**University of Patras**
**Department of**
**Mechanical Engineering and Aeronautics**

**Diploma Thesis**
**Academic Year**
**2022-2023**

**Patras, Greece**

# CONTENTS

# INTRODUCTION

The Diploma Thesis (DT) is an important component of a student's education. Its purpose is to give the student the opportunity to work in a scientific manner, utilizing both the general and specialized knowledge acquired during their studies in the Department of Mechanical Engineering and Aeronautical.
The aim of DT is to offer the student the chance to delve into a subject of particular interest to them, which will introduce them to the corresponding field of application and research, and may even serve as the first step towards a related professional and research career.
It carries thirty-six (36) ECTS credits and fifty-five (55) teaching units, and its successful completion, presentation, and grading are essential prerequisites for graduation. The thesis is registered in the ninth and tenth semesters of study, and its execution lasts at least two semesters.
The student, after consulting with a professor or an E.DI.P. (Special Laboratory Teaching Staff) member they wish to collaborate with, selects the thesis topic, and a three-member committee is appointed to oversee the work. The student then applies to the Department's Secretariat for the approval of the thesis supervisor, the topic, and the three-member committee by the Department Assembly. Upon approval by the Assembly, the student can begin their thesis work.
Regarding the content, the diploma thesis must include the following:

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

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

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

Thesis presentations are held three (3) times a year after the exam periods in June, September, and February, during scheduled open sessions of the Department, on dates and with a program determined by the respective directors. During the presentations, the results of the theses are displayed in A3-sized poster form.
The goal of this booklet is to showcase the results of the theses completed in the Department over recent years.
Below are the abstracts of each thesis.

# DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS (FEBRUARY 2023)

## *NUMERICAL SIMULATION OF BIRD STRIKE IN A ROTATING ENGINE COMPOSITE FAN BLADE*

**Student's Name**
Valais Ioannis
**Student Registration Number**
1059833
Email: up1059833@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059833&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

In the current days aeronautical engineers tend to replace the metals at the aircraft structure with lighter materials, in order to reduce the fuel usage during its lifetime. That is the reason why aircrafts are built from metals, due to their advanced mechanical properties, as well as from composite materials, the applications of which are increasing gradually throughout the years. Additionally, the bolt joints between the parts are being replaced at a certain level with adhesive joints, due to the infinitesimal contribution to the weight of the aircraft. Another concern of the aeronautical engineers is the bird strikes at multiple parts of the structure, and the simulation of the strikes for the optimization design of these parts. The problems referred above inspired this study in which a composite fan blade of a rotating aircraft engine is modeled with a leading edge made from steel and connected to the composite body with adhesive. At the same time a bird strike on the fan blade is simulated at the FEM package LS-Dyna by ANSYS. The simulations are parametrical based on the position of the bird along the blade (25%, 50% and 75% of the total blade length), on the bird kinetic energy before the crush (210J, 160J, 110J and 60J) and on the bird mass (3.6 kg, 1.8 kg and 0.9 kg), while a simulation with pure rotation was conducted for comparison purposes. The results of the position parameter simulation show a significant dependence of the adhesive and leading edge damage from the bird position, while the damage of the composite body is affected less than the other materials from the bird position.

Moreover, the damage of all of the materials does not seem to be affected by the kinetic energy of the bird right before the strike and the bird mass.

*Keywords*

Bird Impact, Rotor Fan Blade, Adhesive Joint, Finite Element Method, Composite Materials

# *INVESTIGATION OF CRACK STOPPING CONCEPTS IN DELAMINATED COMPOSITE PLATES AND SHELLS*

**Student's Name**
Valilis Stavros
**Student Registration Number**
1059783
Email: up1059783@ac.upatras.gr

**Supervisor:**
Labeas Georgios, Professor
**Contact Info**
Email: labeas@mech.upatras.gr
Tel.: (+30) 2610 969498

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059783&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The use of thermoplastic composites in aeronautical and aerospace structures has been increasing in recent years. However, the joining of thermoplastic materials is achieved by the use of mechanical fasteners or adhesives, which presents risks as catastrophic failure can occur due to disconnection of structural parts.

In this thesis, an emerging way of joining thermoplastic composites, welding, was presented and numerical simulation and modelling of delamination in welded joints under different types of loading was carried out. The simulation of the behavior of the conduction welded joints was based on the Cohesive Zone Model and numerical models were developed simulating fracture mechanics experiments on three types of specimens. The specimens developed using the Finite Element method were the Double Cantilever Beam specimen, the Cracked Lap Shear specimen, and the Single Lap Shear specimen. For the validation of the numerical models an experimental procedure was carried out to study the behavior of the conduction welded joints in Double Cantilever Beam specimens and End Notched Flexure specimens under pseudo-static and fatigue loads in mode-I and mode-II loading, and experimental results from the relevant literature were also used. At the end of this thesis, the results of the numerical models were compared with the experimental results.

From the results obtained, it can be concluded that ASTM D5528-13 and ASTM D7905 specifications can be used to characterize the fracture mechanics behavior of conduction welded joints. It also concluded that the developed model can be used to simulate delamination in welded joints with high accuracy and low computational cost. Finally, it is observed that the ANSYS APDL program cannot predict the abrupt propagation of delamination that occurred during the experiments, but the curve of the numerical results seems to follow the trend of the experimental results satisfactorily.

*Keywords*

Thermoplastic Composites, Fusion Bonding, Conduction Welding, Fracture Mechanics, Finite Elements, Cohesive Zone Model

# *DESIGN AND ANALYSIS OF A FOLDABLE ELECTRIC UAV*

**Student's Name**
Georgiadis Ioannis
**Student Registration Number**
1059820
Email: up1059820@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059820&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The scope of this thesis is the preliminary design and analysis of unmanned aerial vehicles (UAVs). In collaboration with my supervisor, a 3D CAD model of a folding- launched UAV was initially provided to analyze it with the commercial computational packages of ANSYS. Then there was a preliminary design of the internal structure of the wing (ribs, spars, stringers).

In the first phase of the paper some historical information about the usefulness of Unmanned Aerial Vehicles (UAVs) throughout history will be mentioned, such as when they were first used and what their evolution was. Then, after some theoretical information about the basic CFD and STRUCTURAL analyses will be mentioned, the way of creating such an analysis will be described.

In this thesis the main topics will be firstly a CFD analysis on the whole UAV model with main interest on Drag and Lift Forces respectively and in a second stage a One-Way FSI analysis. The One Way FSI will not include the whole UAV model, but only one wing on which a CDF and then a STRUCTURAL analysis will be performed in order to find its deformation and the stresses generated as it moves at a constant speed. At this point it should be noted that it was necessary to design the internal structure of the wing with composite materials, mentioned above, in order to examine the points of greatest risk to the structure.

*Keywords*

Design, CFD Analysis, Structural Analysis, Composite Material, Unmanned Aerial Vehicles

# *INVESTIGATION OF AFDS CONVERSION FOR RANGE EXTENSION*

**Student's Name**
Georgiou Evangelos
**Student Registration Number**
1056661
Email: up1056661@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1056661&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The AFDS equipment is weapon system most commonly used as a runway cratering bomb, with various bomblet configurations. It has many closely related platforms and is used by air forces all over the world.

This study's main focus is on extending the system's range. After we examined the currently used weapon systems, their propulsion units and their approach on getting to their target, we constructed accurate trajectory models with the main variables acting on a flying projectile to first map a gliders course and then investigate the effect to our range by introducing foldable wings, a propulsion system or both, while comparing and discussing our results.

Having extracted our necessary parameters, components and requirements for which flight range extension kit works best, we proceed to the optimisation and pre-design phase where we select our final design aspects and the required operating envelope for the new characteristics of our weapon system, with what would work best based on our application's fundamental purpose in mind.

Having all the necessary key parameters in hand, we conclude with the three dimensional design plans for our range extension kit of our AFDS.

*Keywords*

AFDS – RANGE EXTENSION – WINGS – PROPULSION – MODELS – DESIGN

# *NUMERICAL ANALYSIS AND OPTIMIZATION OF DISBOND ARREST FEATURES IN CO-CONSOLIDATED THERMOPLASTIC LAMINATES*

**Student's Name**
Gyftos Panagiotis
**Student Registration Number**
1062678
Email: up1062678@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1062678&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

During normal operation, structures rarely experience static loads. Structures spend the majority of their lifespan submitted to dynamic loads which lead to fatigue. According to ASTM "Fatigue is the progressive, localized, permanent structural change that occurs in materials, subjected to fluctuating stresses and strains that may result in cracks or fracture after a sufficient number of fluctuations". The structural change mentioned refers to microscopic cracks which gradually propagate and combine to form larger cracks that lead to fatal failure of the material. These cracks can develop even under loads lower than the yield stress of the material. In composite materials, these cracks usually appear in the bondline of co-consolidated or adhesively bonded materials or interlaminarly between adjacent plies. In order to improve the behavior of composite materials under such conditions and lengthen their joints' lifespan, a variety of Disbond Arrest Features (DAF) are employed in critical areas.

In the current diploma thesis, the optimization of the design of disbond arrest features of two adherends was investigated using finite element analysis. The adherends were made of TORAY Cetex TC1225 which is a thermoplastic material fabricated with PAEK resin reinforced with carbon fibers in pre-impregnated fabric form. The disbond arrest feature which was tested derived from the Refill Friction Stir Spot Welding (RFSSW) process. Firstly, a comparison of the RFSSW method and other commonly used joining methods such as the use of adhesives or bolts on SLS specimens was presented followed by an optimization of three parameters concerning the placement and size of the RFSSW. Crack initiation and propagation were simulated using the Cohesive Zone Model (CZM) method in numerical models for two different types of specimens. The first was End Notched Flexure (ENF) specimens and the second was Cracked Lap Shear (CLS) specimens, for which two different diameters of sleeves (6 mm and 9 mm), three different plunge depths (70%, 75% and 80% of

the co-consolidated plates' depth), as well as three distances from the beginning of the bonded area (10 mm, 20 mm and 30 mm) for the CLS specimens, were examined. From these analyses, Force-Displacement, Failed Surface Area–Displacement diagrams as well as shear stress and effective plastic deformation contour plots were exported.

It became apparent from the collected results that these features contributed to the eduction of the disbonding rate while increasing the static load-bearing capacity of the adherent system.

*Keywords*

Disbond Arrest Feature, Composite materials, Co-consolidationed joints, Finite element modeling, Cohesive zone model, Refill friction stir spot welding

# *EXPERIMENTAL DETERMINATION OF STRAIN ENERGY RELEASE RATE, COMPARISON WITH J-INTERNAL AND USE OF METHODS TO CALCULATE THE EFFECTIVE CRACK LENGTH*

**Student's Name**
Dimopoulos Georgios
**Student Registration Number**
1059798
Email: up1059798@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster**: https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059798&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this work, an investigation of the fracture behavior of two different adhesive joints is carried out using experiments to evaluate the interfacial delamination under Mode I loading. The two joints utilized are the dissimilar Titanium-CFRP joint, which consisted of a Titanium sheet bonded to a plate of multilayer CFRP material. This joint was reinforced on both sides with two Aluminum beams to increase the stiffness of the joint and prevent plastic deformation of the Titanium. The second joint is symmetrical and consists of two UD-CFRP plates which have been polymerized together with the adhesive film to create the final joint investigated. Static experiments were carried out to obtain results for the fracture resistance of the joints. By calibrating the compliance-crack length curve from the experiments and through analytical equations from literature, various equivalent crack lengths were calculated. The advantages of deriving equivalent crack length are significant as many times visual observation of the crack during propagation is difficult or even impossible. Such cases are the experiments with Mode II loading, where the two bonded sublaminates do not open and the existence of a secondary crack in the specimen where it is not easy to separate the primary and secondary crack, as is the case in the TiCoAJo. The last advantage of the equivalent crack length is that any existence of plastic deformation "in front" of the apparent crackcan be accounted for the calculations. Finally, subject of the thesis is also the comparison of the Strain Energy Release Rate (SERR) obtained from the equivalent crack lengths with the J-Integral calculated through video recording of the experiments.

*Keywords*

Fracture Mechanics, Composite Materials, Effective Crack Length, SERR, J-Integral

# *DEVELOPMENT OF GREEN COMPOSITES WITH FLAX FIBERS AND STUDY OF THEIR FRACTURE BEHAVIOR*

**Student's Name**
Kanellopoulos Ioannis
**Student Registration Number**
1054469
Email: up1054469@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054469&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Nowadays the humanity faces a big challenge for its prosperity and continuous development. This challenge is about the protection of the environment and the right utilization of the materials by minimizing the consumption of energy. Thus, the idea of twisting to more environmentally friendly materials constitutes a necessary step for the protection of the resources of the planet and saving big amounts of energy.

In this thesis, extensive research has been made for the use of flax fibers in composite materials, while it is investigated the interesting scientific topic of biobased resins (resins with a content from renewable sources). The aim of this thesis is to compare materials reinforced with UD flax fibers by alternating the matrix. For this reason, two different types of epoxy resins have been used. Specifically, it has been used a biobased epoxy (GreenPoxy 56) and a conventional epoxy (L-epoxy).

For the comparison of the materials, fracture experiments have been carried out (Mode I,II), while ILSS experiments were also done for further quality inspection. The composite materials were manufactured with the hand lay-up technique, while they were cured at the autoclave according to the cycle of polymerization which gave the manufacturers.

Moreover, in order to enhance the properties of the material, it was used a thermal treatment of the flax fibers. This thermal treatment subjected the flax fibers at high temperatures of 220$^{o}$C for 2h in an inert atmosphere. For the study of the quality of the materials, ILSS experiments were carried out.

After conducting the interlaminar fracture Mode I experiments, it was concluded that the material with the biobased epoxy showed an overall better performance compared to the conventional epoxy (greater GIc by 47%). Concerning the interlaminar fracture Mode II experiments, again the material with the biobased epoxy revealed better performance greater GIIc by 44%).

Lastly, concerning the ILSS experiments, it was shown that the specimens with the biobased epoxy had better interlaminar shear strength compared to the respective with the conventional epoxy (greater by 15% for the composites reinforced with untreated flax fibers and 65% for the composites with the thermal treated flax fibers). Also, the specimens which had thermal treated flax fibers, showed reduced ILSS values compared to the specimens with untreated fibers (fall of 8% for the category of the bioepoxy resin and 55% for the category of conventional epoxy). This fact is attributed possibly to the degradation of the fiber-matrix interface with the apply of the thermal treatment of the fibers.

*Keywords*

Interlaminar fracture toughness, Natural fibers, Flax fibers, Biobased resins, Epoxy resin

# *IMPROVEMENT OF THERMO-ELECTRIC BEHAVIOR OF FIBROUS COMPOSITES BY USING GRAPHENE-BASED NANOSPECIES*

**Student's Name**
Kourmpelis Georgios
**Student Registration Number**
1054543
Email: up1054543@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054543&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

From the middle of the 20th century onwards, a revolution took place in the field of materials, as the first composite materials started developing and gradually the started replacing the traditional materials in high-level applications, as they were no longer sufficient to cover the needs of the modern applications. Now, at the beginning of the 21st century a new need came up, a need for materials not only with better properties but also with the ability to perform multiple functions. In this context, an attempt is being made to develop advanced materials introducing nanoparticles in the composites. The present work is part of this effort, studying the effect of the introduction of graphite nanoparticles on the thermoelectric properties of fibrous composite materials. In the first stages of the work, the composite materials, their properties, and characteristics were studied. Subsequently, more emphasis is placed on graphene and the nanoparticles that are produced from it. Graphene is a very good case of material with great prospects and as the literature search results show, the scientific community has realized it and is intensifying efforts for its development and use in composite materials. This study moved in this direction. Graphene and its nanoparticles were studied After that a small number of samples were prepared to take some measurements. The materials used, were a resin-hardener system, carbon fibers, GNPs and MWCNTs. The mixing of the materials was done by manual stirring firstly and then with the Three Roll Mill. Silicone molds were used, and two types of samples were prepared. The first one consisted of resin and hardener (Neat) only and the second one consisted of resin-hardener and the nanoparticles (Doped), which were polymerized in an autoclave oven. The samples were used to study the electrical and thermal properties of the doped polymers. An increase in electrical conductivity by 10 orders of magnitude was observed, while the increase in thermal conductivity reached 100%. On the next stage films with small thickness were produced using the new doped polymer material in order to observe the properties and the behavior of the material in this form. The electrothermal film gave a surface

temperature of up to 50°C at room temperature, and 35°C at freezer temperature (<-15°C) within five minutes of being activated by supplying voltage of 30V. On the final stage hybrid nanoparticles were incorporated in a multi-layer laminate and then its electrical and thermal properties were measured and compared with the properties of a non-doped laminate. The introduction of GNPs and MWCNTs increased the electrical and thermal properties of the laminate, as the electrical conductivity registered a rise of 130% and the thermal conductivity of 33%.

*Keyword*

Composite Materials, Graphene, Nanoparticles, Electrical Conductivity, Thermal Conductivity

# *DESIGN, ANALYSIS AND EVALUATION OF COMPOSITE SUSPENSION ARMS FOR COMPETITION AUTOMOTIVE APPLICATION*

**Student's Name**
Kostas Theofanis
**Student Registration Number**
1031544
Email: up1031544@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1031544&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The scope of this thesis is the utilization of classical mechanics and statics, mechanics of composites and strength of materials and also essential design axioms to conceptualize, iterate, verify and then materialize a complete double wishbone independent suspension system, appropriate for an automotive application and more specifically, motorsports.

Firstly, an appropriate physical layout will be chosen, one that complies with the physical constraints imposed from the rest of the vehicle that adheres to the desired spatial planning and one that also utilizes in the best of the possible ways enough adjustability, low weight, low center of weight, suspension articulation, steering articulation and more design targets.

Also, the pure kinematics design parameters will be discussed and why these are to be desired, meaning how the characteristics of the tire can be translated through the suspension system so the contact patch can be maximized through the whole suspension articulation, so the grip and ultimately the vehicles performance can be maximized.

Then, maximum load case scenarios will be established, by appropriate estimation of mechanical and aerodynamic loads acting on the center of the weight and center of aerodynamics of the vehicle , reacted through the tire contact patch and ultimately , through the suspension. For this, a code implemented analytical tool will be written in Matlab so the loads can be distributed appropriately in the four corners of the vehicle and each individual worse load case scenario can be accessed. For the establishment of each suspension arm individual load a statics problem will need to be solved for each load case scenario and also through suspension articulation, so it is also crucial to utilize a Matlab code implemented tool for solving the resultant spatial static equations effortlessly.

After the estimated loads are defined, each individual suspension arm design will be refined and iterated by the use of CAD, appropriate material and construction method will be chosen and it will be subjected to stress and fatigue finite element analysis. At this point appropriate load bearing hardware will be dimensioned, like bolts, nuts, bearings, tie rods, and the design process thought and considerations will be discussed.

Next, the benefits of composite materials in this application will be investigated, by appropriately designing the material and the geometry of alternative, carbon fiber composite suspension arms, in an effort to maximize performance by reducing the weight even further through application of Composite mechanics.

The complexity and drawbacks of each consideration will be discussed and also the assumptions, design limitations and the benefits of each system will be explained.

