as well as computational costs and achieving convergence, especially for transient solvers and gradually reduced viscosity.

Keywords

CFD, OpenFOAM, Aorta, Blood flow, WSS

DETAILED PROPANE CHEMICAL KINETICS SCHEME REDUCTION AND SIMULATION OF TURBULENT BLUFF-BODY PROPANE FLAME UNDER INLET MIXTURE STRATIFICATION AND PREHEAT

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ABSTRACT

The study of the flame stabilization can provide important information for the combustion phenomenon and therefore help reduce the gas emissions. However, a chemical kinetics scheme is required for the computational simulation that is needed. Yet the detailed chemical kinetics schemes that exist require a high computational cost and they cannot be used in detailed simulations.

In this thesis, a reduction of a detailed propane chemical kinetics scheme was made, using the Directed Relations Graph (DRG) and Full Species Sensitivity Analysis (FSSA) methods. The resulting reduced scheme was then verified against the original detailed scheme USC Mech II and by comparing combustion results in laminar flow reactors and parameters such as flame speed, concentration of several important species and ignition delay. The scheme was later used in the simulation of a turbulent bluff-body propane flame under inlet mixture stratification and preheat. For the simulation, the Large Eddy Simulation (LES) model was used, more specifically its configuration the Implicit LES. Moreover, an evaluation of the OH* chemiluminescent species levels was made by post-processing quasi-steady state derived algebraic expressions. Then experimental results were used to verify the model and quantify the deviations.

Keywords

Bluff bodies, Large Eddy Simulation, Detailed chemical kinetics scheme reduction, Propane combustion, Turbulent stratified flames

INVESTIGATION OF THE AERODYNAMIC BEHAVIOR OF A THREE-BLADE, HORIZONTAL AXIS WIND TURBINE USING COMPUTATIONAL FLUID METHODS

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ABSTRACT

The purpose of this dissertation is to study the aerodynamic behavior of a three-bladed horizontal axis wind turbine. The SolidWorks program was used to design the wind turbine, while the aerodynamic study was done with the student version of the ANSYS Fluent program.

In the first part of the present work, bibliographic references to the laws of fluid dynamics are made and the behavior of the wind around a spoiler is presented. In addition, references are made to various computational methods and their effectiveness.

The simulation of the phenomenon was done using models of computational fluid dynamics. As for the grid of the model, it has the required density for the best possible resolution of the boundary layer. The turbulent flow was simulated with the RANS k-ω SSt model, which largely predicts flow behavior when it comes in contact with the fins. The simulation was made of a wind turbine with a nominal power of 500 Watt, whose behavior was studied for winds of 1 m / s. The simulation was repeated three times for three different speed ratios and the wind turbine efficiency was studied for each of the speed ratios.

After comparing the different wind turbine efficiencies and identifying the largest one, the changes in wind speed and pressure were studied. Finally, the effects of the rotational motion of the wind turbine were studied, while emphasis was placed on the vortices created due to it.

Keywords

Wind Turbine, Computational Fluid Dynamics, Aerodynamic Behavior, Blades, Airfoils

NUMERICAL STUDY OF THE ELECTRIC FIELD IN PLASMA ACTUATORS - ESTIMATION BASED ON THE BREAKDOWN VOLTAGE

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ABSTRACT

The purpose of this diploma thesis is the simulation and the modelling of the electrostatic field in cold atmospheric pressure plasma actuators. The thesis also includes the calculation of the breakdown voltage and the electric field, that is produced by the electrodes of a DBD plasma actuator with overlapping electrodes. These results are then compared with the experimental data, obtained from a reference paper of Soloviev (Soloviev et al., 2017), in order to reach to the final conclusions. Firstly, an introduction to the flow control and plasma is made, the layout and the principles of a plasma actuator are analyzed, and its different types are mentioned. Afterwards, the mathematical equations are given, which are used for the creation of the actuator's mathematical model. The computational modelling and the solution algorithms are presented and the methodology for the problem's solution is analyzed. Consequently, the problem is defined through the analysis of the process that includes the creation of the geometry, the application of the mesh to the actuator and the implementation of the boundary conditions. The results of the calculations for the electric field and the breakdown voltage are presented, which are then compared with the experimental data of the reference paper. From these comparisons we conclude that the air breakdown takes place in a distance around 50μm from the edge of the high voltage electrode, where the electric field receives the value of the field needed for the air ionization and this value is strongly dependent on the thickness and the electric permittivity of the dielectric. In the final chapter of the thesis, the 3D design and the computational model of a plasma thruster are presented, and a comparison between its electric field and the field of a plasma actuator with non-overlapping electrodes of similar dimensions is made. Finally, from this comparison we can conclude that the electric field, that is produced from the plasma thruster is greater than the field of a plasma actuator, having as consequence the greater momentum transfer to the primary flow and the creation of the appropriate thrust force, which is the main target of plasma thrusters.