In summary, this thesis aspires to cover the majority of design considerations and desired attributes a competition automotive suspension system must adhere to, structurally wise and to give insight to what a final implementation both of commonplace materials and cutting edge solutions, like carbon fiber reinforced polymers, can be.

*Keyword*

Suspension Design, Composite Materials, Automotive, Suspension Arms, Competition

# *DESIGN AND ANALYSIS OF A DEPLOYABGLE ANTENNA FOR NANOSATELLITES*

**Student's Name**
Bekas Ioannis-Theodoros
**Student Registration Number**
1059764
Email: up1059764@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059764&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

One of the leading trends of the past decades regarding satellites has been the ever more reduction in their size, leading to the creation of a class characterized by their small dimensions and light weight, nanosatellites. These have found use cases in a plethora of applications, many of which require high gain telecommunication antennas. The present diploma thesis aims to design and analyze such an antenna suited for use in nanosatellites. At first, a literature overview is conducted, in which deployable antenna concepts designed for satellites and their applicability for nanosatellites are presented. Moving forward, an antenna model is designed in Catia nvironment and kinematically analyzed in MSC Adams environment. With the results and knowledge gained from this model and with the target of greater reduction in stowed volume a second antenna model is created. After its design, kinematic and structural (modal and quasi-static) analyses are performed, with the structural analysis being performed in FEA software. Concluding, the two models are compared and the effect of the design choices on the results of their analyses are outlined. Summarizing, based on the conclusions drawn from the models, changes and optimizations to the design of the antenna as well as the parametrization and execution of the analyses are proposed. Thus, the next steps for the continuation of this work are put forward.

*Keywords*

Nanosatellites, Computer Aided Design (CAD), Kinematic Analysis, Finite Element Analysis (FEA), Aerospace Engineering

# *FATIQUE LIFE PREDICTION OF A COBALT-CHROMIUM STENT PLACED INTO AN ARTERY WITH ATHEROSCLEROTIC PLAQUE*

**Student's Name**
Paraskeva Christina-Lydia
**Student Registration Number**
1054521
Email: up1054521@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054521&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Intravascular stents are medical implants expanded into stenotic arteries to restore blood flow perfusion to the downstream tissues. The stent is placed to open the site of blockage with the dilation of a balloon. The biomedical-industry for stents has been advanced rapidly and nowadays there are different types of stents, such as bare-metal stent, drug eluting stent, bio-absorbable stent, and a dual therapy stent (combination of both drug and bioengineered stent) [18] and with various characteristics. This advancement was facilitated by the simulation through Finite Element Modeling (FEM) in a computer-simulated virtual environment that allowed the exploration of various stent designs and their failure modes in a very cost-effective and timely manner and has thus become an integral part in the design cycle of stents, helping the bio-medical industry to attain quicker turn-around times and a faster time to market [15]. Even though stents are a good alternative to treat narrowed or blocked vessels, stent fracture (SF) has attracted increasing attention and is identified as one cause for stent failures, because the fracture metal/polymer struts protruding into the lumen or arterial wall could trigger acute stent thrombosis or lead to late in-stent restenosis [20, 63]. Repetitive mechanical forces within the artery may result in stent fracture after stent implantation.

This diploma thesis aims to design a type of stent and investigate the behavior-fatigue of a balloon expandable (BE) Cobalt-Chromium stent inside an idealized artery with atheromatic plaque under diastolic-systolic cyclic loading, employing Finite Element Method (FEM). The stent expansion and partial recoil under balloon inflation and deflation were simulated, as well as the simulation of the blood pressure cyclic loading. The methodology followed is based on a global computational approach composed of a mechanical finite element analysis and then followed by a fatigue

analysis.
There are many factors that affect the fatigue life of stents such as material properties, design, manufacturing, specificities of patient and loading conditions. In particular, its FLP is influenced by static loading during deployment or cyclic loading caused by pulsatile blood pressure, bending, torsion, tension, and compression [36, 39]. In general, a stent is designed with approximately a 10-years in-vivo life to be considered safe, as proposed by the FDA. In this study, Goodman method (under three different approaches) was used for the fatigue life prediction of the stent. The Goodman methos gives a global prediction of the fatigue life. Specifically, the results of the two goodman approaches showed that the stent was safe under fatigue loading conditions, whereas the use of the fe-safe software showed smaller cycles until failure.

*Keywords*

Balloon Expandable Stent, Fatigue, Goodman Diagram, Atheromatic Plaque, Finite Element Method.

# *WING DESIGN CASE STUDY FOR A MALE (MEDIUM ALTITUDE LOND ENDURANCE) UAV*

**Student's Name**
Pitsis Antonios
**Student Registration Number**
1059785
Email: up1059785@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059785&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The purpose of this thesis is the design of the wing of a MALE class (Medium Al- titude Long Endurance) unmanned aircraft vehicle. Initially, a survey is conducted with the aim of collecting and comparing the performance of some unmanned aerial vehicles which can also be characterized as "State of the art" in the field of UAVs. Parameters such as flight speed, range, and payload are thus selected for the UAV under design to be competitive. Afterwards in the conceptual design phase, the calculations of the weights through an iterative process are conducted. Then thewing load and the required thrust are selected through a graphical method based on the FAR-23 airworthiness regulations. In the next phase, the design focuses on the geometry of the wing, where basic design parameters will be selected for thetop view of the wing and airfoil. Additionally, through a methodology, based onFAR-23 regulations, the maximum load factor is calculated. After the conceptual design is complete, the wing is designed in CAD software. Then, proceeding to the structural design of the wing, three different candidate structures will be examined and compared with each other in terms of not only weight and stiffness, but also issues related to manufacturing and assembly. The next phase of the study is the aerodynamic analysis of the wing through FLUENT software and the finite element method. The purpose of the aerodynamic analysis is to verify the aerodynamic behaviour but also to calculate the flight loads developed on the wing surfaces for their use in structural analysis. The aerodynamic loads are transferred and applied to the wing surfaces in the structural analysis phase through the FSI (Fluid Structure Inter- action) method. Initially, it is chosen for each of the three structural analyzes to as- sign composite materials. After the forces are transferred and the structural analysis of each scenario is done, the models in which the structures are exclusively designed from composite materials are compared with the corresponding ones designed from aluminium alloy, so that conclusions can be drawn about the effectiveness in re- ducing the weight and the very good mechanical behaviour of composite materials. Finally, a study related to the

manufacturing and assembly of each structure so that useful conclusions can be drawn about which of the three structures is feasible and achievable in terms of construction.

*Keywords*

Preliminary design, Conceptual design, Structural design, CFD analysis, MALE UAV, FSI methods, Structural analysis, Composites materials

# *DEVELOPMENT, STRUCTRURAL ANALYSIS AND NUMERICAL SIMULATION OF STIFFENED PANELS TESTING CONCEPTS UNDER MULTI-AXIAL LOADING*

**Student's Name**
Polyzoidis Sraimper Jason
**Student Registration Number**
1064358
Email: up1064358@ac.upatras.gr

**Supervisor:**
Labeas Georgios, Professor
**Contact Info**
Email: labeas@mech.upatras.gr
Tel.: (+30) 2610 969498

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064358&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The main objective of the current thesis is the establishment of the most ideal and cost-efficient testing rig configuration for the experimental investigation of the curved stiffened panel behaviour. The investigated panels should be capable to carry static loads, which are calculated from real flight conditions. A stiffened curved panel is constructed in the FE codes of ANSYS APDL and LS DYNA to enable comparisons between the numerical results of the full fuselage model and the stiffened panel model. The geometrical dimension and material properties of the Finite Element model (F.E.) are obtained by a typical passenger jet airplane.

Aircraft fuselage structures consists of complex structures with components geometries which depend on numerous factors, such as aircraft size, mass, position of the component in the aircraft, flight conditions, etc. The complex fuselage section is simplified to a curved stiffened panel aiming to simulate its behavior with that of the fuselage. An extensive literature research will be carried out with the aim of reporting the experimental arrangements for stiffened panels and the advantages of the arrangement chosen.

Initially, a full barrel fuselage section will be modeled to find the desired stress and radial displacement response to achieve at the panel level. From previous studies, three main testing rig models were considered most efficient and accurate, which carried internal pressure, tension and bending stresses. In the current thesis, emphasis will be placed on the simulation of internal pressure. For each one, the panel was modelled in F.E. format with the respected boundary and loading conditions. This step is essential for having realistic and representative full-scale fuselage simulations. The post processing data where then compared to the theoretical full barrel section model (fuselage response) and the data of each test-rig version will be collected, with the aim of choosing the best layout.

The last part of this work is the introduction of an airbag in the experimental set-up to simulate the internal pressure of the cabin more realistically in normal flight conditions. Polyurethane foam pieces will be inserted between the panel stiffeners so that the loads are transferred evenly to the panel and the airbag is protected by them. At this point, the model will be optimized by changing the geometrical characteristics of the airbag, the rigid body and the foam components, aiming at the best possible distribution of pressure on the stiffened panel.

Finally, a more detailed optimization will be made for the Rod arrangement and its geometrical characteristics in such way that the deviation of Radial Displacements and Stresses between panel and full barrel section level were minimized.

*Keywords*

Stiffened Panel, Testing Rig, full-scale fuselage simulations

# *DESIGN, ANALYSIS AND CONSTRUCTION OF AN EXPERIMENTAL DEVICE FOR STIFFENED AIRCRAFT STRUCTURAL PANELS*

**Student's Name**
Rigkos Panagiotis
**Student Registration Number**
1059720
Email: up1059720@ac.upatras.gr

**Supervisor:**
Labeas Georgios, Professor
**Contact Info**
Email: labeas@mech.upatras.gr
Tel.: (+30) 2610 969498

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059720&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The purpose of the present diploma thesis is the design of an experimental layout, in which experiments will be conducted on stiffened panels of an airplane fuselage, which will be submitted to specific loads in order to study their behavior while under these loads. As a panel we identify a section of an airplane fuselage, which in the following experiments is stiffened using re-enforcing elements in the axial and transversal directions, stringers and frames respectively, in order for its elastic properties and strengths to be enhanced. The loadings that this panel will be submitted to, are compressive, internal pressure loads as well as a combination of these two. These types of loads will be applied through a compression machine (hydraulic press) and an airbag. After the designing of this experimental test-rig there will be an analysis so that the dimensions of the parts, of which it is consisted, are calculated with precision (optimization procedure). The dimensioning will be based on the stress and displacement diagrams. The designing as well as the analysis will be conducted on the computer environment known as Solidworks. Finally, comes the construction of this experimental arrangement in the area of the laboratory facility.

*Keywords*

stiffened panels, experimental test-rig, designing, analysis

# *AEROELASTIC AND STRUCTURAL SIMILARITY OPTIMIZATION OF SCALED WING MODELS*

**Student's Name**
Filippou Evangelos
**Student Registration Number**
1059758
Email: up1059758@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059758&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The ongoing pursuit for more efficient transportation has led engineers to design lighter and blended wings in order to reduce fuel consumption and emissions. However, these designs introduce strong aeroelastic couplings that can result in failure. As a result, aeroelastic analysis and optimization have become crucial aspects of aircraft design in modern times. Additionally, aeroelastic testing of scaled models is another key phase in the development of aircrafts. The accurate prediction of aeroelastic response through the construction of models is vital for cost reduction and avoiding risky flight testing. This is achieved by maximizing the similarity of stiffness and mass distribution along with the flow field similarity during the creation of the scaled model. However, in today's lightweight aircrafts, the exact same geometry cannot be scaled down, requiring the use of a different configuration. This variation in configuration affects the aeroelastic response, making the use of computational aeroelasticity tools and optimization algorithms necessary. This computational technique constitutes a modern approach to aeroelastic scaling.

This thesis focuses on developing an aeroelastic scaling framework using multidisciplinary optimization. Specifically, a parametric wing finite element model (FEM) is created that incorporates both thickness and geometry parameterization, primarily using shell elements. The aerodynamic loads are calculated using the DLM method along with twist and camber correction factors, and the coupling is established through the use of infinite plate splines. The aeroelastic model is then integrated with an Ant Colony Optimization (ACO) algorithm to achieve static and dynamic similarity between the scaled model and the reference wing. The key contribution of this thesis is the inclusion of internal geometry parameterization within the framework.

The results of the implementation of a two-step optimization technique indicated high similarity in both the static aeroelastic and modal response of the two wings. The root mean

square error (RMSE) of the in-flight shapes converged to 0.055m in the full scale and the mean MAC value of the first 5 modes was 0.934.

*Keywords*

Aeroelasticity, NASA Common Research Model, Scaling, Fluid-Structure Interaction, Design Optimization

# *REMAINING USEFUL LIFE PREDICTION OF COMPOSITE PANELS UTILIZING ADVANCED HEALTH INDICATORS*

**Student's Name**
Fytsilis Efthymios
**Student Registration Number**
1059776
Email: up1059776@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059776&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the context of a rapidly changing and fiercely competitive global economy, aeronautical engineering endeavors towards enhancing aircraft safety, reliability and extending its operational lifetime have become of vital importance. To this end, Prognostics and health management (PHM) is deemed as key to revolutionize the maintenance paradigm in this sector. The most critical step in PHM is the remaining useful life (RUL) prognosis; a challenging task that demands special attention. In this work, a novel two-stage data-driven framework for direct RUL prediction of complex aeronautical elements is proposed, combining advanced health indicators and ensemble learning (EL). Multi-stiffener composite panels (MSPs), subjected to variable amplitude compression-compression fatigue, provide the necessary condition monitoring data, in the form of strain measurements. The latter are utilized to construct several damage sensitive features, i.e., health indicators (HIs) that properly capture the degradation process of the MSPs. A feature-level fusion of the aforementioned HIs is performed, utilizing Genetic Algorithms to create an enhanced HI, in terms of monotonicity and prognosability attributes. An upscaling methodology is attempted, by exploiting data from single-stiffener panel (SSP) histories, in order to estimate the advanced HI and eventually the RUL of the MSPs. The proposed framework involves the formulation of an ensemble approach capable of aggregating the RUL predictions in an adaptive way. The latter is obtained by training diverse sub-models built upon each SSP, and then combining the RUL predictions with a dynamic weighting strategy, based on Fuzzy Similarity Analysis (FSA). Two data-driven models, namely Support Vector Regression (SVR) and Long Short-Term Memory Network (LSTMN) are considered as the regression technique to map the input data to its corresponding RUL output. A comparison between the aforementioned machine learning (ML) and deep learning (DL) ensembles demonstrates the capabilities of the proposed framework. Ultimately, prognosis depends heavily on the HI behavior and trend, while confidence intervals get narrower as more condition monitoring data is incorporated, an essential trait of a robust prognostic algorithm. However, it is

observed that no regression model significantly outperforms the other, since both SVR and LSTMN achieved better performance for different MSPs.

*Keywords*

Composite Structures, Remaining Useful Life estimation, Health Indicators, Ensemble Learning, Uncertainty Quantification

# *LIFE CYCLE ASSESMENT (LCA) STUDY OF COMPOSITE MATERIALS REINFORCED WITH NATURAL FIBERS*

**Student's Name**
Christoforatos Gerasimos
**Student Registration Number**
1047307
Email: up1047307@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047307&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The last decades have led to a remarkable growth in the level of awareness considering the environment and its valuable resources. The preservation of its integrity and subsequently of the humanity living within it, is arguably a main concern in the scientific world. This awareness is necessary, considering the rate at which humanity is increasing the energy demands in order to continue existing with the comforts that have been introduced into our lives. A rapidly developing technological field is that of composite materials. Composite materials have been used for decades in various applications and due to their excellent performance, they have been successfully introduced into most construction fields. These are materials designed by man, and that makes them excellent construction options, as they can be produced according to the needs of each construction. In recent years, green composites materials have been making their appearance dynamically, providing good mechanical properties as well as a very low environmental footprint. Both natural fibers, deriving from a variety of plants, as well as biodegradable matrices, have replaced conventional composite materials. Green composites provide engineers with remarkable mechanical properties that can fit into most construction fields, while also having a much smaller environmental footprint than conventional ones. The production process of a product is directly related to its overall environmental footprint. The various technologies that have been developed to produce components from composite materials can have different burdens and in different impact categories. In this study we characterized the mechanical properties of composite materials, reinforced with flax fibers and we compared three production scenarios. These three different methods of production were observed with the Life Cycle Assessment (LCA) method and the results were evaluated in various impact categories.

*Keywords*

Natural Fibers, Life Cycle Assessment, Sustainability, Production of Composite Materials, Composite Materials

# *DEVELOPMENT OF LIGHT WEIGHT HARD ARMOR PANELS FOR ANTIBALLISTIC PROTECTION*

**Student's Name**
Psathas Alexandros-Anastasios
**Student Registration Number**
1059849
Email: up1059849@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059849&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The purpose of this work is to develop lightweight hard anti-ballistic shielding vest panels using nanotechnology. It is important that anti-ballistic vests are not heavy in order not to burden the person wearing them and offer flexibility of movement during use. The use of nanotechnology has been shown in the past to have a beneficial effect on the anti-ballistic properties of materials by improving their performance. The hard panels used in these applications are multilayer structures of high molecular weight polyethylene (UHMWPE) with the trade name TENSYLON. In order to achieve panel reinforcement, TENSYLON sheets were surface modified using nano-modified and non-pellet polyamide particles (GRILTEX 1330 A). Four different types of specimens were prepared which are SKIN_5L, GRILTEX DOPED_5L, GRILTEX NEAT_3L and GRILTEX DOPED_3L. SKIN_5L is defined as the specimen made from 5 layers of the TENSYLON base material without the addition of GRILTEX. This material is the reference material and the basis for comparison with the others. For GRILTEX DOPED_5L and GRILTEX DOPED_3L five and three layers of TENSYLON were used respectively. Between each layer, particles produced from the nano-modified pellets were deposited by the dry deposition method. The nano-modified pellets contain multiwalled carbon nanotubes (MWCNTs) in an amount of 10%wt. GRILTEX NEAT_3L material was prepared from three layers of TENSYLON and non-nanotropic GRILTEX 1330 powder. This was followed by the evaluation of the developed materials by high velocity impact tests. By conducting the experiments, the values of the bullet velocity before and after the impact were recorded. The velocity data were used to calculate the energy absorbed by the test specimen during impact and the percentage of energy absorbed to the initial energy of the sphere. According to the results, the following conclusions are drawn. The addition of the nano-modified particles to high molecular weight polyethylene wafers has a positive effect on energy absorption during high-speed impact and consequently an improvement in its anti-ballistic properties. This is probably because the nanoparticles entering the polyethylene introduce additional absorption mechanisms into the material.

The fact that the lighter weight reinforced plates could perform better than the original material in the impact tests led to another valuable conclusion. Along with the increase in impact resistance, it was further observed that it is possible to reduce the weight of the material without compromising its anti-ballistic properties. The result of the research was the development of a lighter anti-ballistic material with improved properties, confirming that the contribution of nanotechnology to anti-ballistic protection applications is particularly important.

*Keywords*

Anti-ballistic vests, TENSYLON, UHMWPE, MWCNTs, high-velocity ballistic impact test

# DIVISION OF DESIGN AND MANUFACTURING (FEBRUARY 2023)

## *DAMAGE DIAGNOSIS IN THE SEMI-SUBMERSIBLE WIND TURBINE DTU 10 MW OO-STAR WIND FLOATER UNDER VARYING ENVIRONMENTAL CONDITIONS VIA MACHINE LEARNING TYPE METHODS*

**Student's Name**
Anastasiadis Nikolas
**Student Registration Number**
1047349
Email: up1047349@ac.upatras.gr

**Supervisor:**
Sakellariou Ioannis, Assistant Professor
**Contact Info**
Email: sakj@upatras.gr
Tel.: (+30) 2610 969494

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047349&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

The present study focuses on the problem of damage detection in the floating wind turbine DTU 10 MW OO-Star Wind Floater under varying environmental conditions. The examined methods are based on a machine learning framework using acceleration time series. The greatest challenge that must be addressed is the uncertainties introduced into the system due to changing environmental conditions, which can either conceal the influence of incipient damages on the measured dynamics or lead to a high rate of false alarms. To address the above problem, various methods which are based on Vector Autoregressive Multiple Models (MM-VAR) and Functionally Pooled (FP) models of scalar and vector operating parameters (FP-VAR, Vector FP-VAR) are utilized. The assessment of the methods is performed using Monte Carlo simulations including 1041 scenarios of (unknown) healthy and damaged states under various environmental conditions. The data used for the evaluation are generated from the simulation of the wind turbine DTU 10 MW equipped with the semi-submersible substructure OO-Star Wind Floater using the Fatigue Aerodynamics Structure and Turbulence model (FAST) and are acceleration time series measured at the floater substructure, at the tower top and at a selected position on it. The examined damages correspond to the stiffness reduction at the tower base, damping and stiffness reduction at the drivetrain and error in the yaw control system which may be due to

various damages in its components (e.g., gears, axles, measuring instruments, etc.). The considered varying environmental conditions include the mean wind speed and direction, the significant height, peak period, and direction of waves, as well as the orientation and speed of surface currents. From these, the mean wind speed and direction are considered independent, while the rest are considered as functions of them. The results indicate that the methods achieve adequate detection performance for stiffness reduction at the tower base for over 20%, over 10% for the drivetrain and over 8 degrees for yaw error, while no method detects the reduction of damping in the drivetrain.

*Keywords*

Structural health monitoring, floating wind turbine, varying environmental conditions, simulation, parametric stochastic modeling, Monte Carlo Simulations.

# *DIGITAL TWINS FOR FATIGUE ANALYSIS OF METALLIC PARTS BASED ON STRESS-DEFORMATION MODELS*

**Student's Name**
Damianopoulos Christoforos
**Student Registration Number**
1026845
Email: mead6932@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026845&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The purpose of this thesis is the complete modeling and study of a type 8.8 screw of dimensions M8*150 made of carbon steel of known specifications with a 2mm deep U-type notch for greater stress concentration and therefore faster failure, both in static and dynamic uniaxial and biaxial loading using stress and strain models. This is achieved by using the Ansys simulation program to model the screw arrangement and derive the required results and then calculate the corresponding theoretical results as derived from stress, strain and fatigue theory. The results we are interested in are initially, the static analysis of the screw when a constant force is applied to it in the y-axis at a specific point by calculating the von Mises equivalent stress and strain. This is followed by the dynamic analysis of the bolt which studies the behavior of the specimen initially under purely alternating stress under which the bolt is under the same force as the one used in the static analysis and then under a repeated random loading history containing loads smaller or equal to the one used in purely alternating loading and modeled using the Rainflow counting method to extract full loading cycles from the random history for the purpose of comparing behavior of the specimen under these 2 different loadings. The calculation of damage accumulation is done with Miner's linear cumulative rule, but also with a non-linear damage accumulation model in order to compare them. This analysis is done with 2 different models, first stress models and then strain models. After dynamic analysis, a comparison of results is made between the methods used in static analysis as well, but also an additional comparison of the results of these 2 methods with each other. Once the uniaxial analysis is complete, we can proceed to the analysis for biaxial stress where we add a torsional moment at the same point where the force is applied in order to develop shear stresses. The analyzes performed for the biaxial loading are exactly the same as those mentioned in uniaxial loading. A very important part of this thesis is the effect of the notch on the behavior of the specimen in both static and dynamic analysis as it is responsible for the phenomenon of stress concentration as well as the degradation of the fatigue strength of the bolt. After the results have been extracted both from the model and from the theoretical calculations, the thesis can proceed to the

final stage which is the comparison of the results of each method and the drawing of conclusions about the accuracy of these methods, the quality of the model as well as the proposal ideas for improving the fatigue behavior of the screw.

*Keywords*

Rainflow counting method, stress concentration, damage accumulation, von-Mises equivalent stress, stress and strain models

# *DESIGN AND SIMULATION OF HYBRID PRODUCTION SYSTEMS EMPLOYING HUMAN ROBOT COLLABORATION - APPLICATION IN THE BUS ASSEMBLY SECTOR*

**Student's Name**
Karpanos Antonios
**Student Registration Number**
1025935
Email: mead5976@ac.upatras.gr

**Supervisor:**
Stavropoulos Panagiotis, Associate Professor
**Contact Info**
Email: pstavr@lms.mech.upatras.gr
Tel.: (+30) 2610 910160

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1025935&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This Thesis aims to investigate the implementation of a large parts manipulation robot, cutting-edge technology robots and human-robot collaboration schemes combined all together and applied in a theoretical case study. The case study regards a production line of modular roof modules of busses and aims to increase the shop floor flexibility in the stages of preassembly and assembly of large panels.

At first, this Thesis presents the requirements for assembling large scale parts and explore current industry practices.

Applied to the theoretical case study of a bus roof modules production line and assembly, this Thesis then investigates the available technologies, including innovative robots, and explores the possibility of their implementation to the production line and compare them to the existing production methods. At first, an analysis of the current production line is made. The current production line is categorized in several stages and each stage is analyzed and assessed based on several different factors. A new production line layout is then proposed, using new technologies.

Based on the proposed layout and the needs of the proposed automation to be implemented in the production line, a State-of-the-Art study is conducted. This includes both State of Market research of the technologies proposed and a Research Paper Study that will draw information and available resources to be used in the layout proposed.

A simulation of the proposed layout is then presented, using Delmia. Taking information out of this program, as well as out of bibliography, an evaluation method with both quantitative and qualitive criteria is used to assess the performance of the suggested production system.

*Keywords*

Automation, cable / cooperative robots, large parts

# *TRIBOLOGICAL ANALYSIS OF HYDROGEN INTERNAL COMBUSTION ENGINES VEHICLES (HICEV) COMPRESSION RING*

**Student's Name**
Nikolopoulou Vasiliki-Ioanna
**Student Registration Number**
1054527
Email: up1054527@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054527&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Hydrogen's combustion properties made it as a green fuel, which use in ICE can contribute to the reduction of net greenhouse gas emissions by at least 55%. Furthermore, due to the current geopolitical developments, hydrogen as fuel can lead to independence from natural gas and generally from conventional fossil fuels and electrical energy. Therefore, the research objects of this diploma thesis are developed around fuels: hydrogen gas/$H_2$ and compressed natural gas/CNG.

In particular, the Blow-by phenomenon, where mass of combustion gases flow from the combustion chamber past the ring pack to the crankcase, is modeled in relation to the first compression ring of a four-stroke, reciprocating, piston-bearing engine. Blow-by has an important effect on engine performance, oil consumption/quality and exhaust emissions. The objective of this modeling, which is created in a numeric computing platform, is to calculate the gas pressure behind the first compression ring, as a function of the crank rotation angle. In fact, in order to obtain even more realistic results, a new, combined thermal model is proposed to find the dynamic viscosity of fuel-air mixture, which is based on the in-cylinder gas temperatures.

This back pressure is then used as an input value in a suitable CFD code, the implementation of which, through computational fluid dynamics analysis, results in calculation of the minimum film thickness and generated friction in the compression ring-liner conjunctional gap. In addition, the total friction generated in the conjunctional gap lead to power losses, thus increased fuel consumption in order to run the engine under any operating conditions.

In conclusion, as these losses, attributed to the piston compression ring conjunction with the cylinder, are estimated to be up to 5% of the total IC engine losses and that the 1/3 of consumed fuel is aimed to counterbalance the friction, it is crystal clear the importance of

this tribological model, conducting results, further discussion and taking out useful conclusions.

*Keywords*

ICE ; $H_2$ vs CNG ; Blow-by ; Dynamic viscosity of fuel-air mixture ; Compression ring – liner conjunction ; Lubrication

# *FAULT DIAGNOSIS IN AN UNMANNED AERIAL VEHICLE BASED ON STATISTICAL TIME SERIES METHODS*

**Student's Name**
Patras Spyridon

**Student Registration Number**
1020228
Email: up1020228@ac.upatras.gr

**Supervisor:**
Sakellariou Ioannis, Assistant Professor
Panagiotis Koustoumpardis, EDIP
**Contact Info**
Email: sakj@upatras.gr,
koust@mech.upatras.gr
Tel.: (+30) 2610 969494, (+30) 2610 969491

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1020228&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The problem of damage diagnosis in the propeller of an unmanned aerial quadcopter vehicle is examined in the present thesis, using on board stochastic vibration signals obtained from an embedded sensor of the vehicle. The damage detection and importance identification (characterization) of 5 typical early-stage damages to one propeller of the vehicle are considered using stochastic methods of machine learning type. 130 experiments are conducted, 30 with the healthy vehicle and 20 for each damage scenario, where one vibration acceleration response signal to the vertical vehicle direction is obtained in each experiment under hovering conditions. Damage detection is attempted via four unsupervised statistical time-series methods based on: (i) the Power Spectral Density (PSD) of the measured signals using Welch estimator, (ii) the parameters of AutoRegressive models (AR-P method), (iii) the residual variance of AR models (AR-V method) and (iii) the residual whiteness of AR models (AR-RU method). Given the fact that specific types of the considered damages affect similarly the vehicle dynamics, damage characterization is attempted based on methods that employ Multiple Stochastic Models, called as Multiple Model (MM) methods. In particular, the following MM methods are used: (i) the MM-PSD based on Welch estimator, (ii) the MM-AR-P and MM-ARMA-P based on the parameters of AR and AutoRegressive Moving Average (ARMA) models, (iii) the MM-PCA-AR according to which the parameter vector of the MM-AR method is reduced via Principal Component Analysis (PCA), (iv) the MM-AR-RV and MM-ARMA-RV based on the residual variance of the corresponding models and (v) the MM-AR-RU and MM-ARMA-RU based on the models residual whiteness. The damage detection results are presented through ROC (Receiving Operator Characteristic) curves indicating the overall superiority of the AR-RU method that achieves 100% correct detection for 0% of false alarms for all considered damage scenarios. The assessment of each method in damage identification is performed via Confusion

Matrices and the results illustrate that the MM-PSD method achieves the highest percentage of correct identification, while adequate results are obtained via the MM-ARMA-RU method.

*Keywords*

Unmanned Aerial Vehicle, Damage Detection, Damage Classification, Quadcopter, Statistical Time Series Methods, U.A.V., propeller

# *PROCESS MONITORING AND OPTIMIZATION BASED ON DIGITAL TWIN AND VIRTUAL REALITY*

**Student's Name**
Petroulias Stamatios
**Student Registration Number**
1059740
Email: up1059740@ac.upatras.gr

**Supervisor:**
Mourtzis Dimitrios, Professor
**Contact Info**
Email: mourtzis@lms.mech.upatras.gr
Tel.: (+30) 2610 910150

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059740&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Over the last decades, the digitalization of manufacturing processes and manufacturing systems has enabled engineers to collect data regarding machining operation. Based on the utilization of such data, in conjunction with the development of suitable frameworks, for data acquisition, data fusion, and data processing, it has become feasible to acquire a data-based estimation of the machine and the process status. By extension, the utilization of the datasets derived from the monitoring lay has involved the foundation for controlling the machine operation and the machining process execution parameters, to the engineers. Further to that, process monitoring based on the implementation of sensing systems can facilitate the control of ultra-precision machining. Therefore, the conventional manufacturing paradigm is transforming into the so-called Digital Manufacturing. It is stressed that this transformation is highly driven by the ongoing developments of Industry 4.0. In addition to that, cutting-edge digital technologies, such as Extended Reality (XR) (Augmented Reality – AR, Mixed Reality – MR, Virtual Reality – VR) are constantly being integrated into modern manufacturing systems, to visualize processes, gain access to data, and optimize processes. The technology of Digital Twin gains more and more space in the industrial domain, as it enables a digital interface between the user and the digital representation of the machine. As a result, time and costs are minimized basically during the maintenance and production phases. So, the scope of this thesis is the design and development of a digital desktop manufacturing cell consisting of a 3D Printer and a Robot, in Unity Game Engine. As for the monitoring, Virtual Reality Oculus Rift headset will be utilized. Through the integration of the aforementioned state of the art technologies, and the use of simulation, training courses and improvements on the manufacturing plant can be performed.

*Keywords*

Process Monitoring, Digital Twin, Optimization, Virtual Reality, Simulation

# *ROBOTIC CELL RELIABILITY OPTIMIZATION BASED ON DIGITAL TWIN*

**Student's Name**
Tsoumpou Sofia
**Student Registration Number**
1054530
Email: up1054530@ac.upatras.gr

**Supervisor:**
Mourtzis Dimitrios, Professor
**Contact Info**
Email: mourtzis@lms.mech.upatras.gr
Tel.: (+30) 2610 910150

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054530&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In recent years, the traditional manufacturing industry has been affected by the development of digital technologies and Industry 4.0 wave. Due to the rising digitalization in every step of the manufacturing, manufacturing companies have now the chance to reach a completely new level of productivity. Robotic systems have become a standard tool in modern manufacturing, due to their unique characteristics, such as repeatability, precision, speed, high payload, and ability to operate in dangerous areas. However, robotics manipulators suffer from low reliability. Low reliability increases the probability of disruption in the manufacturing processes, delays are induced in the manufacturing/production systems' short-term schedule, faults and failures are arising, minimizing in this way the productivity and by extension the profit. This research work presents a methodology for the improvement of reliability in a robotic cell based on the technologies and tools that offered by Industry 4.0 and particularly by the Digital Twin (DT) concept as well as the Machine Learning (ML) techniques under the framework of Predictive Maintenance (PdM). The reliability is highly associated with the maintenance processes. As a result, by implementing maintenance at the optimum time, the reliability of the robotic cell can be improved. Firstly, our aim is focused on the DT concept in order to monitor and control the health status of our system. Secondly the scope is to identify the critical components of a robotic cell, detect and classify the faulty behavior of the critical component and propose the framework of the prediction of its Remaining Useful Life (RUL) in order to improve the reliability of the whole robotic cell. Then, based on the diagnostic and prognostic results, engineers can apply the appropriate maintenance tasks to prevent their robotic cell from serious failures and ensure high performance of their system.

*Keywords*

Reliability Optimization, Robotic cell, Industry 4.0, Predictive Maintenance, Digital Twin, Remaining Useful Life, Machine Learning

# *DESIGN AND IMPLEMENTATION OF HUMAN ROBOT COLLABORATIVE MANUFACTURING CELL FOR EDUCATIONAL PURPOSES*

**Student's Name**
Christakos Themistoklis
**Student Registration Number**
1047242
Email: up1047242@ac.upatras.gr

**Supervisor:**
Stavropoulos Panagiotis, Associate Professor
**Contact Info**
Email: pstavr@lms.mech.upatras.gr
Tel.: (+30) 2610 910160

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047242&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The integration of human-robot collaboration technology in the industry makes it possible to combine the strong points of a human operator and a robot in a manufacturing cell to improve both its performance and the working environment. As the performance and the smoother integration of this technology depends on the peoples' attitude, educational programs and hands-on experience with collaborative robots are important to inform and enhance their knowledge on the issue for them to understand the positive effects. In this project an educational collaborative cell was designed and constructed for this purpose. After its use in several workshops, data from the participants have been gathered and analyzed to validate the design and propose changes which could enhance the experience.

*Keywords*

Human robot collaboration, attitude towards robots, education, workshop, assembly

# DIVISION OF ENERGY, AERONAUTICS AND ENVIRONMENT (FEBRUARY 2023)

## *ENERGY AND ENVIRONMENTAL APPLICATIONS OF AN EXTENSIVE GREEN ROOF SYSTEM*

**Student's Name**
Arvanitis Iason-Vlassis
**Student Registration Number**
1054468
Email: up1054468@ac.upatras.gr

**Supervisor:**
Michalakakou Giouli, Professor
**Contact Info**
Email: pmichala@upatras.gr
Tel.: (+30) 2610 969478

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054468&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

The ever-increasing urbanization in relation to overpopulation has modified modern cities into a huge, dense, artificial complex that gives priority to the accommodation of more and more citizens in the smallest possible space totally neglecting, however, green and the quality of life. All the above combined with the hectic lifestyle and the rapid technological developments have led the energy demands to be higher than ever before. This situation, however, deteriorates due to the urban heat island effect, during which the temperature of the air in the cities is significantly increased in contrast to the air temperature in the suburbs and the surrounding rural areas. The main reasons behind this phenomenon is the obvious lack of green, the geometry and the size of urban areas, human activity, the qualities of the building materials, air pollution as well as local meteorological parameters. Since the urban heat island effect has serious consequences not only on humans but also on the environment, it is absolutely necessary to confront it. The most efficient ways to deal with it have proven to be the use of renewable energy sources, the use of cool materials, energy building design and the increase of greenery. The present thesis focuses on the final method being achieved though green roofs. A green roof, also known as planted roof, is a common roof insulated with plant-based bedding. Regarding the construction, the green roof is not a modern approach, but it has roots in ancient times and specifically in ancient Mesopotamia. However, it has recently become a relevant idea, thanks to the spring of ecology. Green roofs are divided according to the thickness of the soil layer and the density of vegetation in ascending order regarding extensive, semi-intensive and intensive. For such a construction

to be safe and fully functional, certain requirements should be covered such as the static endurance of the building with the addition of a green roof, the possible inclination of the roof and the selection of the most suitable plants. The typical layers of a green roof include from bottom to top the following: vapor control, insulation, water-proving membrane, root barrier, support panel, drainage layer, filter fabric, soil layer and finally the vegetation. Having discussed the above issues, the thesis ends with the energy and environmental benefits that a green roof offers to a building, examining experimental data across the globe.

In the computational part of the present thesis, 10 different case studies were analyzed with or without insulation and with or without green roofs of many conditions. For each case, the thermal transmittance coefficient was calculated followed by the creation of a table of final results. Then, a comparison of the results with the semi-intensive and intensive type of green roof was realized in order to investigate the impact of the thickness of the plant bedding to U-values rates. Lastly, the efficiency of green roofs as a thermal insulation medium was probed into and general results were extracted.

*Keywords*

Green roof, urban heat island effect, planted roof, thermal transmittance coefficient, U - values, thermal insulation

# *COMPUTATIONAL SIMULATION OF FIRE DEVELOPING ON A BUILDING FAÇADE*

**Student's Name**
Vrouvis Panagiotis
**Student Registration Number**
1047264
Email: up1047264@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047264&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this thesis is the computational simulation of fire spread according to SP Fire 105 Swedish fire test method. Specifically, fire development will be studied to determine the reaction to fire of materials and external wall assemblies or façade claddings, when exposed to fire from a simulated apartment fire with flames emerging out through a window opening. Basic tool for this process is Pyrosim which is the graphic interface of the open source software FDS and Autodesk Revit where the construction will be designed. The construction and numerical solution were accomplished on versions FDS 6.7.6 and Pyrosim 2021.4.2021.