Keywords

CFD, DBD plasma actuator, OpenFOAM, Flow control, Breakdown voltage

COMPUTATIONAL MODELING OF LNG DISPERSION AFTER LEAKAGE

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ABSTRACT

This diploma thesis focuses on the depiction of one of the Burro series experiments using one of the most widely reliable CFD codes – ANSYS Fluent. The experiment that we recreate in this project is Burro-8, in which Liquified Natural Gas (LNG) is being released through a pipe onto a pond of water through slightly stable atmospheric conditions. The LNG is being released at a cry-ogenic temperature of -162°C for 107s in an ambient temperature of 33.1°C and due to great the temperature difference, it evaporates instantly creating a vapor cloud.

The goal of this thesis was to be able to efficiently recreate the vapor cloud dispersion using the less possible computational effort. Because of that, the estimated pool method is utilized, which assumes that the LNG evaporates instantly and covers the hole water pond surface as soon as it released. The LNG vapor, assumed to be saturated, enters the domain over the water pond area with a vertical velocity which is calculated from the given spill rate.

The thesis represents the entire process of modelling, including the selection of the most effi-cient grid though a mesh-independence process and the selection of the most suitable turbulence model. After we get the results, we compare them with another numerical simulation of Burro – 8, which uses the same approach as we did. Furthermore, velocity, concentration and temperature contours are being represented through the entire domain in order to visualize the whole vapor-cloud dispersion process.

Our goal is to develop the appropriate technical knowledge for the simulation of LNG disper-sion in order to prove that the evolution of the computational efficiency has made CFD codes like ANSYS Fluent absolutely capable of replacing big-scale experiments that need great funding and can cause structural damage or even harm the staff.

Keywords

Liquified Natural Gas, Dispersion, Numerical Simulation, Estimated Pool Formation, CFD

PARAMETRIC ANALYSIS OF CURVED AND LONGITUDINAL VORTEX GENERATORS INSIDE A DUCT OF ORTHOGONAL CROSS-SECTION, WITH THE USE OF COMPUTATIONAL FLUID DYNAMICS CFD

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ABSTRACT

Among the most crucial matters that modern society tries to arrange is the conception of efficient and eco-friendly designs that significantly reduce the energy consumption. The present research observes the behavior of two distinct types of geometries that produce vortices. These geometries are compared by their ability to create long-lasting and powerful vortices. The importance of studying longitudinal vortices inside pipes arises from the fact that they enhance heat transfer. The main advantage of the designed geometries is the fact that they do not require additional energy from an external source to disturb the flow, thus with an appropriate design that aims to keep the pressure drop low, an efficient layout can be acquired. The geometries were designed by using the designing program CATIA. Nine geometries were produced, from which five are curved vortex generators while the rest are longitudinal. Moreover, using the simulation package ANSYS-FLUENT, which utilizes the technique of finite volumes, the flow field of each geometry is examined. Significant attention is given to the creation of the mesh and, in the identification of the areas that require extra refinement, to make sure that the obtained results are reliable and accurate. Also, different turbulence models were compared, and through a thorough examination of the available literature, the realizable k-ε model is chosen to perform the analyses. The various designs are compared by the examination of the coefficient of pressure Cp and by the pressure, velocity, and vortex contours and diagrams. The selected geometry is the one that produces intense and long-lasting vortices while it has low levels of pressure loss. Summarizing, the results are promising and show that vortex generators can aid in the formulation of efficient heat exchangers, as a consequence future research goals are established from whom the most important is the creation of an experimental set up as well as the use of liquid natural gas (LNG) instead of air.