The computational analysis happened on a 0.1m grid size. Firstly, a results oriented comparison of grid sizes 0.1m, 0.15m and 0.2m preceded the analysis. Generally, the use of 0.2m grid is not recommended due to the higher aberration from the other two. Both the 0.1m and 0.15m meshes offer decent similarity with some deviations mostly inside the fire room and around the fire. Consequently, in order to obtain reliable results around the fire there may be a need for a finer rather than a coarser mesh of a $D^*/\delta x$ rate more than 30, even though the suggested rate is between 4-16 because these values yield good results from a precision and time simulation perspective.

For the particular problem façades of expanded polystyrene and rockwool are used. Thermocouples and plate thermometers have been placed in front of the façade, in the fire room and some places of interest to measure the temperature. Also, measurements of gas velocity, oxygen availability, HRR and heat fluxes were taken along the simulation. The comparison of results for the two façades indicated that rockwool develops higher temperatures along the façade due to the higher thermal conductivity coefficient. EPS showed higher values of heat fluxes due to the different emission factor and surface temperature. The rockwool surface temperature rise had a higher impact to the result rather than rise rockwool's emission factor.

Lastly, a comparative analysis for a 1000kW risen HRR was carried out. As expected, almost every value increased accordingly, especially around the fire and the smallest changes were seen on gas velocity.

There is enormous potential in FDS capabilities for predicting realistic results on various fire scenarios using only user-inserted inputs and access to computational power. At the same time, there is need for high expertise and very precise inputs due to the sensitivity of the program, the various parameters and uncertainties. FDS is an important tool to simulate fire phenomena and combined with experimental data can be the cornerstone for studying and predicting specialized situations.

*Keywords*

Building Fire, ETICS (External Thermal Insulation Composite System), Computational Fluid Dynamics, Fire Simulation, Fire Dynamics Simulator (FDS), Pyrosim, SP FIRE 105

# *EXPERIMENTAL STUDY OF A SPRAY COOLING SYSTEM FOR POWER ELECTRONICS*

**Student's Name**
Gavalas Antonios
**Student Registration Number**
1059761
Email: up1059761@ac.upatras.gr

**Supervisor:**
Perrakis Konstantinos, Lecturer
**Contact Info**
Email: perrakis@mech.upatras.gr
Tel.: (+30) 2610 997271

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059761&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Power electronics are found in a variety of applications related to the development of artificial intelligence, internet, supercomputers, as well as telecommunications and transports. Their function is related to heat release, which causes an increase in their temperature, resulting in reliability decrease. The issue of increased temperatures is exacerbated due to the constant reduction of their size and the increase of their power caused by rapid advances in technology. Conventional cooling methods are unable to satisfy high heat dissipation needs, so innovative cooling methods are introduced. Spray cooling, identified as one of the most effective cooling methods due to the achievement of high heat transfer rates in low surface temperatures, is among these methods. In this dissertation, spray cooling method is presented, heat transfer mechanisms that govern this method are overviewed and data obtained from a closed-loop R410A spray cooling system, are analyzed, in order to explore the influence of mass flow rate and spray height on the efficiency of this method. In particular, four mass flow rates from 4.5 to 7.5 g/s at 15 and 25 mm were examined. The results indicated that increase in mass flow rate induced deterioration of heat transfer performance, whereas at greatest spay height critical heat flux values and surface temperatures were improved. Heat flux values of more than 200 W/cm$^2$ were achieved, while surface temperatures were maintained below 37°C. Impinging velocity, number and diameter of droplets, as well as spray coverage area, recirculation in spray chamber and thickness of fluid's layer above the surface are major parameters, affected by mass flow rate and spray height, that determine the spray cooling performance.

*Keywords*

Spray cooling, critical heat flux, mass flow rate, spray height, R410A closed-loop configuration

# *BUILDING INTERGRATED PV SYSTEMS - APPLICATION IN CLIMATIC ZONE B*

**Student's Name**
Georgoulias Dimitrios
**Student Registration Number**
1058137
Email: up1058137@ac.upatras.gr

**Supervisor:**
Michalakakou Giouli, Professor
**Contact Info**
Email: pmichala@upatras.gr
Tel.: (+30) 2610 969478

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1058137&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The subject of the present diploma thesis is the investigation of the energy properties and the way to enhance them of a hypothetical building which is established in the area of Attica. According to the KENAK the area of Attica pertains to the climatic zone B. We consider the building to be an office or a machine shop or even a warehouse.

Our goal is to calculate the thermal losses and gains of the building for five different cases of insulation. For the two of them we also have addition building integrated PV systems. Also, in order to simplify our study we overlooked some specific properties of the building's structural element and internal thermal gains.

First we analyze the technology behind PV systems, we introduce the photovoltaic effect and its properties and we present their implementations all over the world. After that, we describe the heat transfer mechanisms and the way to improve the thermal efficiency of the buildings.

The mathematical expressions and the calculation of the thermal properties are based on the instructions of TOTEE. We designed the geometry of our building in the Sketchup pro 2022 program and we extracted the results about the heat transmission rate, the thermal losses and the thermal gains in the Microsoft office EXCEL. By gathering the results of the calculations we were able to make comparisons, observe the changes in thermal losses and thermal gains during a year and find the optimal case of insulation for our study.

*Keywords*

Energy performance of buildings, heat transmission rate, PV Systems, Thermal losses, thermal gains

# *FLOW CONTROL OVER A WING WITH ACTIVE DIMPLES*

**Student's Name**
Dimitriadou Maria
**Student Registration Number**
1059844
Email: up1059844@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059844&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present diploma thesis intends to calibrate an aerodynamic balance in order to measure the aerodynamic forces on a wing with active dimples. Active dimples are an active flow control method, that is not thoroughly tested. Thus, in this experiment, the flow around a wing with active dimples will be examined. The calibration is carried out through the application of known forces on the aerodynamic balance. Firstly, the structures that are necessary for the calibration are designed and implemented. These structures are a table for the support of the aerodynamic balance throughout the calibration and two rings for the application of the forces and torque. Subsequently, the equations that associate the applied forces with the load cells' indications, are constructed. By executing the measurements of the calibration and using the equations, the distances, that the forces are applied on the load cells, are determined. The suitable values of the distances are selected, based on the convergence of the measured, through the equations, forces, with the real forces that are loaded. Eventually, the validity of calibration's results is evaluated through diagrams that show the convergence of the measured forces.

*Keywords*

Flow control, active dimples, wing, calibration, aerodynamic balance

# *COMPUTATIONAL STUDY OF THE EFFECT OF DIMPLES AND BUMPS ON AN UNMANNED AERIAL VEHICLE WING, CONFIGURATION OPTIMIZATION AND COMPARISON WITH EXPERIMENTAL WIND TUNNEL RESULTS*

**Student's Name**
Dimitropoulos Dimitrios
**Student Registration Number**
1059723
Email: up1059723@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059723&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The climate crisis and the environmental degradation that have emerged in recent years have made the reduction of the aviation industry's carbon footprint, via the aerodynamic optimization of aircrafts, a very important research topic. The aim of the present work is to improve the aerodynamic performance of the ethERAS UAV wing, by delaying the separation of the boundary layer on its suction surface using dimples and bumps. These modifications are a means of passive boundary layer control, which have been mainly used in golf balls. Their function is based on introducing instabilities and turbulent fluctuations to the flow, which lead to larger momentum transfer to the boundary layer, enabling it to travel longer distances, even under the effect of large adverse pressure gradients. To determine the optimal size and position of the modifications, five configurations were designed for each modification type, resulting in a total of ten configurations. All CAD models were created using DASSAULT SYSTEMES Catia. Afterwards, the models were prepared for the computational simulations using ANSYS Spaceclaim. All wing designs, including the original, non-modified wing, were studied at a low velocity (7m/s), to simulate landing conditions. From this case study, the best performing configuration for each modification type was chosen. The two chosen configurations and the original, non-modified wing design were studied at cruising speed (27m/s). The computational grids were created in ANSYS Fluent Meshing, using the Poly-Hexcore method of the ANSYS Mosaic Meshing technology. The computational simulations were implemented using the ANSYS Fluent pressure-based solver, the SST k-omega (SST k-ω) turbulence model and second order spatial discretization schemes. The numerical results of the 7m/s case study were validated using experimental,

wind tunnel data. The two chosen configurations from the 7m/s case study and the original, non-modified wing were 3D printed on scale of 1:4 and were used for the experimental study. The comparison of the computational and Computational Study of the Effect of Dimples and Bumps on an Unmanned Aerial Vehicle Wing, Configuration Optimization and Comparison with Experimental Wind Tunnel Results experimental results showed good agreement. From the overall study it was concluded that the use of dimples aided in the enhancement of the aerodynamic performance of the wing, by improving its aerodynamic efficiency. The use of bumps proved to be inconsistent, leading to the overall degradation of the aerodynamic performance.

*Keywords*

Aerodynamics, UAV, Boundary Layer, Separation, Passive Control, CFD, Poly-Hexcore

# *COMPUTATIONAL ANALYSIS OF THE EFFECT IN THE FLOW AND THERMAL FIELD OF A U-TUBE WITH CONSTANT WALL TEMPERATURE, OF THE SHAPE OF ITS CROSS SECTION FOR MAXIMUM EXPLOITATION OF THE CURVATURE EFFECTS*

**Student's Name**
Ziavras Christos
**Student Registration Number**
1059818
Email: up1059818@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059818&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Energy crisis is a critical problem nowadays, which is creating challenging conditions in various aspects of live. To achieve energy conservation, it is important to examine solutions that can create enhanced heat transfer and less pressure drop. The U-tube is a very common type of pipe, since it is applied almost everywhere due to its ability to accommodate highly packed structures in a very limited space and utilizing the centrifugal forces for improving the flow and thermal characteristics of a system, thus lowering significantly the overall construction and operating cost. In this study, various cross sections of a U-tube are examined regarding their flow and thermal performance. More specifically, an analytical study of a circular, elliptical, rectangular and trapezoidal cross section was made, providing better comparative understanding of the phenomena taking place inside these pipes. The simulations were conducted using Ansys Fluent 2020R2 computational package, with a standard hydraulic diameter of 38mm and at Reynolds Number 10k. For the elliptical and trapezoidal cross sections, 3 and 2 respectively, alternative dimensions are offered, based on constant length ratios. The working fluid is water, entering the tubes at 298.15K and ca. 1atm, with constant wall temperature at 353.15K. The simulations showed that the circular cross section offered at the outlet the highest mean temperature and mean tangential velocity, while the elliptical cross section offered the smallest pressure drop, depending though on its orientation in space. Sharp corners caused a negative effect on heat transfer ability as well as on flow parameters.

*Keywords*

Turbulent flow; U-tube; cross section variations; heat transfer enhancement; CFD simulations

# *THERMODYNAMIC CYCLE FOR SPRAY COOLING*

**Student's Name**
Katsenos Spyridon
**Student Registration Number**
1059779
Email: up1059779@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059779&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In recent years, there has been a trend towards downsizing and increasing the energy managed by power electronics, which are being implemented in renewable energy applications, hybrid cars, and other technologies. This has led to increased demand for the development of cooling methods that can dissipate extremely high heat per unit area, as the cooling requirements of electronics increase with their power. Various cooling methods have been proposed to meet these requirements, with spray cooling being one of the most attractive options due to its high cooling capability and ability to maintain low and uniform surface temperatures. This paper presents an analysis of heat transfer mechanisms and enhancement parameters based on the literature, as well as the experimental setup developed to obtain measurements. The experimental measurements were conducted by the research team, using one nozzle placed at two different distances from the surface, and four R410A coolant fluxes, in a closed loop cooling cycle. The maximum heat dissipation rate achieved was 223.3W/cm$^2$, and the maximum heat transfer coefficient reached 59.3kW/m$^2$K. Thermodynamic cycles for every coolant flow and height were also developed, through which the cooling efficiency calculated, fluctuating between $\mathbf{15}$, $\mathbf{71}$% and $\mathbf{32}$, $\mathbf{95}$%. Finally, the experimental results are compared with corresponding literature results, and it is concluded that, although they are in relative agreement, there is still room for improvement in the installation's parameters to achieve the highest rates.

*Keywords*

Spray cooling, spray cooling heat transfer mechanisms, spray cooling enhancement parameters, high heat dissipation, smooth surface

# *COMPARISON OF PROPULSION METHODS a) CLASSIC JET ENGINES, b) HYDROGEN JET ENGINES, c) TURBO-ELECTRIC ENGINES, d) HYBRID ELECTRIC ENGINES. ESTIMATION OF COST AND ENVIROMENTAL IMPACT*

**Student's Name**
Kotsampasakis Athanasios Marios
**Student Registration Number**
1031538
Email: up1031538@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1031538&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Nowadays, saving energy is one of the most important subjects of science and especially engineering in the field of aviation. In the present thesis a literature review is presented about classic jet engines, electric propulsion in aircrafts, as well as hydrogen as an aviation fuel. In addition, comparisons of basic aircraft design calculations are presented between aircrafts which use jet, electric or hydrogen propulsion.

More specifically, classic jet engines are analyzed in terms of categories, advantages and environmental cost of these engines . Also, electric propulsion in aviation is analyzed with advantages and disadvantages. The different problems that exist in electric propulsion are analyzed and the engineers must find solutions about them, so that electric propulsion become the future of aviation. This thesis shows also to us the potential of hydrogen jet engines in aviation with the aim of abandoning classic jet engines, because of saving energy and environmental pollution.

At the last section of this thesis, we examine with basic aircraft design calculations, the effect of changing the aircraft A320 from classic jet engine to an electric aircraft, hybrid electric, full electric and hydrogen aircraft to its weight, fuel consumption and wing acreage.

*Keywords*

jet engine, electric propulsion, turbo-electric propulsion, aircraft A320, hydrogen engine, propulsion methods

# *COMPUTATIONAL INVESTIGATION OF COAXIAL SWIRLING FLOWS*

**Student's Name**
Koumenteas Panagiotis-Kaspar
**Student Registration Number**
1054541
Email: up1054541@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054541&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The current thesis deals with the computational investigation of the interaction effect of an inner swirling outflow beam with an outer swirling annular flow propagating in coaxial tubes. The aim of the study is to extract results through computer simulation, and then to compare them with results obtained from the experimental investigation conducted by A. Naxakis [6] within the framework of the Laboratory of Technical Thermodynamics and Applied Statistical Engineering.

Two important advantages that make swirling flows in high demand in various aspects of industry are their ability to improve mixing, enhance dispersion and help stabilize the flow. However, due to the complexity of the nature of the phenomenon, understanding and by extension the proper management of such flows is difficult.

A key feature of swirling flows is the breakdown of the axial macro-turbine (Vortex Breakdown). The phenomenon can be explained differently as the disturbance characterized by the formation of an internal stagnation point in the vortex axis, followed by reverse flow in a region of limited axial extension.

Computational fluid dynamics has for many years been a very accurate and useful technique for the description and understanding of any fluid fields under investigation. More generally, beyond accuracy, the widespread use and advancement of the field of computer simulation today lies in the fact that it requires low cost and offers engineers a faster solution to many kinds of problems.

The process of modelling the geometry, discretizing the mesh, defining the conditions and properties, and the calculations were performed with the help of the ANSYS Fluent for Student computational simulation package software, which is offered free of charge to students.

The work is completed by comparing the results of the computer simulation with those of the experiment, for cases of the same initial and boundary conditions, in terms of the form of the structures formed as well as the velocities. Similarities of the simulation results with cases of experimental investigation of different initial and boundary conditions are also compared.

*Keywords*

Swirling Flows, Coaxial, Vortex Breakdown, Computational Fluid Dynamics, ANSYS Fluent

# *INSTALLATION STUDY OF AN EXPERIMENTAL UNIT FOR POWER GENERATION AND STORAGE FROM RENEWABLE ENERGY SOURCES*

**Student's Name**
Lampropoulos Fotios-Foivos
**Student Registration Number**
1064018
Email: up1064018@ac.upatras.gr

**Supervisor:**
Perrakis Konstantinos, Lecturer
**Contact Info**
Email: perrakis@mech.upatras.gr
Tel.: (+30) 2610 997271

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064018&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Renewable energy sources are rapidly being integrated into the energy mix due to the finite quantity of fossil fuels and the environmental burden caused by their use. Optimizing the design of renewable energy systems is essential for their development.

The purpose of this paper is the installation study and the identification of the technical feasibility of a power generation and storage unit from renewable energy sources. The unit has an educational purpose, as it is planned to be installed in a building of the Department of Mechanical Engineering and Aeronautics at the University of Patras.

The unit consists of photovoltaic-thermal panels, with the purpose of simultaneous production of electricity and heat. Furthermore, the design includes a small wind turbine. Solar and wind energy are characterized by uncertainty and therefore the existence of an energy storage system was deemed necessary. The latter consists of batteries. Also, a tank is utilized for the storage of heat and the production of domestic hot water (DHW).

At first, the theory behind the above-mentioned systems is presented, followed by the detailed design and sizing for the unit. Finally, it consists of photovoltaic-thermal panels with a total capacity of 4 kWp, a small wind turbine with a capacity of 1 kW, batteries with a nominal capacity of 25440 kWh, an inverter with a capacity of 2.2 kW and a tank with a capacity of 300 ℓ. The loads covered include the perimeter and interior lighting of the installation building and the needs for DHW.

Additionally, simulations are carried out to verify the effectiveness of the initial design. Specifically, the optimal tilt angle for the panels is determined to be 50° and the energy production of the system is calculated. Ultimately, the selected electric load is covered by

84% and the thermal load by 49% by the system, and it is shown that the chosen battery capacity is optimal.

*Keywords*

Photovoltaic – Thermal, PVT, Wind Turbine, WT, Batteries, PVT – WT – Battery, Design, Simulation

# *COMPUTATIONAL STUDY OF THE EFFECT OF DIMPLES AND BUMPS ON AN UNMANNED AERIAL VEHICLE WING IN TWO-PHASE FLOW, CONFIGURATION OPTIMIZATION AND COMPARISON WITH EXPERIMENTAL WIND TUNNEL RESULTS*

**Student's Name**
Bourdousi Panagiota-Vasiliki
**Student Registration Number**
1064020
Email: up1064020@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064020&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the aeronautics industry, increasing the range of an aircraft and reducing fuel consumption are major issues to be solved. Based on some previous studies on this subject, an attempt to improve the aerodynamic characteristics of an existing UAV aircraft wing, was made. More specifically, this improvement was tried to be carried out through the addition of bumps or dimples in two different sizes and placed in specific positions on the suction side of the wing. The geometries that we used for the simulation was designed using CATIA V5 and Spaceclaim while Poly-Hexcore method of Ansys Mosaic Meshing technology was used for the meshing part. The CFD simulations were performed using SST k-ω turbulence model, for a landing speed of 7 m/s. For the simulation of fire conditions, a two-phase flow of air and anthracite particles was selected, using the DPM model and Euler-Lagrange method. To validate the results obtained from the simulation, an experiment was carried out in the wind tunnel of the laboratory for three, 3D printed, scaled wings, the most significant ones from all configurations. For safety reasons, the two-phase flow in the experiment was simulated as air-sand particle flow. The computational results showed that the addition of bumps on the surface has a negative effect on the aerodynamic behavior of the original wing, while the dimpled wings are proved to be more optimistic. The wing with 5 mm diameter bumps at 40% of the chord showed the greatest rate of reduction, while the one with 2.5 mm diameter dimples at 40% of the chord had the greatest improvement in aerodynamic performance. The path of the anthracite particles seems to be unaffected by the presence of a surface modification but is affected by increasing

angle of attack. The computational results are relatively close to the experimental ones, with some deviations due to the experimental conditions and the two-phase flow equipment. We conclude that CFD simulations are very useful for a mechanical engineer, as it enables preliminary study and visualization of conditions, such as a fire, that are impossible to study at the time they occur.

*Keywords*

CFD, ANSYS Fluent, Poly-Hexcore, SST k-ω, DPM, dimples, bumps, UAV, Eppler 420

# *DESIGN AND ANALYSIS OF STRESS IN THREE HYDROFOILS AND COMPARISON OF THEIR RESULTS*

**Student's Name**
Dinopoulou Ioulia
**Student Registration Number**
1026526
Email: mead6597@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026526&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

During the flow around hydrofoils, there are forces that act on them, the drag force and the lift force. This particular work focused on the investigation of drag and lift forces on three NACA series hydrofoils. The first objective of this project is to model and calculate the hydrodynamic behavior of the hydrofoils. Then, the forces acting on the different hydrofoils for nine different angles of attack were compared. The comparison was repeated for two velocity cases and two turbulence models (k-omega, SpalartAllmaras) to validate the results. The Cl/Cd ratio values were calculated and used to compare the hydrofoils and select the one that exhibits the best behavior. NACA 4418 was found to have the best behavior presenting the highest Cl/Cd ratio among the three hydrofoils.

*Keywords*

lift coefficient, drag coefficient, angle of attack, k-omega, SpalartAllmaras

# *COMPUTATIONAL SIMULATION OF SPRAY COOLING*

**Student's Name**
Parissis Panagiotis
**Student Registration Number**
1071202
Email: up1071202@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1071202&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The rapidly increasing use of power electronics in a variety of state-of-the-art technological applications (space, artificial intelligence, medicine, transport, large servers, telecommunications data centers, etc.) makes it absolutely necessary to develop new and more powerful electronic devices while reducing their overall size. Inevitably, the increase in power requirements demands the development of effective techniques and methods able to dissipate large amounts of heat to ensure the continuous and stable operation of power electronics, something that conventional cooling methods fail to provide. Spray cooling has emerged as a promising method, capable of dissipating large amounts of heat while maintaining a uniform temperature distribution on the surface of the electronic. Given the complexity of the heat dissipation mechanism and the number of parameters that affect the performance of the method, the development of computational fluid dynamics (CFD) models, in parallel with the required experimental investigation, is necessary for a better understanding and development of the method. In this study, an extensive analysis of the physical mechanisms governing spray cooling is carried out, while at the same time the literature review focuses on the computational models that have been developed to simulate spray cooling. The aim of this work is to develop an efficient simulation model of cooling by spraying water on a hot copper surface under which a constant heat flux density is applied. The commercial code ANSYS Fluent 2021/R2 was used to develop the simulation model. The results were compared and verified with computational and experimental results available in the literature. Finally, the extracted results demonstrated that forced convection due to droplet momentum is the dominant cooling mechanism, while the distributions of temperature, heat flux and liquid film thickness on the cooled surface were evaluated, thus drawing useful conclusions about the effectiveness of the spray cooling method.

*Keywords*

Computational Fluid Dynamics, Ansys Fluent, DPM, Power Electronics, Spray Cooling, Boiling, Droplet Dynamics, Two-Phase Flows, Heat Transfer, Transport Phenomena

# *SIMULATION OF THE MIXING AND REACTING FIELDS OF TAY-TYPE GAS TURBINE COMBUSTOR FOR PROPANE/AIR MIXTURES UTILIZING THE PARTIALLY STIRRED REACTOR MODEL, TWO-STEP CHEMISTRY AND AN OPEN-SOURCE SOLVER*

**Student's Name**
Spyropoulos Charalampos
**Student Registration Number**
1059801
Email: up1059801@ac.upatras.gr

**Supervisor:**
Koutmos Panayiotis, Professor
**Contact Info**
Email: koutmos@mech.upatras.gr
Tel.: (+30) 2610 997244

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059801&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This thesis concerns the simulation of the isothermal mixing field as well as the reacting of a Tay-type gas turbine combustor (Rolls Royce Tay). First, a brief description of combustion is given, various important combustion parameters are mentioned and combustion problems are classified accordingly. Then, the main types of combustors are presented, mainly used in aeronautical applications for aircraft propulsion, and the main design requirements are highlighted. Then the basic equations that govern combustion problems are presented, such as the conservation of momentum, mass, species mass etc, and are appropriately modeled to be applied to our problem. For the present study, the Partially Stirred Reactor (PaSR) model was used and the turbulence was modeled with the Lilly-Smagorisnky LES model. The fuel used was the propane and for the chemical reactions modeling , two-step reduced reaction mechanism was used. The boundary conditions used for the simulation are explained, as well as the simplifications and assumptions made. The geometry and the mesh were generated in the open-source software Salome and the simulation was executed in the also open-source OpenFOAM. The results were compared with the experimental measurements of Heitor and Whitelaw, and closing the thesis, conclusions are presented and future studies are suggested.

*Keywords*

Gas Turbine Combustors, Computational Fluid Dynamics (CFD), OpenFOAM, Partially Stirred Reactor (PaSR) model, Large Eddy Simulation (LES)

# *COMPUTATIONAL STUDY OF THE EFFECT ON THE THERMAL AND TURBULENT FLOW FIELD IN A TUBE OF RECTANGULAR CROSS-SECTION WITH CONSTANT WALL TEMPERATURE OF A VORTEX GENERATOR (VG) WITH A RECTANGULAR HOLE FOR DIFFERENT VALUES OF THE ANGLE OF ATTACK AND SOLUTION PARAMETERS*

**Student's Name**
Stathopoulos Georgios
**Student Registration Number**
1051352
Email: up1051352@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1051352&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present diploma thesis aims to investigate computationally the effect of a vortex generator of longitudinal flat blade with a rectangular hole on the flow and thermal field of a rectangular cross-section pipe. The investigation is carried out for two different angles of blade positioning with respect to the horizontal longitudinal axis of the pipe, i.e. for angles of 30° and 45°.

To begin with, the theoretical background concerning fluid mechanics, heat transmission and heat transfer is presented. In particular, the properties of fluids and flow characteristics are presented. The velocity boundary layer, secondary flows, pressure loses within the pipe, heat transfer mechanisms and the thermal boundary layer are also analyzed. The basic characteristics of Vortex Generators and their effect on heat transfer are presented, too. Afterwards, turbulence modelling is discussed and an introduction to the computational package ANSYS fluent is given.

The next part of the project is the design of the geometry, which id carried out exclusively in the ANSYS Design Modeler graphical environment. The two layouts under study are designed with the VGs forming angles of 30° and 45° with the pipe. The geometries are then discretized, the mesh quality is evaluated and the stability of the mesh is examined.

Then the basic parameters of the problem are defined and the solution is constructed with two different turbulence models. The simulations were performed for Re numbers of 5000, 10000, 15000 and 20000.

Thereafter, the results of the models are presented, compared and commented using appropriate charts, tables and figures in order to draw conclusions on the effectiveness of the models. Finally, suggestions for future investigation are recommended.

*Keywords*

Vortex Generators, Heat trasnfer, k-ε enhanced wall treatment, k-ω SST, ANSYS fluent

# *SPACE CHARGE DIFFUSION NUMERICAL MODEL FOR FLOW IN COLD PLASMA ACTUATORS*

**Student's Name**
Stratakos Pavlos
**Student Registration Number**
1064013
Email: up1064013@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064013&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The ability to control a flow actively or passively is of the utmost technological importance. Active flow control is an essential aspect of modern technology, involving the manipulation of flow by adding energy or momentum in a controlled manner. More specifically, plasma aerodynamic actuators are increasingly preferred over other methods of active flow control owing to their diverse benefits. In this context, this thesis aims to develop a computational model to simulate the effects of an AC SDBD plasma actuator more accurately by focusing on the electrostatic conditions after the discharges in each AC cycle. An introductory overview is presented in order to understand the physical principles underlying plasma formation and its effects on fluid dynamics. The turbulence model and discretization methods used are discussed, followed by a comprehensive description of the equations used and how they were derived. To address the challenge of simulating the difference in time scales between plasma formation and fluid flow, the model was divided into two parts, and a specific algorithm was used to represent the real-life phenomena as accurately as possible. The rationale behind the model creation is elaborated upon, and the simulation results are presented and analyzed. Specifically, simulations were conducted using three fixed charge values for three different shapes of charge distribution.

*Keywords*

Active flow control, AC SDBD plasma actuator, numerical model, discharge, charge distribution

# *COMPUTATIONAL STUDY OF THE AERODYNAMIC BEHAVIOUR OF A RACING CAR IN CORNERING CONDITIONS*

**Student's Name**
Fotopoulos Apostolos
**Student Registration Number**
1020687
Email: up1020687@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1020687&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

One of the vital design parameters during vehicle design is their aerodynamic behavior. The aerodynamic behavior of a car differs when it moves in a straight and curved trajectory. In racing cars where the goal is the highest possible cornering speed, the aerodynamic behavior of the automobile in cornering conditions becomes even more critical. Until recently, to study the aerodynamic characteristics of a vehicle in cornering conditions, experimental measurements in wind tunnels were needed.

This paper presents the application of a modern car simulation technique in cornering conditions. Four analyses were performed under steady conditions, with the air velocity selected at 40 m/s. More specifically, an open-wheeled monocoque model was simplified with the help of SpaceClaim. Using ANSYS ICEM CFD and ANSYS Mesher, four meshes with different cell densities were constructed. Then, a grid independence study was fulfilled to select the ideal grid for the needs of the later analyses. Then, these optimal grid settings were applied to four different geometries, two involving straight-line conditions and two involving cornering conditions. The simulations were concluded with the help of ANSYS Fluent 22 R1, where the k-ω SST turbulence model is selected. The results between the models were compared to obtain a spherical picture of the aerodynamic behavior of the aids, such as the shark fin and the rear wing. Additionally, an evaluation of the simulation method in cornering conditions was made.

Finally, the conclusions drawn from the results were recorded, and proposals for future expansion of the work were presented, both at the level of computational modelling and physical phenomena that occur during cornering.

*Keywords*

Simulation, analysis, cornering conditions, aerodynamic behavior, ANSYS

# *REACTING SIMULATIONS OF TURBULENT, FULLY-PREMIXED PROPANE/AIR FLAMES STABILIZED IN A WEDGE-SHAPED BLUFF BODY UNDER THE INFLUENCE OF REACTANT PREHEAT UTILIZING THE LARGE EDDY SIMULATION MODEL, TWO-STEP GLOBAL CHEMICAL KINETICS AND AN OPEN-SOURCE SOLVER*

**Student's Name**
Charalambous Constantinos
**Student Registration Number**
1049802
Email: up1049802@ac.upatras.gr

**Supervisor:**
Koutmos Panayiotis, Professor
**Contact Info**
Email: koutmos@mech.upatras.gr
Tel.: (+30) 2610 997244

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1049802&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Premixed turbulent combustion is a problem of considerable practical significance, for example in gas turbine combustors, spark-ignition engines, and accidental explosions. Much effort has therefore been devoted to gaining a better understanding of premixed flames to aid in the design of practical combustion systems. The increasing computational capacity in recent years has spurred the growing use of combustion Large Eddy Simulation (LES) for engineering applications.

The object of the present thesis is the simulation of a cold flow and of a turbulent, fully-premixed propane flame, which is stabilized on a bluff-body with a triangular cross-section. The purpose of the work is to study the accuracy of the results through the Large Eddy Simulation. The propane combustion was solved by a general chemical mechanism with 5 species. Chemical kinetic was modeled on the Partially Stirred Reactor (PaSR) model. The Partially Stirred Reactor model is believed to tackle turbulent combustion phenomena better than other existing models because its partially stirred assumption in the finer scales is more relevant to the nature of the problems studied here. Specifically, the model considers the existence of an ideal structure in which the phenomenon of chemical kinetics and turbulent flow field interact and co-exist.

From the results, we can understand the dependence that exists between the numerical methods and the subgrid models and the dependence of the results both on the correct choice of simulation models and in the quality of the grid.

Finally, let us mention that the simulations was executed using the open source software OpenFoam.

*Keywords*

Large Eddy Simulation (LES), Turbulent fully-premixed flame, Bluff body, Numerical error, Partially Stirred Reactor model (PaSR)

# *STATISTICS ON EXPERIMENTAL TEMPERATURE DATA OBTAINED OVER A HORIZONTAL HEATED PLATE*

**Student's Name**
Psaraki Vasiliki
**Student Registration Number**
1064021
Email: up1064021@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064021&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this dissertation the statistical analysis of temperature data obtained over a horizontal heated plate in an open cavity is investigated, in order to study a convective turbulent thermal field. A bibliographic review over turbulent flows, the statistical description of turbulence and Gaussian mixture models is carried out and various types of diagrams are derived accompanied by their interpretation.

Based on the phenomenon of intermittency which appears in turbulent flows, each of the experimental temperature values emerges from the interaction of various air structures that coexist over the heated plate. That is, at each point where the temperature is measured, the thermal flow is not the result of a single air vortex, but of an interaction. Additionally, the homogeneity in turbulent flows is interwoven with a gaussian/normal distribution, whereas distributions that deviate from the gaussian are associated with the existence of intermittent flow fields. The aim is to break down an initial experimental distribution (PDF) into five gaussians distributions. By finding some statistical properties I ventured an attempt to interpret the existence and origin of different air structures that interact with one another in the turbulent flow and eventually some conclusions about where different air structures came from spatially and temporally were drawn.

Using MATLAB, an Unsupervised Machine Learning algorithm, called EM (Exposition-Maximization), is constructed. With the single input of experimental temperature data, the algorithm aims to find the parameters of the individual normal distributions, regenerate the mixture distributions and estimate their probability density. After ensuring that the code effectively fits multivariate Gaussian mixture models to the data several diagrams are displayed. These include the mixture and the five individual PDFs at each measure height in 2D and 3D graphs, the Contour diagrams of the mixtures as well as the Scatter charts of experimental data. This study concludes that very close to the surface there is more homogeneity and suggests that as the distance from the surface grows, local buoyant layers

of fluid (thermal plumes) appear alternately at the measuring points and accelerate away from the hot surface. This indicates the existence of organized structures in the flow that come from different directions and history and create intense turbulence.

*Keywords*

Turbulence, intermittency, gaussian mixture models, PDFs, statistics

# DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMEHANICS (JUNE 2023)

## *THE INFLUENCE OF NANOFILLERS ON THE DAMPING PROPERTIES OF COMPOSITE MATERIALS REINFORCED WITH NATURAL FIBERS*

**Student's Name**
Angelis Charalampos
**Student Registration Number**
1064512
Email: up1064512@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064512&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

The need for more recycling, environmental friendliness, and greater accessibility to raw materials without compromising their properties has led scientists to undertake extensive research aimed at discovering a new category of composite materials. This category is known as "green" composite materials, which are materials whose reinforcing phase consists of natural fibers. Of particular interest to the scientific community are composite materials with flax reinforcement and polymeric matrix. Their dynamic behavior, as demonstrated by studies conducted in recent year, appears to approach, or even surpass that of Glass Fiber Reinforced Polymers.

In such natural composite materials, the possibility of reinforcing them with various nanoparticles is given. Carbon nanotubes, due to their exceptional mechanical and thermal properties, as well as their large specific surface, are widely used as additional reinforcement in composite materials to improve damping and other properties.

Additionally, another type of nanoparticle used to enhance the damping properties of composites is multilayered graphene. Specifically, it is supported that their two-dimensional geometry outperforms the one-dimensional geometry of carbon nanotubes in terms of improving these properties.

The objective of this thesis was to study the damping of nano-enhanced and non, thermoplastic materials, as well as natural composite materials. Initially, samples of High-

Density Polyethylene (HDPE) and nano-enhanced HDPE with 0.5% and 1% wt. content of carbon nanotubes were prepared using the Injection Molding technique.

Subsequently, these materials were used in pellet form to develop nano-modified and non, thermoplastic films. Furthermore, commercially available HDPE pellets reinforced with multilayered graphene at a concentration of 0.8% wt. were used to produce nano-modified films. The developed films were used to manufacture multilayered thermoplastic composites reinforced with glass and flax fibers. From these multilayered composites, the necessary specimens were obtained to conduct Dynamic Mechanical Analysis (DMA) experiments, through which damping was determined by calculating the Loss Factor (tanδ). Finally, an analysis and comparison of the results were conducted to assess the influence of individual materials on the damping of each composite Specifically, the addition of nanoparticles to the polymer did not significantly improve damping. However, the Loss Factor for the composite with flax reinforcement showed an increase of 24.1% compared to that of the composite with glass reinforcement. Finally, graphene nanoparticle reinforcement exhibited the most significant improvement in damping compared to other nanoparticle reinforcements. Several future objects were proposed for the development and improvement of these results.

*Keywords*

damping, carbon nanotubes, flax fibers, dynamic mechanical analysis, loss factor

# *EFFECT OF SALINE ABSORPTION OF THE MECHANICAL BEHAVIOUR OF 3D-PRINTED PLA COMPOSITE SCAFFOLDS*

**Student's Name**
Angelopoulou Alexandra
**Student Registration Number**
1064510
Email: up1064510@ac.upatras.gr

**Supervisor:**
Mihanetzis George, E.E.D.I.P.
**Contact Info**
Email: gpakm@upatras.gr
Tel.: (+30) 2610 969460

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064510&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The purpose of this thesis is the fabrication of 3D porous scaffolds and solid materials made of the biodegradable plastic material PLA through the 3D-printing method and the study of the effect of biological fluid (SBF) on the mechanical properties and topography of their surface after immersion in the fluid. A dynamic magnetic stirrer experiment was designed to mimic blood circulation. Specifically, the degradation of the scaffolds and the % change in their weight after maintaining them in the biological fluid, at a constant temperature of 37° C like in the human body, were studied for different immersion times (t = 0, 1, 3, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84 days). Further on, scanning electron microscope (SEM) images were taken to observe the degradation rate of the scaffolds, and mechanical compression tests were conducted to study the mechanical properties of the scaffolds (elastic modulus and compressive strength). In addition, the mechanical properties (elastic modulus and hardness) of the solid materials were studied, through the nanoindentation technique combined with Atomic Force Microscopy, after immersing them in biological fluid for different immersion times (t = 0.1, 3, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84 days). After the first days of immersion, the competition between the phenomenon of absorption and that of degradation was pronounced. Scanning Electron Microscopy images showed details of the step-by-step degradation process. The structure of the scaffolds was relatively good for one week, but after that the plasticization effect as well as the degradation started to be more pronounced. After 56 days, the scaffolds were significantly damaged and no longer had a cubic geometry. The compressive modulus was degraded by 50% (from 100 to 50 MPa), after 40 days of immersion. The surface properties of solid PLA samples were significantly devalued after 70 days of immersion, with a decrease of the compression modulus from 7 to 4 GPa. The feedback of human stem cells to scaffolds with 100 μm pores was positive. The cells proliferated rapidly in the pores especially in the first 3 days. However, due to lack of space, their mineralization process began quite quickly.