Keywords

CFD, curved vortex generators, Realizable k-ε, LVG, pressure drop

COMPUTATIONAL STUDY OF SUBSONIC AND SUPERSONIC, ONE-PHASE FLOW OVER THE ORBITER OF THE SPACE SHUTTLE WITH SEVERAL TURBULENCE MODELS AND COMPARISON WITH THE RESULTS OF EXPERIMENTAL STUDY IN SUBSONIC FLOW

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ABSTRACT

In past decades the aerospace industry has seen many a change, from winglets to improve flight performance to novel materials used for lighter aircraft structures, all in an effort to make flight more viable and environmentally friendly. The increase in computational power has enabled companies, even without test facilities, to design, test and develop innovative concepts faster than ever with the use of Computational Fluid Dynamics (CFD), which allows for relatively low cost simulations, compared to full scale wind tunnel testing. In this thesis, a full scale (1:1) and a small scale (1:100) CFD study of the Space Shuttle Orbiter is conducted, in the subsonic (7, 14, 28, 56 m/s) and a supersonic (Mach 1.5) flow speeds, using the Spalart-Allmaras and the k-ω SST turbulence models. Standard practices for a proper CFD simulation are applied, given the unconventional geometry and the limited computing power available for the simulations. The CFD study is then complemented by an experimental wind tunnel study made with a 3D printed small scale model (1:100) at the laboratory of Fluid Mechanics. Though at different Reynolds numbers, a comparison of the two turbulence models of the computational full and small scale results with the experimental small scale results is made. The full scale CFD results indicate that the aerodynamic lift and drag coefficients of the Orbiter are practically identical at all subsonic speeds but their values differ at the supersonic speed

Keywords

experimental fluid dynamics, computational fluid dynamics, supersonic flow, subsonic flow, wind tunnel

INVESTIGATION OF THE USE OF PV-THERMAL HYBRIDS FOR ELECTRICITY PRODUCTION AND GREENHOUSE HEATING

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ABSTRACT

The aim of this thesis is to evaluate the use of hybrid photovoltaic PV-T systems for electricity production and greenhouse heating. The first chapters will refer to factors that affect greenhouse operations as well as the conditions that facilitate the cultivation. Next, we will list the most common conventional and alternative central heating systems, that are used nowadays for greenhouse heating. In the fourth chapter, there will be a reference on set up and construction of a PV-T system, qualified for greenhouse heating and the process followed to install and setup the experiment. The fifth chapter focuses on the importance for automation on a greenhouse that uses a relative system, both for functional reasons and for accuracy in the results, for this arrangement. More specifically, an Arduino-Nano microcontroller was used in combination with LM-335z temperature sensors and power relay actuators, to control each electrical appliance.

The next chapter provides a complete description of how to gather and save the data using LabView software, as well as managing them to extract useful results. Thesis was complete with the latest chapters, where the results are presented, as well as with a study on the viability of such a system in a greenhouse unit, making use of the collected data from the experimental arrangement.

Keywords

Greenhouse, Heating, Hybrid, PVT, Automation

DESIGN AND COMPUTATIONAL STUDY OF PLANE AND CURVED ELEMENTS WITH PUNCHED HOLES INSIDE OF RECTILINEAR TUBES OF RECTANGULAR CROSS-SECTION FOR THE OPTIMIZATION OF VORTICES GENERATION

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ABSTRACT

In this study seven models of longitudinal vortex generators are numerically investigated in turbulent flow inside of rectilinear tube of rectangular cross-section. Their effectiveness of inducing vorticity is evaluated taking into consideration the pressure losses. The raised level of vorticity contributes to a more efficient mixing of the fluid, a mechanism which enhances the heat transfer in heat exchangers. For the investigation of the models the Computational Fluid Dynamics (CFD) program ANSYS FLUENT was utilized. The geometries of the seven models of longitudinal vortex generators remind the shape of a ramp, with the first four models referring to plane ramp and the next three models to a curved one. In the first set of models the efficiency of fins, which are attached to the center of the ramp, is investigated and also the effect of the shape of the holes, which are punched on the ramp lengthwise, is studied, while in the second set of models the effect of the angle of the arc of the curved ramp is investigated. The study of the seven models takes place for four different flow conditions, with the corresponding Reynolds Numbers of 5000, 10000, 15000 and 20000. The accuracy of the computational study is validated through a stability analysis. Finally, conclusions are deduced for the effectiveness of the models and the most effective geometry is proposed.