Overall, the designed scaffold is promising for application in bone tissue engineering.

*Keywords*

PLA scaffolds, degradation of biomedical scaffolds, 3D-printing, scanning electron microscopy, moisture absorption

# *AERODYNAMIC OPTIMIZATIION, STRUCTURAL AND ELECTROMAGNETIC ANALYSIS OF GAIA 160HY HEXACOPTER, AIMING TO MINIMIZE ITS ELECTROMAGNETIC TRACE*

**Student's Name**
Alexopoulos Spyridon
**Student Registration Number**
1054542
Email: up1054542@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054542&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present research focuses on the examination of Unmanned Aerial Vehicles (UAVs) and specifically a Hexacopter. The studied Hexacopter was created by the company Foxtech and is the GAIA 160HY – Hybrid model. The purpose of the study is to optimize its aerodynamics to increase the payload capacity carried in each flight and additionally, structural and electromagnetic analyses of its construction materials are conducted to minimize its electromagnetic signature and classify it as a Stealth Aircraft. Using the design software Catia, the complete model of the Hexacopter was designed and a variety of propellers were designed and categorized based on their airfoils, maximum thickness, and pitch, to find the optimal combination. Following the design phase, Ansys a simulation program was utilized to perform the necessary analyses for determining Hexacopter's characteristics. Using the Ansys Fluent tool, both the propellers and the airflow field during the Hexacopter's flight was analyzed and examined to determine the total Thrust and the Pressure on its surfaces. The ACP & Structural tool was used to model and to analyze various combinations of composite materials panels to assess the structural integrity of the Hexacopter under different loads. Significant attention was placed on materials that absorb electromagnetic radiation, Radiation Absorbing Materials, to minimize the electromagnetic signature. The study then transitioned to the Ansys HFSS program, where the electromagnetic response of the Hexacopter was examined within frequency ranges generated by military radar – antennas, ranging from 450MHz to 1GHz, using the Radar Cross Section (RCS) index. Summarizing, the results obtained from the study were promising, both in terms of the Hexacopter's flight capabilities and its invisibility. It was demonstrated that the preferred materials are composites, constructed from Carbon and Kevlar Fibers, as they exhibit the best behavior to electromagnetic radiation. Additionally, future research goals and

development were established, including experimental evaluation procedures for the analytical results, weight reduction, and further optimization of the Hexacopter's flight characteristics.

*Keywords*

Hexacopter GAIA 160HY – Hybrid, CFD, Structural Analysis, Electromagnetics Analysis, Electromagnetic Signature - RCS

# *BOND DEGRADATION OF CORRODED REINFORCED CONCRETE ELEMENTS UNDER INCREASED DYNAMIC LOADINGS (LIFE CYCLE, BOND STRENGTH AND SLIP)*

**Student's Name**
Arapakos Georgios
**Student Registration Number**
1026826
Email: up1026826@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026826&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

As it is widely known, corrosion of reinforcing steel is now recognized as the major cause of premature ageing and degradation of concrete structures in many parts of the world. Particularly, in Greece, a country the major part of which is located in a coastal environment, the high concentration of chlorides favors the phenomenon of corrosion. The electrochemical phenomenon of corrosion in combination with the intense seismic activity of the area, greatly deteriorates the durability of reinforced concrete constructions over time. The main effect of corrosion on the mechanical behavior of reinforced concrete is the deterioration of the steel–concrete interface, which leads to concrete cracking and results in significant degradation of the bond strength. The aforementioned deterioration of the interface is owed to the oxides produced on steel, which occupy greater volume than the parental steel mass. Consequently, the conditions at the interface between steel and concrete are altered, thus limiting the ability to transfer forces.

Taking into account the above-mentioned knowledge, this work focuses on the response of bonding mechanism (steel – concrete) due to corrosion, under dynamic loads. For the needs of the present study, reinforced concrete samples were produced, accelerated corrosion laboratory tests were conducted to simulate corrosion damage on the steel reinforcement examined, and then mechanical pull-out tests were carried out by imposing dynamic loads. The degradation noticed on bonding mechanism of corroded reinforced concrete elements, under increasing Dynamic Loads was captured through the estimation of service life (load cycles), bond strength (maximum force) and relative slip between steel and concrete, considering the level of steel mass loss and the level of clamping through the transverse reinforcement (stirrups). It was proved that corrosion adversely affects the bond mechanism, by rapidly reducing the bond strength and limiting the service life of reinforced concrete under dynamic loads. At the same time, degradation of steel-concrete interface,

due to corrosion impact, allows the development of relative slip and reduces the bond strength between them, as well as it permits the pullout of the bar from concrete, a parameter which is inextricably related to the rotational capacity of the corroded reinforced concrete elements.

The results obtained proved that stirrups provide regional tightening, which maintains bond strength and life expectancy of reinforced concrete. However, stirrups are not capable to prevent the development of relative slip between the two materials. Given the above presented results, further experimental study and analysis is deemed necessary in order to investigate in detail the influencing parameters of the bonding mechanism in corroded Reinforced Concrete elements, when they are stressed under strong dynamic loads (loads originating from strong seismic events).

*Keywords*

Reinforced Concrete, corrosion, bond, slip, dynamic pull-out

# *SIMULATION OF DYNAMIC RESPONSE IN 3D MESH COMPOSITE MATERIAL USING FINITE ELEMENTS*

**Student's Name**
Avgousti Katerina
**Student Registration Number**
1056667
Email: up1056667@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1056667&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the context of the characterization of a 3D woven composite specimen consisting of a carbon fiber reinforced epoxy matrix, dynamic tension and shear experiments were performed with the Split Hopkinson high strain rate testing apparatus, using specimens of 0° and 90° fiber orientation. the specimens with 0° fibre orientation did not fail, showing higher strength than the specimens with 90° fibre orientation. A finite element computational model was then performed in LS-Dyna software, simulating the dynamic response of the composite material, to generate the stress-strain curve and characterize the material. The analysis includes two load cases, one corresponding to the load of the experimental procedure, but also for higher loads to fully investigate the dynamic response of the material at high strains too.

The computational model did not fail after the first pulse, also demonstrating higher strength, as in the 0° fiber orientation tension experiment. When the material was subjected to higher loads during simulation it reached failure, showing high maximum stress, suggesting its potential suitability for high strength applications in industries such as aerospace or automotive.

*Keywords*

Split Hopkinson testing method (SH), Dynamic material response, 3D woven composite material, Finite element model, Simulation.

# *DESIGN, ANALYSIS AND OPTIMIZATION OF AN UNMANEED AERIAL VEHICLE (UAV)*

**Student's Name**
Vlachopoulos Nikolaos
**Student Registration Number**
1054461
Email: up1054461@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054461&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this paper is to develop the basic design of an unmanned aerial vehicle (UAV), which will be electric, with the specifications given.

The following design is based on a structural diagram that details each stage. The weights of the aircraft are calculated in detail (take-off weight, payload weight, empty aircraft weight and fuel weight of the aircraft, for which we have a battery in this case). Then through the mission requirements are found the (W/S)(wing load) and (W/P)(engine power) which are critical variables for the geometry design and also for the aircraft performance, allowing us to determine the drag that the aircraft undergoes in different flight situations. This is followed by the calculation of the centre of gravity based on the geometry developed and the stabilizers where from there the stability of the aircraft is found. Throughout this process, testing of various values is followed to optimize the design at each step.

The UAV will be first analyzed analytically on paper, followed by drawing in a design program(CATIA v5) and analyses of the aircraft aerodynamics in two computer programs(XLFR5, Ansys fluent).

*Keywords*

aircraft design, UAV design, conceptual design, preliminary design, electric UAV

# *NUMERICAL SIMULATION OF THREE-DIMENSIONAL SCAFFOLDS OF DIFFERENT GEOMETRY USED FOR HEALING OF BONE FRACTURES*

**Student's Name**
Kontogiannopoulos Georgios-Christos
**Student Registration Number**
1057790
Email: up1057790@ac.upatras.gr

**Supervisor:**
Polyzos Demosthenes, Professor
**Contact Info**
Email: polyzos@mech.upatras.gr
Tel.: (+30) 2610 969442

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1057790&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The subject of the present thesis is based on the field of tissue engineering and more specifically on cells cultivation with the ultimate goal of tissues growth and generation. The technology of Tissue engineering is mostly used in biomedical issues and in particular in skin, bones and other vital organs injuries and fractures in order to create the appropriate tissues and then regenerate and heal the wounds and weak functions of the respective body parts.

An important factor for successful process of cell culture is the use of bioreactors, which are an essential tool for the appropriate initiation, maintenance, guidance and control of cell proliferation and tissue generation in a three-dimensional and stable environment, that can be used for the medical purposes for which they are intended.

Parts of these important tools, (Bioreactors) are 3D scaffolds, where their use is widespread for the necessary support and shaping of the morphology that needs to be present during tissue creation for the final regeneration of a wound. In order to achieve this, their construction material, geometric characteristics and structure must be appropriately selected, as all these factors are key for the stresses and deformations that will be induced during blood flow, and finally for cell culture and tissue growth.

The above-mentioned issue, of three-dimensional scaffolds, their properties, and the change in their geometry and structure, cause a significant influence on the stresses and deformations that they undergo at all of their points, because of the blood flow and body forces. So as a result, the cultivation process and the tissue-generating environment are also affected. These differences that will arise with changes on the Scaffolds geometry will be discussed in more extensively in this paper, by using finite element modelling.

*Keywords*

Tissue engineering, Bioreactors, 3D Scaffolds, cells culture, Bone healing

# *LASER BASED SURFACE TREATMENT FOR ADHESIVE BONDING OF COMPOSITE MATERIALS*

**Student's Name**
Malafanti Christina
**Student Registration Number**
1064511
Email: up1064511@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064511&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This diploma thesis deals with the investigation of an innovative process for preparing the surface of composite materials for co-bonding using lasers. It consists of three main parts. Firstly, an introduction is provided on composite materials, specifically focusing on Carbon Fiber Reinforced Polymers (CFRP). The method of surface preparation using laser is examined, and the experimental setup with laser characteristics is described. This is followed by a description of the construction of test specimens through bonding with epoxy adhesive. The resulting samples undergo Mode I Fracture Testing experiments to study their fracture mechanical properties. Finally, a statistical investigation and analysis of the experimental results are conducted.

In the introduction, the increasing use of composite materials, particularly carbon fiber reinforced polymers, in structures requiring high specific mechanical properties is mentioned. Applications in aerospace as well as everyday applications are discussed. The need for repair of structures made of composite materials due to damages or degradation and the search for new surface processing methods using lasers are highlighted. The automation of the process and the optimization of the mechanical properties of the co-bonding through laser usage are emphasized.

Next, using a green laser and statistical tools such as Box-Behnken Design, 15 experiments were performed to determine the optimal settings of three parameters: scanning speed, frequency, and distance between scans. Then, Mode I Fracture Toughness Tests were conducted to calculate the Energy Release Rate at crack initiation (G initiation) and during crack propagation (G propagation) for each specimen using R-Curves Method. By utilizing Analysis of Variance (ANOVA), a study was conducted on these factors and the statistical analysis of the experimental results.

*Keywords*

Carbon Fiber Reinforced Composites, Laser, Surface Treatment, Statistical Optimization, Box-Behnken Design, Mode I Fracture Toughness Tests

# *ACCESSING THE ENVIRONMENTAL IMPACT OF AN AIRCRAFT COMPOSITE/TITANIUM ENGINE BLADE: A LIFE CYCLE ANALYSIS APPROACH*

**Student's Name**
Manousaki Ioanna
**Student Registration Number**
1067334
Email: up1067334@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067334&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The current era is widely known for its increasing sensitivity towards the environment and sustainability. The aerospace industry faces increasing demands for structures that are both stronger and lighter. The primary goal of the aerospace industry is to improve aircraft performance by reducing the weight of their structures while, simultaneously, increasing the payload. This is achieved through the application of composite materials, creating lighter and more energy – efficient aircraft. However, the production of a product is closely linked to its overall environmental footprint. In this study, it was investigated the production of an aircraft engine blade made of a 3-D woven composite material consisting of a thermosetting matrix (Resin 2896) reinforced with carbon fiber (IM7) and titanium alloy (TA6V). The composite material was produced using the Resin Transfer Molding method (RTM) and the two materials were bonded together using a structural adhesive film (AF 191). The initial idea and the purpose of the work was to develop an assessment tool for both environmental and social risks that can be generated from the production of the raw materials, the construction of the final products, its use throughout its lifespan and its final disposal or recycling. Specifically, the examination and comparison of four different methods of disposal or recycling of the composite material were carried out using the Life Cycle Assessment (LCA) method and the results were evaluated in various impact areas. The LCA method is used to assess the overall footprint of a product from production to end-of-life. Also, it takes into account the environmental resources used, the greenhouse gas emissions and impacts on the environment and human health. Through this study, it is possible to understand and compare the environmental impact of different disposal and recycling methods for the studied structure selecting the optimal deposition method that combines minimum environmental footprint with high product performance. SimaPro software and the environmental impact assessment method ReCiPe 2016 Endpoint (H) were used to carry out the study examining four cases of composite material deposition: landfill disposal,

incineration disposal, solvolysis recycling and hydrolysis recycling. The results showed that the production of the composite material causes the highest environmental burden compared to the individual components that constitute the overall structure, with the production of carbon fibers having the biggest influence. In addition, the recycling processes perform better due to the energy recovery potential and the co-production of heat and electricity, with solvolysis and hydrolysis being the optimal processing methods as they result in lower impacts on human health, ecosystems and resources. Finally, it was observed that hydrolysis has the greatest positive impact on the environment, as it contributes to limiting the majority of environmental impacts and enhancing sustainability.

*Keywords*

Composite materials, Life cycle assessment, Landfill, Incineration, Solvolysis, Hydrolysis, Sustainability

# *MICROMECHANICAL HOMOGENIZATION OF ADDITEVELY MANUFACTURED COMPOSITES USING SEGMENTED μ-CT IMAGES BY NEURAL NETWORKS*

**Student's Name**
Nikolaou Christos
**Student Registration Number**
1026901
Email: up1026901@ac.upatras.gr

**Supervisor:**
Polyzos Demosthenes, Professor
**Contact Info**
Email: polyzos@mech.upatras.gr
Tel.: (+30) 2610 969442

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026901&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The primary objective of this study was to investigate the use of conventional micro-CT and neural network (NN) algorithms for image processing to accurately visualize and detect the fibers in 3D printed composites and to use the information of the fiber detection in analytical micromechanical homogenization model in order to predict their homogenized elastic properties. To this end, a custom version of YOLO (You Only Look Once) v7 Tiny model was used. The model was trained on manually labeled images of micro-CT results for a 3D printed composite reinforced with continuous Kevlar fibers and another one reinforced with continuous carbon fibers. The micro-CT scans were performed in the Vrije Universiteit Brussel (VUB), in Brussels Belgium and were utilized in this study.

The results demonstrate that the YOLOv7 algorithm was able to capture the boundaries of the fibers accurately leading to clearly defined fibers in the matrix material. Furthermore, the ability to provide results for thousands of images in a few minutes indicates its time efficiency and practicability. Due to the aforementioned factors, the custom version of YOLO v7 is a valuable addition to the scientific literature and can be used by both industry and academic professionals to obtain rapid and accurate results of fibers from micro-CT images.

Finally, the results of the segmented images allowed to measure the volumes of the fibers and the matrix materials and estimate their volume fractions. In turn, the volume fractions were included in seven analytical micromechanical models to estimate the homogenized elastic properties of the single printed filaments of nylon reinforced with Kevlar fibers. The homogenized elastic properties were compared to tensile tests and showed great agreement. Out of the seven models, the best agreement to the most accurate one, the concentric cylinder model of Polyzos et. al., was achieved by the upper and lower bounds of the Hashin-Rosen model.

*Keywords*

Additive manufacturing, micro-CT, Fiber detection, YOLO, Micromechanical homogenization.

# *SIMULATION OF LIQUID SLOSHING IN FLEXIBLE TANKS USING THE SMOOTHED PARTICLE HYDRODYNAMICS AND FINITE ELEMENT METHODS*

**Student's Name**
Ntavarinos Aristeidis
**Student Registration Number**
1059836
Email: up1059836@ac.upatras.gr

**Supervisor:**
Saravanos Dimitrios, Professor
**Contact Info**
Email: saravanos@mech.upatras.gr
Tel.: (+30) 2610 969437/ 2610 962753

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059836&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This thesis focuses on the simulation of liquid sloshing problems in flexible tanks using the ABAQUS/EXPLICIT software, utilizing the smoothed particle hydrodynamics (SPH) and finite element methods (FEM) to model the fluid and solid parts respectively. The simulations involve complex and violent free surface flows with both rigid and deformable structures.

The paper begins by presenting theoretical chapters on the importance of sloshing studies and modeling, as well as separate chapters for presenting the SPH and FEM methods for simulating fluids and solids, respectively. SPH-FEM coupling formulation methods are also presented before the various simulation results to test different phenomena. Rigid tank simulations are performed initially to validate the SPH model's ability to simulate free surface flows accurately and its ability to demonstrate the free surface return to its original position due to viscosity damping inside the liquid.

The simulations are then extended to investigate the sloshing of the tank in sinusoidal excitation at different frequencies to detect the occurrence of resonance and changes in contact forces and pressures in the tank walls due to different frequencies. Impact simulations are also presented to evaluate the effect of the impact velocity of the fluid on the contact pressure on the tank's walls.

Finally, complete fluid-structure interaction (FSI) problem simulations are performed using deformable shell elements for the tank walls, and the effect of the shell's thickness on the tank stress and deformation outputs will be studied to investigate the occurrence of resonance phenomena due to the change of the system's natural frequency. Overall, this paper aims to provide insights into sloshing behavior in flexible tanks and improve the accuracy of sloshing simulations by coupling SPH and FEM methods.

*Keywords*

Smoothed Particle Hydrodynamics (SPH), Finite Element Method (FEM), Fluid-Structure interaction (FSI), Sloshing, Numerical Methods, ABAQUS/Explicit

# *DESIGN AND ANALYSIS OF A 3U CUBESAT FOR MATERIAL EXPOSURE EXPERIMENTS IN SPACE*

**Student's Name**
Dinos Andreas
**Student Registration Number**
1067306
Email: up1067306@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067306&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Space is an unfriendly environment, where the materials of the space shuttle mission are going to face significant challenging conditions. As a result, a big part of the ongoing research concerns the materials' degradation under space conditions. However, the ideal way to achieve this is by sending an actual space shuttle into space, exposing the materials to the environment, and inspecting them in a non-destructive way. Still, the economic aspect is an obstacle for universities to apply their knowledge in this particular research field. On the other side, the participation of universities in aerospace has grown dramatically over the last few years, with more and more technical departments designing and sending nanosatellites into space. The aim of the present thesis is the design a 3U CubeSat, which will include a deployable part for conducting a material exposure experiment in space, recording the samples through a camera, and transferring the results to Earth for further analysis. After completing the necessary bibliographic review, in the first phase all the components of the satellite designed using CATIA are presented in detail. Then and after the required specifications related to the geometry of the satellite have been checked, the deployment part of the structure is kinematically analyzed in the ADAMS software, where three different torsional springs are compared to be used for the purposes of the experiment. Finally, the designed model is imported into ANSYS finite element software in order to perform the necessary analyses and verify its structural integrity, examining its behavior under quasi-static and dynamic loadings.

*Keywords*

CubeSat, Material Degradation, Computer-Aided Design (CAD), Kinematic Analysis, Finite Element Analysis (FEA)

# *DESIGN AND STRESS ANALYSIS OF A TABLETOP TENSION/COMPRESSION TESTING MACHINE*

**Student's Name**
Rojar Reyes Mijalis Alberto
**Student Registration Number**
1059780
Email: up1059780@ac.upatras.gr

**Supervisor:**
Labeas Georgios, Professor
**Contact Info**
Email: labeas@mech.upatras.gr
Tel.: (+30) 2610 969498

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059780&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this diploma thesis is the basic design of a tabletop machine for axial tension and compression capable of 25kN maximum force. Firstly, this thesis covers the general information pertaining fatigue machines, for example the various parts of the corresponding machine, and the design goals such as low overall machine weight, low volume of machine, significant maneuverability of machine and the usage of easily sourced and low cost parts and techniques for the constructionof the machine. Afterwards, the analysis of existing literature is presented, from published papers with similar purpose as of this thesis and the commercially available fatigue machines. Following the analysis of the literature, the underlying theory of the phenomenon called metal fatigue is formulated in the macro and micro scale while also mentioning some generals rules for axial fatigue tests. The various components of the fatigue machine except the frame will be commercially sourced with the actuator specifically being a linear electrical actuator capable of 16kN force. The frame of the fatigue machine is designed using steel beams and aluminium extrusions separately. After multiple different designs aided by finite element simulation of a tensile experiment, the frame of the fatigue machine is decided to be constructed by UPN100 beams welded together to form a rectangle and also strengthening the flanges of the beams with various methods. Similarly using aluminium extrusions and after a number of tension analysis the frame of the machine is decided to be built using aluminium extrusions 90x90 connected together via aluminium assembly plates using bolts and T type nuts. Both of the above frames of the machine can last indefinitely under 25kN load. Also in this diploma thesis a fatigue machine capable of withstanding indefinitely a load of 50kN is designed using aluminium extrusions 135x135, that employs two actuators capable of 10kN force each. Lastly the final form of the machines using the aforementioned frames for each material are showcased and the most optimal one, which is the fatigue machine using aluminium extrusions 90x90, is picked based on the design goals

*Keywords*

designing, analysis, fatigue, fatigue machine, finite element method

# *NUMERICAL STUDY OF FATIQUE DAMAGE DETECTION AND CLASSIFICATION IN THERMOPLASTICS THROUGH RANDOM VIBRATION SIGNALS*

**Student's Name**
Chalkiadaki Eleni
**Student Registration Number**
1054446
Email: up1054446@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054446&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The object of this thesis is the numerical study of the vibration response of composite thermoplastic material with fatigue damage under white noise excitation. The numerical analyses were performed using the LS DYNA computing package.

The specimens studied consisted of 16 orthotropic layers of [-45/0/45/90]2S a polymer matrix of thermoplastic material reinforced with carbon fibers and had dimensions of $250mmx25mmx2.24mm$. The modeled boundary conditions limited the translational movement of the specimen in the y direction at 2 set of nodes. The white noise excitation was modeled using the MATLAB computing package. The frequency domain was used to facilitate the comparison of numerical results with experimental measurements.

Firstly, FRF (Frequency Response Function) and PSD (Power Spectral Density) test analyses were performed to select the appropriate boundary conditions, mesh and white noise load. Then, from the C-scan images of the fatigued specimens, the damage was modeled. The main damage observed was delamination and was modeled by non-merging of element nodes and degradation of appropriate properties in specific layers.

The results obtained were in the form of PSD diagrams. At first, experimental and numerical results were compared for the healthy specimen as well as for the damaged specimens. Then, the 3 main affected natural frequencies as well as damage parameters are presented as fatigue damage detection and classification criteria.

The numerical results have a satisfactory convergence with the experimental ones and small deviations are mainly due to errors during the experiment and to defections during the construction of the material. Strong differences were observed in the vibration responses of the different specimens after the same loading cycles as well as changes after each case of

damage in each specimen separately. The first is due to the construction of the materials which affects the propagation of the damage and therefore a different modeling was done, while the second is due to the degradation of the material due to fatigue which results in the reduction of the natural frequencies. Finally, damage classification was done using damage parameters based on geometry and property degradation, natural frequencies and area from the oscillatory responses.

*Keywords*

thermoplastics, structural health monitoring, vibration-based detection methods, fatigue, white noise, delamination

# DIVISION OF DESIGN AND MANUFACTURING (JUNE 2023)

## *ADAPTIVE CONTROL OF 3D PRINTING DEVICE BASED ON DIGITAL TWIN CONCEPT*

**Student's Name**
Varsamis Antonios
**Student Registration Number**
1067278
Email: up1067278@ac.upatras.gr

**Supervisor:**
Mourtzis Dimitrios, Professor
**Contact Info**
Email: mourtzis@lms.mech.upatras.gr
Tel.: (+30) 2610 910150

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067278&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

In the realm of the fourth Industrial Revolution, digital technologies are constantly integrated in Manufacturing processes in order to improve system reliability, monitor processes accurately and ultimately optimize processes. In order to tackle these issues, advanced simulation techniques such as Digital Twins (DT) have to be developed. Further to that, modern manufacturing systems are based on the integration of non-conventional processes, such as Additive Manufacturing (AM). Therefore, the scope of this thesis is to design and develop a Digital Twin based framework for Fused Deposition Modeling (FDM). The purpose of the Digital Twin is to integrate quality assessment modules, and setup a database for monitoring all the experiment results. Additional modules will also be created and integrated, such as compensating the effects of printing, as well as immersive interfaces enabling the users to control and monitor the machine state remotely. Consequently, one of the key concepts of this thesis is the design of the information flow between the above-mentioned modules for optimizing the FDM process parameters, and thus minimize time and resources caused by human error. The implementation of the proposed framework is based on the integration of suitable communication channels.

*Keywords*

Fused Deposition Modeling, Additive Manufacturing, Digital Twin, Mixed Reality

# *THERMAL FATIGUE DESIGN OF ADDITIVE MANUFACTURED METAL PARTS WITH LATTICE STRUCTURES USING SELECTIVE LASER MELTING METHOD*

**Student's Name**
Kalyva Despoina
**Student Registration Number**
1059755
Email: up1059755@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059755&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Additive manufacturing is more and more used as a primary way of manufacturing to multiple industries from aerospace and automotive, to bio-engineering, architecture and several more, due to its great advantages. For example, lightweighted parts, environmentally friendly production, lower cost, rapid production and so much more. The definition of AM given by the American Society for Testing and Material (ASTM) is as follows. "Additive manufacturing is a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies". The additive manufacturing processes following these steps are being presented as well as their applications. The main goal of the present research is to simulate an additive manufactured model and to compare it with a traditional made one. First, a simple geometry is simulated, a cantilever cylindrical beam. For the additive model, solid material is replaced by an infill of lattice structure. Lattice structures are considered a way to reduce weight while maintaining the required properties. Extra attention is needed in the way of shaping them to avoid high stress, deformation, strain or overhanging areas. Multiple types are being presented and tested through simulation concerning their performance under load. Following that, lattice optimization takes place for the beam and its results are proven better, resulting in it being a more preferable method to simulate the additive manufactured beam. Afterwards, based on the results from the beam, a more compound geometry, a piston, is simulated with the same way, but examined for fatigue failure under thermo-mechanical loads. Finally, the results of the original geometry and the additive manufactured one are compared and discussed.

*Keywords*

additive manufacturing, lattice structure, lattice optimization, thermo-mechanical analysis, fatigue, topology optimization

# *DAMAGE DETECTION IN A THERMOPLASTIC BEAM WITH NON-LINEAR BEHAVIOR UNDER THE INFLUENCE OF MAGNETIC FIELD*

**Student's Name**
Katsalis Christos
**Student Registration Number**
1059839
Email: up1059839@ac.upatras.gr

**Supervisor:**
Sakellariou Ioannis, Assistant Professor
**Contact Info**
Email: sakj@upatras.gr
Tel.: (+30) 2610 969494

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059839&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this Thesis, Structural Health Monitoring (SHM) is performed on a thermoplastic beam constructed by co-bonding four identical thin beams of Lexan together. The beam exhibits inherently nonlinear behavior and is subject to operational uncertainties, as well as the influence of a magnetic field. The monitoring is conducted using stochastic statistical time series methods. These operational uncertainties, due to the varying distance of the magnet from the beam, affect the dynamic characteristics of the structure in a similar way to damages. Therefore, robust methods are necessary for damage detection under uncertainties to eliminate false alarms. The examined vibration signals are generated by stochastic excitation of white noise type, and the system's dynamics are identified using parametric, stochastic, nonlinear models Nonlinear AutoRegressive with eXogenous input (NARX), while comparison with linear AutoRegressive with eXogenous input (ARX) models is also performed. For damage detection, machine learning methods are utilized, based on vibration statistical time series methods, which belong to the broader family of Multiple Models (MM) methods used to represent the healthy dynamics of the studied structure. Thus, damage detection is pursued using MM-NARX, and comparison with MM-ARX models is conducted. For the excitation of the structure, an electrodynamic transducer is used with three different voltage levels: low, medium, and high, and the studied vibration signals are recorded by an accelerometer located at the free end of the beam. The performance of the methods is systematically evaluated based on tens of thousands of cases examined in the Inspection Phase, after the methods have been trained (Baseline Phase), for the healthy and the two damaged conditions. These two damages are categorized as Type 1 damage, which concerns an artificial crack on one of the four Lexan beams, and Type 2 damage, which consists of two artificial cracks on two of the four Lexan beams that make up the overall beam. The results of damage detection are presented through scatter plots and Receiver Operating Characteristic (ROC) curves, showing both applied methods, MM-ARX and MM-

NARX, to work from very well to excellently, with the former achieving excellent results, as the nonlinearity of the beam is deemed weak according to appropriate criteria used, while the latter achieves approximately similar performance with significantly smaller model structure.

*Keywords*

Nonlinear structures, uncertainties, vibration stochastic statistical timeseries methods, damage detection, machine learning based on stochastic Multiple Models

# *STRUCTURAL HEALTH MONITORING IN AN OFFSHORE WIND TURBINE MODEL UNDER VARYING WIND SPEED AND DIRECTION USING MACHINE LEARNING METHODS AND MEASUREMENTS OF VIBRATION SIGNALS*

**Student's Name**
Korolis Ioannis
**Student Registration Number**
1063211
Email: up1063211@ac.upatras.gr

**Supervisor:**
Sakellariou Ioannis, Assistant Professor
**Contact Info**
Email: sakj@upatras.gr
Tel.: (+30) 2610 969494

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1063211&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Structural Health Monitoring (SHM) in Offshore Wind Turbines (OWTs), including early stage damage detection and identification, is of great importance as it directly affects their reliable and successful operation. Vibration signals can be easily and inexpensively collected from an OWT during normal operation, providing rich information about its dynamics that can be effectively utilized for SHM. However, OWTs operate under varying conditions primarily due to wind ambient excitations, which affect the vibration signals in a similar manner to potential damages. Therefore, robust methods are necessary for damage detection and identification in OWTs under varying operating conditions, aiming to eliminate false alarms and downtimes. This study investigates the detection and identification of early-stage damages in OWTs under varying wind speed and wind direction. Machine Learning methods, along with a reasonable amount of vibration signal measurements for their training, are employed. Damage detection is achieved through two statistical time-series Machine Learning methods, namely U-MM-AR and U-MM-PCA-AR. Both methods interpret the healthy dynamics of the OWT using the feature vectors of multiple conventional AR models, with the latter method employing a reduced feature vector obtained via principal component analysis. For damage identification, five Machine Learning methods are explored. The first three are based on the multiple model concept, where two of them (MM-AR and MM-PCA-AR) utilize typical AR models, and the third (MM-PSD) employs Welch-based Power Spectral Density estimation as the sensitive feature with respect to damage type. The remaining two methods, based on the k-NN and K-Means algorithms, also rely on typical AR models for extracting the feature vector, which is used as the feature vector for

damage identification. Vibration signals are captured using a single accelerometer mounted on a lab-scale model of a floating Wind Turbine. The model operates under three different wind speeds and three different wind directions, effectively generated by a typical air fan. The performance of the methods is systematically evaluated based on hundreds of experiments conducted on the healthy OWT model, as well as on a model with three levels of mechanical looseness at the mounting bolts of the core, two different crack levels at the blade, and two different added masses on the blade simulating potential ice accumulation. The damage detection results are presented through ROC (Receiving Operator Characteristic) curves, which demonstrate the overall superiority of the U-MM-AR method for all considered damage scenarios, which achieves 100% correct detection for 2.2% of false alarms. The evaluation of each method in damage identification is carried out using Confusion Matrices, and the results indicate that the MM-PSD method achieves the highest percentage of correct identification.

*Keywords*

Structural health monitoring, damage detection-identification, floating Wind Turbine, Varying Operating Conditions, vibration-based Statistical Time Series methods, Machine Learning methods

# *WEAR PREDICTION OF JOURNAL BEARINGS LUBRICATED BY MAGNETORHEOLOGICAL FLUIDS (MRFs)*

**Student's Name**
Michalos Athanasios
**Student Registration Number**
1059800
Email: up1059800@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059800&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

All modern rotating machines, no matter how complex or sophisticated they are, still rely on fundamental machine elements, the journal bearings, of which their performance in a wide range of operating speeds greatly influences the macroscopic behavior of the respective rotating systems. Recently, many researchers are focused on the design optimization of hydrodynamic bearings via the semi – active dynamic control of their behavior using magnetorheological fluids. These "smart" fluids behave rheologically like Bingham fluids while their viscosity changes when an external magnetic field is applied.

In the current work the numerical simulation of a magnetorheological journal bearing is presented, using ANSYS software package. At first, a 2D axisymmetric magnetostatic model is created to consider for the magnetic flux generation in the lubricant layer and consequently the change of its yield stress from the appliedcurrent load on the electromagnet of the particular model. For the estimation of the performance characteristics of the journal bearing, takes place a 3D computational fluid dynamics (CFD) analysis modeling the magnetorheological fluid as a Bingham plastic in CFX solver of ANSYS, while the problem of the hydrodynamic balance of the journal is solved in a MATLAB script that integrates the numerically computed hydrodynamic pressure distribution to determine the load force components and evaluate the equilibrium point of the journal.

Journal bearing performance parameters, such as eccentricity ratio, attitude angle, pressure distribution and friction forces are presented for several aspect ratios (L/D) and dimensionless shear stress values T0 of the magnetorheogical fluid in the form of classical Raimondi & Boyd charts for a range of Sommerfeld number values. To conclude, it seems that magnetorheological fluids have a promising application from the fact that the load carrying capacity increases as the magnetic field intensity increases, however, at the expense of greater frictional force. Moreover, their wide operating range allows not only for

bearing's operational fine tuning but also for wear compensation on the bushing due to immediate contact between the shaft and bearing during start up and shut down phases.

*Keywords*

Journal bearings, Magnetorheological Fluids, CFD Analysis, Wear Compensation, Smart Fluids

# *TRAINING AND VALIDATION OF DEEP LEARNING MODELS WITH GENERATED SYNTHETIC DATASETS FOR OBJECT DETECTION APPLICATIONS IN MANUFACTURING*

**Student's Name**
Paraskevopoulos Dimitrios
**Student Registration Number**
1059721
Email: up1059721@ac.upatras.gr

**Supervisor:**
Stavropoulos Panagiotis, Associate Professor
**Contact Info**
Email: pstavr@lms.mech.upatras.gr
Tel.: (+30) 2610 910160

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059721&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Object Detection is an essential computer vision task for the industry, as it can be used for counting and inspecting products in production lines. Collecting high-quality datasets for the training of object models is expensive and time-intensive, but when applying object detection to the context of production lines, CAD models of the objects to be detected are often available. Creating a Blender script that can generate photo-realistic images, including bounding box annotations of the object of interest is an alternative option. This Diploma thesis presents an approach of using the CAD model to render synthetic images for training Deep Learning models on object detection. Various experiments are conducted to figure out the ideal parameters for rendering and training, using the suggested metrics for object detection tasks. The experiments demonstrate that the concept of training models solely on synthetic data is promising since the approach is evaluated on real images. Our method is adaptable, which is a huge advantage for object detection in the dynamic environment of the industry. It can lead to considerable cost savings and increased productivity.

*Keywords*

Deep learning, Object detection, Synthetic data, Transfer Learning, CAD models, Artificial Intelligence

# *DEVELOPMENT AND FABRICATION OF A GRIPPER FOR A PERCHING UAV*

**Student's Name**
Rentzou Maria
**Student Registration Number**
1059828
Email: up1059828@ac.upatras.gr

**Supervisor:**
Panagiotis Koustoumpardis, EDIP
**Contact Info**
Email: koust@mech.upatras.gr
Tel.: (+30) 2610 969491

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059828&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This abstract provides an overview of the design and fabrication process of a gripper specifically developed for a perching Unmanned Aerial Vehicle (UAV). The first chapters, focus on the development of the mechanism, starting from the conceptual design to define the requirements and constraints of the problem and ending with a configuration. Following is a detailed analysis of the final mechanism, which incorporates flexible materials at its ends with rigid elements, which act as an exoskeleton, providing support and reinforcement. In addition, its operation is passive, contributing to the low energy requirements of the gripper. Simulations were then carried out to evaluate the strength of the mechanism under expected loads. However, due to the inability to accurately represent soft materials in simulations, a prototype was necessary to test the final mechanism. The fabrication process was 3D printing technology, which resulted in a high-performance gripper, with a simple, fast and cost-effective manufacturing method. Tests were then carried out to assess the gripper's performance in perching. It was also tested in object pick up, involving objects of varying materials, dimensions and geometries. The gripper performed impressively in these experiments. Finally, suggestions are presented in order to improve the functionality and overall performance of the gripper.

*Keywords*

Robotic gripper, aerial manipulation, design

# *TRIBOLOGY OF JOURNAL BEARINGS UNDER THE INFLUENCE OF THE TEMPERATURE FIELD AND THE KINEMATICS OF NANO-ADDITIVES IN THE LUBRICANT*

**Student's Name**
Sykiotis Antonios
**Student Registration Number**
1059821
Email: up1059821@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059821&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Nowadays, lubrication is a rapidly growing practice among a significant number of industrial sectors owning to the fact that by applying substances known as lubricants in various machinery, it contributes to the reduction of the friction and wear that is developed during their operation. Specifically, friction and wear degrade the mechanical and functional properties of machinery causing their failure as well as generate heat energy which results in energy losses. One type of machine element whose functionality, capability and lifespan are greatly dependent on its lubrication is the journal bearing. Journal bearings are widely incorporated into a significant number of industrial equipment in order to prevent and reduce friction and wear between the contact surfaces of two relatively rotating components of the equipment. Throughout the duration of its operation, shearing stresses are developed and heat is generated which is transferred to the lubricant and hence the lubricant temperature increases and tribological properties such as its viscosity are modified leading to an overall degradation of it. Therefore, it is evident that the type of the applied lubricant as well as the lubrication conditions in which the journal bearing operates are crucial factors that have to be investigated and reviewed. It also has to be considered that among the diverse types of applied lubricants, the ones which contain a certain concentration of nanoparticles and are known as nanolubricants represent a major scientific interest in our days.