Keywords

Vortex Generators, Vorticity, Computation Fluid Dynamics, Flow Simulation, Turbulent Flows

NUMERICAL QUASI-3D SIMULATIONS OF HEAT TRANSFER IN A CURVED SQUARE DUCT

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ABSTRACT

The project presented below is a computational study of a fully developed flow inside a duct with a curved geometry. Computational Fluid Dynamics (CFD) was used for our problem and through the OpenFOAM software, the preferred geometry was created and the equations governing the specific flows have been solved. The problem's parameters correspond to flow with Dean numbers of 100, 125, 137, 150 and 368 within a duct with a curvature ratio Rc = 15.1. The flow was examined both dynamically and thermally. To achieve the simulation of the fully developed flow, a section of the duct was constructed near the outlet (240o), discretization was performed, initialization was applied, boundary conditions were defined and grid independence was studied to obtain the optimal computational result. Finally, the results of the thermal analysis for different Prandtl numbers, Pr=0.7, 5 will be visualized and compared with the numerical and experimental study of a reference publication.

Keywords

Curved duct, Dean number, Prandtl number, OpenFoam, thermal flow

COMPUTATIONAL INVESTIGATION OF CAVITATION IN PULM INSTALLATIONS FOR PUMPING DIFFERENT FLUIDS UNDER DIFFERENT FLOW AND GEOMETRY CONDITIONS

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ABSTRACT

In the present thesis, we explore the parameters that effect the pumping of various liquid in pump installations, avoiding the risk of cavitation. Initially, the theoretical background of the pumps and their mode of operation is presented. More specifically, the process of pumping liquids with dynamic pumps is analyzed, as well as its characteristic sizes. A centrifugal pump, in an installation shown, is mounted vertically above the free surface of the liquid of a tank, which is open to the atmosphere, in order to drain the liquid without the risk of cavitation. The purpose of this work is to calculate and check the maximum installation height of the pump above the liquid level with data on the supply and diameter of the suction line, the maximum liquid supply with data on the installation height of the pump and the diameter of the pipe, and finally the minimum inner diameter of the suction pipe given the supply and the installation height of the pump. Using excel software, these calculations are made and the corresponding diagrams are constructed. Finally, the results and the curves of the diagrams are compared, and the observations are made on the points with the optimal function.

Keywords

certifugal, pump, cavitation, installation height of the pump, liquid supply, diameter of the pipe

COMPUTATIONAL INVESTIGATION OF THE EFFECT OF A VORTEX GENERATOR 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 have emerged as a very promising method for heat transfer enhancement. In the present work, the effect of a vortex generator of longitudinal flat blade type on the flow and the thermal flowfield of a rectangular cross-section pipe is examined. The research became for six different aspect ratios of the pipe's cross-section and the width of the blade, and especially for pipe's aspect ratio (height / width) 3/2, 2/2, 1/2 and blade's / pipe's width equal to 0.1 and 0.05.

Initially, fundamentals of Fluid Mechanics and Heat Transfer are presented for the reader. Furthermore, an introduction is being made for CFD using ANSYS FLUENT, which is the using CFD program.

In the main part of the work, the rectangular pipe is designed with the blade inside at 30° angle. After that, the mesh is constructed and a mesh independence study is occurred. Then, the turbulence model k-e Realizable is chosen and the appropriate boundary conditions are determined. Lastly, the simulation is running until the converge criterion for residuals of approximately 1e-05 have reached.

The first simulations were for Re=10.000 and found that model 2, with pipe's aspect ratio 3/2 and ratio of blade's / pipe's width 0.05, is the more efficient. In particular, it combines an adequate rise of 8% for Nusselt number and tolerable friction loses (only 5% increase).

Moreover, investigations made for various Reynolds number from 5.000 to 20.000. Found that the flat blade isn't suitable in high Re numbers, because doesn't affect significantly in heat transfer and causes considerable friction losses. Also, in low Re number low aspect ratios models found to work better and, in medium Re number (≈ 10.000) confirmed that model 2 is the best option above all.

Keywords

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

DIVISION OF MANAGEMENT AND ORGANIZATION (SEPTEMBER 2021)

EVALUATING THE SERVICE QUALITY OF A COMPANY THAT SPPECIALIZES IN DESIGNING, INSTALLING AND PROVIDING NETWORK SERVICES

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ABSTRACT

In recent years, the increase in the use of the Internet has brought about significant changes at companies-organizations that provide business services in the field of study, installation and provision of a network in our country. This particular corporate sector is flourishing and the competition between the companies in this sector is becoming huge. Each business tries through the quality of the services that provides to the customer, to "gain" his trust and a competitive advantage over the others. Achieving the desired quality in the provision of services is a complex process that requires effort, organization, cohesion, ambition and many more characteristics from the company's part. The main aim of the current work is the evaluation of the quality of the services provided by a company, which is active in this sector.

Initially, basic concepts such as "service", "quality", "quality of service", "customer" and "customer satisfaction" are analyzed. Then we present techniques for measuring customer satisfaction and refer to important quality of service evaluation models. In addition, we describe the statistical techniques applied in the current work, such as Principal Component Analysis (PCA) and clustering through the K-means algorithm.

For the purpose of the research, a specially designed questionnaire was constructed according to the standard ServQual model, which was completed by 120 external customers of Compugen. The whole statistical analysis was conducted using the IBM SPSS Statistics 27

statistical package. Initially, the basic descriptive measures for our initial variables were calculated. The internal consistency of the questionnaire was then tested, and the quality indicators of accessibility, personnel, installation, consistency and cost of services were constructed as weighted averages of the initial variables. The normality assumption of the new variables was then examined, compared their medians and examined their correlations. We tested the impact of demographic characteristics on the level of satisfaction of the company's external customers with the ongoing variables. Moreover, we applied Principal Component Analysis to extract uncorrelated components. Finally, the company's external customers are grouped based on their level of satisfaction into two groups (high level of satisfaction group, low level satisfaction group) and the characteristics of each group are investigated.

This diploma thesis concludes with the discussion-commentary of the results and the suggestion of proposals aiming at upgrading the quality of the services provided and the general strengthening and profitability of the company.

Keywords

service, quality, service quality, customer satisfaction, design – install and supply of network, ServQual, questionnaire survey

A COMPARATIVE CONSIDERATION OF MACHINE LEARNING TECHNIQUES THROUGH THEIR APPLICATION TO REAL DATA FOR THE PREDICTION OF RELIABLE CUSTOMERS IN RESIDENTIAL LOANS SECTOR

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ABSTRACT

Machine learning and its algorithms, also like computer science, are areas of development that scientists have focused on and show continuous progress. The main objective of these efforts is to facilitate various processes in the everyday life of employees using new tools, but also people in general, through the creation of various software programs and applications.

The sector that has flourished in recent years is Data Mining. The science of extracting useful information from large-scale sets or databases, as is its exact definition, is characterized as an iterative process, which uses various techniques and methods in order to extract useful knowledge for humans. Data Mining is being used in many branches of everyday life. From the way a simple housewife buys, to the biology and the way climate change. One of them is also the banking industry.

Banks are trying to exploit this huge amount of data that flows into their systems every day, so that they can improve their benefits and behavior towards the consumer public. At the same time, they wish to ensure their own sustainability, using data mining for risk management, money laundering detection, marketing, and many other areas. One of them is the process of granting a mortgage loan, using data Mining in order to try to secure the repayment of the loan, analyzing in the right way the characteristics of prospective customers.

Keywords

Machine Learning, Data Mining, Banking Sector, Residential Loan

GraphDocsPy: A PYTHON LIBRARY FOR REPRESENTING MULTIPLE TEXTUAL DOCUMENTS AS A SINGLE GRAPH

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ABSTRACT

In text analysis, document representation is one of the most important steps. Among the methods of text representation that have been proposed, a method – which has become increasingly popular in recent years – is the representation of texts as a graph. This way of representing texts has many advantages, such as visualizing the relationships between words and employing graph theory for text analysis problems. Although computer science is widely used in both the design and analysis of graphs, as well as in text analysis, software packages that combine both fields are rare. One such case is the GraphDocsPy library, a graph–based text representation library written in the programming language Python. A special feature of GraphDocsPy is that it enables the representation of more than one documents in a single graph. This diploma thesis presents in detail the development of the aforementioned library. In particular, the graph–based text representation model that the library implements is first described. Then, all the included functions are analyzed one by one. Finally, to test its effectiveness, the GraphDocsPy library is used in classical text analysis applications.

Keywords

Text analysis, Natural language processing, Text representation, Graph libraries, Graph algorithms.

PRICING OF INTERMODAL FREIGHT TRANSPORT WITH THE ABC SYSTEM

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ABSTRACT

The major objective of this thesis is to investigate the different modes of freight transport and more precisely focus on the analysis of intermodal freight transport.

The first section intends to determine the different types of freight transport modes which are involved in the intermodal transportation such as sea freight, rail and road transport. The aim is to assess the advantages and risks of each transport mode.

Throughout this paper, qualitative and quantitative analysis is conducted, and definitions and terminology are presented.

Furthermore, the initiatives which have been taken from the European Union are described thoroughly and the current legislation is presented including the major proposals for improvement and reinforcement of the combined freight transport. There are also references in hubs, combined freight transport and different transport modes.

Also, the different systems/methods of costing are described for each transport mode and the thesis provides a comparison regarding the costing methods between the traditional modes of transport and the ones based on activity. A detailed description of the Extend v6 modeling program is given. Following the dissertation, an extensive analysis and modeling of a case of the transport company is carried out. Finally, a comparison of the results is made to resolve the case.

Keywords

Various types of transport, combined transport, freight transport, freight centers, Activity Based Cost (ABC), extend

DEVELOPMENT OF A RECOMMENDER SYSTEM OF UTILIZING THE REVIEWS OF THE AMAZON.COM PLATFORM

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ABSTRACT

Nowadays, many e-commerce stores ask their consumers to share their opinions about the products they have purchased, and give them the opportunity to submit their reviews along with a specific polarity rating. As a result, thousands of reviews are generated daily, which makes difficult for an individual to decide whether or not to buy a particular product. However the importance of the reviews has given rise to spam, which includes false opinions about a product. In addition, in some cases, there is a mismatch between the review and the rating. To address the above problems, this paper proposes a model-based collaborative filtering, which utilizes sentiment analysis, using VADER, and the detection of duplicate or near-duplicate reviews on a set of Amazon.com platform's product reviews. Then, the accuracy of the predicted ratings of the proposed model is evaluated against the accuracy of a "simple" model-based collaborative filtering. The results demonstrate that the proposed model is superior to the "simple" approach because it's most accurate based on MAE and RMSE and improves the trustworthiness of recommendations.

Keywords

Recommender system, sentiment analysis, review spam, collaborative filtering

THE TRANSITION OF THE GREEK ENERGY SYSTEM TO SUSTAINABILITY

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ABSTRACT

The electricity generation system is globally focused on becoming more environmentally friendly. To follow this global trend, Greece has to make its own policy to make its system more sustainable. The main goal of this project is to present today's electricity market and make an estimation about the effects on employment for 2050, based on the Green New Deal and Greece's National Plan for Energy and Environment. The model, that is built to predict the evolution of employment and carbon emissions, is made using the iThink software and is based on a System Dynamics methodology. This estimation is based on three scenarios, which are referring to the evolution of installed capacity and electricity generation per source and the CO2 emissions that are coming from them. The results are presented on diagrams and figures in order to compare the differences between each scenario more easily and export data about employment's evolution and the carbon footprint of the new energy system. To make this estimation, parameters that will affect the way that employment works, such as the automation of the production, are assumed to be negligible.

Keywords

Electricity, Renewable resources, Lignite, Employment, CO2 emissions, Energy system

MIXED-INTEGER LINEAR PROGRAMMING MODEL FOR PIPING PRODUCTION PROGRAMMING

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ABSTRACT

The scope of the present thesis is the presentation of the general term of Mathematical Programming along with its sections and the creation of a mathematical model based on real data provided by a company which located in industrial area of Patras. Subject thesis provide the opportunity to reader to understand the necessity of Mathematical Programming in industries which have as a target the optimization of production operation or the reduction of final products' prizes. As a result, we have achieved a more efficient operation and at the same time the maximum profit for a company. Additionally, we present the tools that are available to create a function model of Mathematical Programming and its solution. Through the below thesis we will discover the large variety of industry sections which the Mathematical Programming could take place. Furthermore, we will quote examples on which the Mathematical Programming could give important solutions on problems which a company faces during operation and strategic planning. Especially we create a model of mixed integer linear programming which helps the subject company in the section of production programming and to be flexible in various sudden changes in the market. Through the abovementioned research, we can export important conclusions.

Keywords

Mathematical Programming, Linear Programming, Mixed Integer Linear Programming, Best solution, Operational research