The purpose of this study is to represent the lubrication properties and mechanisms of nanolubricants and to examine various research that have proposed methodologies to conduct statical and thermal analysis on a journal bearing in order to formulate and write a programming code where this analysis can be performed. This analysis is performed both for an analytical model as well as a numerical-based model, in each of which, a conventional lubricant and a nanolubricant are applied correspondingly with the aim of evaluating the

variation of certain variables as well as validating the beneficial use of nanolubricants. The program is written in two separate files for each model type using the Matlab software, where the results are represented by value matrices and depicted by figures.

*Keywords*

Journal bearing, Lubrication, Conventional lubricant, Nanoparticles, Analytical model, Numerical-based model, Static analysis, Thermal analysis, Finite difference method, Matlab

# *DIAGNOSIS, PROGNOSIS AND ESTIMATION OF REMAINING USEFUL LIFE ON BALL BEARINGS UNDER FAILURE USING CONVOLUTIONAL NEURAL NETWORKS*

**Student's Name**
Tsagkarakis Georgios
**Student Registration Number**
1047354
Email: up1047354@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047354&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Rolling element bearings are one of the most critical mechanical components of various rotary machinery. Their natural operation is necessary for the smooth operation of the whole system. Any deviation from this balance indicates the existence of a fault that urgently needs to be detected and dealt with, in order to avoid its dispersion to the rest of the system and breakdown of the machinery. This task is managed by Prognostics & Health Management (PHM), which aims at early diagnosis and prognosis of the imminent failure. Artificial Neural Networks (ANNs) and Convolutional Neural Networks (CNNs) have shown great advantages in automated fault diagnosis and prognosis without depending on the human factor. In this paper a study of Neural Networks, their supervised learning and their usefulness on diagnostics and prognostics of rolling element bearings is conducted. Their effectiveness is shown after their implementation in vibration data, which have been acquired from the experimental platform PRONOSTIA of FEMTO – ST institute. This paper proved the superiority of 1D CNNs over ANNs in fault diagnostics and their capability in estimation of Remaining Useful Life (RUL) on rolling bearings under the same operating conditions.

*Keywords*

Rolling bearings, fault diagnosis, prognosis, RUL, CNN

# DIVISION OF ENERGY, AERONAUTICS AND ENVIRONMENT (JUNE 2023)

## *PASSIVE COOLING OF BUILDINGS AND COOL MATERIALS: SENSITIVITY ANALYSIS OF RADIATIVE COOLERS*

**Student's Name**
Valimitis Dimitrios
**Student Registration Number**
1064506
Email: up1064506@ac.upatras.gr

**Supervisor:**
Michalakakou Giouli, Professor
**Contact Info**
Email: pmichala@upatras.gr
Tel.: (+30) 2610 969478

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064506&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

Over the last decades the effect of climate change can be seen in the rising global temperatures. Climate change is a big contributor to the urban heat island (UHI) phenomenon, where in urban areas there is an air temperature increase in conjunction with the one from climate change. Given the severe thermal discomfort, both indoors and outdoors, due to this phenomenon there is a trend of increasing the use of active cooling of buildings using ventilation and air-conditioning. This creates a two-fold problem, it increases energy consumption in the summer months as well as it adds more heat to the already saturated urban environment. The use of cool material in roofs and pavements can reduce the surface temperature significantly, thus offsetting the heating effect of conventional ones (which is one of the main contributors to UHI). While the use of passive cooling of buildings using nocturnal and diurnal radiators has also shown promising results. With that in mind a sensitivity study was performed on a nocturnal radiator, using the weather data that were captured from the area of Patras for the whole month of August of 2005. The sensitivity study focuses on the output air temperature of the radiator, while it has been performed in two scopes. The first scope focuses on the sensitivity analysis with regards to the design parameters of the radiator, namely the radiator's material, internal wind speed and overall dimensions. While the later focuses on the environmental parameters, namely the external wind speed and cloud coverage.

*Keywords*

Urban heat island (UHI), climate change, passive cooling of buildings, nocturnal radiator, sensitivity analysis

# *EXPERIMENTAL STUDY OF REACTION TO FIRE OF THERMOPLASTIC MATERIALS USING THE CONE CALORIMETRY METHOD*

**Student's Name**
Diamantopoulos Dionysios
**Student Registration Number**
1026284
Email: mead6335@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026284&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this thesis is implemented the study of the behavior of some specific forms of polyethylene based on their reaction to fire. The materials under study are intended for cable insulators. This is an experimental work that was implemented with the help of a cone calorimeter, with which the appropriate measurements were done to carry out the corresponding calculations.

First, the material the work deals with is described, as well as its main uses and properties. Then there is a description of the cone calorimeter as well as the process of preparation and execution of the experiment, based on the international standard ISO 5660. More specifically, during the execution of the experiment, the respective material is forced to ignite, and its behavior is observed as it burns, as variables such as the time it took to burn, the weight of the combustion waste, the gases production during this specific combustion process, and others are measured.

Then, the outputs of the experiment are presented, with the of the necessary calculations that were made to characterize the attributes of the materials in reaction to fire and their classification in the European EUROCLASS system. Finally, the conclusions of the study are presented in relation to the safety of use of the materials under consideration in industry.

*Keywords*

Polyethylene, Fire protection, Cone calorimeter, Reaction to fire

# *EXPERIMENTAL INVESTIGATIONS OF FLOW CONTROL TECHNIQUES*

**Student's Name**
Zachos Panagiotis
**Student Registration Number**
1059838
Email: up1059838@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059838&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The main goal of flow control is to improve the aerodynamic characteristics of the aircraft. This improvement includes the reduction in total drag and stall phenomenon. The concept of the dimpled aircraft wing is constantly gaining interest lately, as a way to achieve these improvements in aerodynamic characteristics. The introduction of dimples on the wing surface creates turbulence by creating vortices which delay the boundary layer separation resulting in decrease of drag and also increase in the angle of stall. The main objective of this paper is to present the three main systems that make up the experimental setup, the modified wing, the aerodynamic force balance and the pneumatic system responsible for the changes in pressure inside the wing. Then, the description of the experimental procedure, the five different dimple depths considered ( 0 mm, 1 mm , 1.5mm , 2mm , 2.3mm) and the angles of attack considered ( 0° – 20° ). In addition, the equations for calculating the aerodynamic quantities of lift, drag and pitching moment are derived and the results of the experimental procedure are presented. Finally, the results are evaluated and the show a decrease in total drag, following by a simultaneous decrease in lift, keeping the L/D ratio almost the same for angles of attack close to stall phenomenon.

*Keywords*

Drag, boundary layer separation, flow control, dimples, aerodynamic characteristics

# *NUMERICAL STUDY ON THE INTERACTION BETWEEN COAXIAL FLOWS WITH SWIRL*

**Student's Name**
Liapis-Raikakos Christodoulos
**Student Registration Number**
1054453
Email: up1054453@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054453&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This paper deals with the computational investigation of the interaction between coaxial and parallel flows with swirl under conditions approaching those of vortex breakdown. This investigation is carried out computationally using the ANSYS Fluent program and then the results obtained for four different sets of initial and boundary conditions are compared with the corresponding experimental data.

Computational fluid dynamics aim to derive approximate solutions for various problems of fluid dynamics and heat transfer. Packages such as ANSYS Fluent are essentially solvers of P.D.E systems equipped with physical and turbulence models, as well as the ability to create computational grids and post-processing the results of their analysis.

Swirling flows are a phenomenon with wide applications in the technological field and mainly in flow fields, both in inert jets and in reactive flows. Some of their advantages are the improvement of flow stability and dispersion as well as mixing rations between flows.

One of the most complex phenomena in swirling flows is the phenomenon of vortex breakdown. This phenomenon is defined as a disturbance characterized by an internal stagnation point of the flow followed by a flow reversal in a region of limited axial extent. Despite the intense study of the phenomenon, there has been no fully acceptable interpretation of it, which reveals its wide complexity.

After presenting the procedures of modeling the apparatus, creating the geometry and mesh as well as defining the initial and boundary conditions, the results are presented and then compared with the corresponding results of the experimental investigation in order to draw conclusions.

*Keywords*

Computational Fluid Dynamics (CFD), swirling flows, coaxial flows, vortex breakdown, ANSYS Fluent

# *STUDY OF ANALYTICAL SOLUTIONS FOR THE PREDICTION OF THE ACOUSTIC FIELD AROUND A SEMI-INTINITE RIGID WEDGE*

**Student's Name**
Marketou Anastasia
**Student Registration Number**
1067322
Email: up1067322@ac.upatras.gr

**Supervisor:**
Menounou Penelope, Assistant Professor
**Contact Info**
Email: menounou@mech.upatras.gr
Tel.: (+30) 2610 969462

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067322&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the present thesis the problem of diffraction of a spherical and plane signal incident on an acoustically hard wedge is considered. The spherical signal is studied through three approximate solutions, two existing (one of 2 and one of 4 terms) and one new (one of 4 terms), and the exact solution. The exact solution is brought into a new form, so its integrability is proven. Under a small time assumption the new 4 – term approximate solution is formed from the new form of the exact solution. The three approximate solutions are compared for their accuracy and computation times. For each of the approximate solutions a characteristic quantity is derived that allows the a priori estimation of the time evolution of the diffracted signal (its amplitude and its time wave form). Comparisons of these quantities and the diffracted signal show that the proposed quantities indeed offer an a priori prediction of the time evolution of the diffracted signal without the need for calculating diffraction. For the existing 4 – term approximate solution a further study of its characteristic quantity leads to equations for the positions of the Shadow Boundaries for every angular combination of source – wedge. The results are presented in a Figure that describes to which term the Shadow Boundaries correspond. For the same approximate solution, the Mapping theory that has been presented for the 2 – term approximate solution is extended. Additionally, the diffraction of plane signal is studied and a new exact unit step response is presented. That solution is analyzed for specialized wedge angles.

*Keywords*

Diffracted signal, Analytical solutions, Time domain, Unit step response, Characteristic Quantities

# *COMPUTATIONAL SIMULATION OF FIRE DEVELOPMENT INSIDE A BUILDING, USING OPEN SOURCE SOFTWARE*

**Student's Name**
Pettas Dimitrios
**Student Registration Number**
1051347
Email: up1051347@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1051347&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Fires in enclosed living spaces such as apartments, houses and office and workspaces have particular characteristics and, due to the associated human activity, particular importance due to the potential for loss of life and destruction of property. Therefore, the investigation and analysis of the evolution of these phenomena is extremely important.

In this thesis, the evolution of the fire in a small two-room apartment was examined, which was considered to be caused by carelessness/negligence of the occupant (lighted cigarette falling on a piece of furniture). The FDS platform was utilized where the problem was appropriately modeled and simulation based on computational fluid dynamics was performed.

The results of the simulation in general confirmed what was expected in relation to the evolution of the fire mentioned in the relevant literature.

*Keywords*

FDS, apartment fire, fire simulation, computational fluid dynamics

# *BUILDING INTERGRATED PV SYSTEMS - APPLICATION IN CLIMATIC ZONE C*

**Student's Name**
Politidis Antonios
**Student Registration Number**
1054569
Email: up1054569@ac.upatras.gr

**Supervisor:**
Michalakakou Giouli, Professor
**Contact Info**
Email: pmichala@upatras.gr
Tel.: (+30) 2610 969478

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054569&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

First of all, the main subject of this thesis is photovoltaic systems as well as the energy management of a building which is located in climatic zone C area and contains building - integrated photovoltaic systems. This thesis includes 2 parts. The first one is the bibliographical part and the second part is the computational part.

The first part includes information about photovoltaic systems that have been collected by bibliographical research. The first part includes 3 different chapters.

The first chapter begins with a reference to renewable energy sources, solar energy and semiconductors and then it continues with a reference to the photovoltaic effect and photovoltaic systems and there is a description of the way they operate. After that there is a presentation of the different parts that a solar panel consists of, and next there is an analysis of the subsystems that form a photovoltaic system.

In the second chapter there is an analysis of the different types of solar cells which may differ in their construction materials or manufacturing processes for example. Moreover, there is a categorization for photovoltaic systems and then there is an analysis for each one of the categories. In all previous chapters there is extra material including pictures and shapes for plenitude purposes.

In the third chapter, there is a reference and analysis of the technical specifications of solar panels and there are extra graphs and sketches for better understanding. In the end there are some extra pictures showing different solar cell applications.

The second part of this thesis which is the computational part, contains calculations about the energy behavior of a building which is studied with some simplified assumptions. The calculations are made for both cases where either there are photovoltaic panels integrated in the building either not. In this part there are all the formulas that are necessary for the

calculations as well as the results of the calculations. Finally there are comments and observations about the results, the conclusions of the study and there are also some suggestions. This part includes 2 chapters.

In the fourth chapter there is an analytic presentation of the problem which is studied in this thesis and also all the formulas which are necessary for the calculations are presented. Furthermore there are many charts with the results of the calculations.

The fifth chapter contains some graphs based on the results of the calculations and there are some comments and observations about the graphs. The chapter ends with some conclusions about the study and some suggestions.

*Keywords*

solar cells , building-integrated photovoltaic systems , energy management , solar energy , renewable energy sources

# *COMPUTATIONAL INVESTIGATION OF THE EFFECT ON THE FLOW AND THERMAL FIELD IN A RECTANGULAR CROSS-SECTION DUCT WITH CONSTANT WALL TEMPERATURE, OF A CROSS-SHAPED FLAT PLATE WITH HOLES, FOR DIFFERENT NUMBER OF HOLES AND REYNOLDS NUMBERS*

**Student's Name**
Poulopoulos Ioannis
**Student Registration Number**
1047340
Email: up1047340@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047340&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The scope of the present thesis is the study of the effect of a cross-shaped flat plate with holes, which is functioning as a vortex generator, on the thermal and flow field of a rectangular cross- section duct with constant wall temperature. Vortex generators have been characterized as efficient geometrical aids used in fluid dynamics applications in order to induce secondary flows and reconstruct the flow field. The purpose of the investigation is to enhance the heat transfer lengthwise the duct by simulating 4 geometrical models, which differ in the number of holes in the longitudinal section of the inclined cross-shaped ramp, for Reynolds numbers 5000, 10000, 15000 and 20000. The computational investigation is based on Computational Fluid Dynamics (CFD) and is carried out using Ansys Fluent software.

First, a theoretical introduction to fluid mechanics and heat transfer is given, with emphasis on turbulent flows, secondary flows, forced convection and heat transfer enhancement with vortex generators. An introduction to computational fluid dynamics, Reynolds-averaged Navier-Stokes (RANS) equations, and turbulence modeling follows, too. Afterwards, the modeling process in Fluent is described, where the geometry design and the mesh generation of the simulations are taking place. Thereafter, the k – ε Realizable turbulence model is chosen for the solution phase, while an air inlet temperature equal to 273 K and a constant wall temperature equal to 650 K are applied.

In the first stage, the simulations of the four models for Re=10000 are carried out and the results are compared, both with each other and with the corresponding results for the same flow in a plain duct. The comparison is mainly focused on the bulk temperature $T_{bulk}$ and the heat transfer coefficient $h$ along the duct, the Nusselt number, as well as the friction coefficient $f$. The same procedure applies for the models for the rest of Reynolds numbers and the most efficient model is proposed in each case. Finally, general observations from this study, as well as suggestions for future research, are presented.

*Keywords*

Heat transfer enhancement, Vortex generator, Computational fluid dynamics, k – ε turbulence model, Ansys Fluent

# *NUMERICAL SIMULATION OF FIRE IN A SCHOOL*

**Student's Name**
Rigakos Georgios
**Student Registration Number**
1047318
Email: up1047318@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047318&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This paper focuses on the study of fire safety within indoor spaces, specifically in the context of a fire outbreak in a school classroom. Investigating the spread of fire within a building and accurately predicting the ease of evacuation in such scenarios is of significant interest, as regulations impose strict requirements for the proper design of buildings to ensure the safe and efficient evacuation of occupants during fire incidents. Extensive literature exists on these topics, including the development and use of simulation models and software for fire spread dynamics within buildings or building evacuation modeling, as well as real-time experimental studies.

The objective of this research is to conduct a scientific study that examines various aspects of a fire incident within a school facility or complex, referred to as a school unit. The study aims to explore and analyze multiple factors, such as ambient temperature, the use of fire protection systems, fuel characteristics, ventilation systems, and more, associated with a fire within a school unit.

To achieve this goal, a series of simulations are performed within the spaces of an actual school unit, using approved software widely used by the scientific community to investigate similar fire-related issues. The software allows for high-parameterization fire scenarios and provides visual representations of the simulation results.

Through these simulations, critical parameters related to fire incidents within a school unit are identified and conclusions are drawn. Further investigation can be conducted to explore ways to limit these parameters, such as controlling the temperature within the environment or regulating their rate of increase, ultimately enhancing the safety and ease of evacuation for individuals within these spaces.

The structure of the thesis includes an overview of fire simulation software, modeling methods, and their purposes in Chapter 2. Chapter 3 provides an extensive description of the fundamental capabilities of the FDS and smokeview software. Chapter 4 presents simulations conducted in specific spaces corresponding to real school facilities, particularly a

school complex. Chapter 5 presents the conclusions drawn from the study. Chapter 6 includes the source code used for the simulations. Finally, the last chapter lists the references utilized, which served as the foundation for this research.

*Keywords*

Fire Safety, Indoor Fire, Building Evacuation, Fire Spread, Simulation Modeling, Fire Protection Systems, School Building Modeling, Fire Dynamics, Heat Release Rate, Parametric Scenarios, FDS Software, Smokeview Software, Simulation Results, Critical Parameters, Fire Temperature, Heat Release, Combustible Materials, Ventilation, Sprinklers, Safety Measures, Code Implementation

# *SEMI-EMPIRICAL FORMULAS FOR THE PREDICTION OF THE ACOUSTIC FIELD AROUND A WEDGE*

**Student's Name**
Salagas Sotirios
**Student Registration Number**
1059797
Email: up1059797@ac.upatras.gr

**Supervisor:**
Menounou Penelope, Assistant Professor
**Contact Info**
Email: menounou@mech.upatras.gr
Tel.: (+30) 2610 969462

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059797&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present diploma thesis analyzes new approximate solutions for the prediction of acoustic diffraction field around a semi-infinite acoustically rigid wedge in the frequency domain. Firstly, the 4-term modified Directional Line Source Model (mDLSM 4-term) in the frequency domain is extracted from an approximate time domain solution for spherical, cylindrical and plane incident waves (Menounou, Spiropoulos, & Nikolaou, 2023) and then is reformulated in a unified form. The behavior of the approximate model is examined and compared with both the exact Oberhettinger solution (Bowman-Senior, 1969) and the approximate mDLSM 2-term solution (Menounou, Spiropoulos, & Nikolaou, 2023). It is worth noting that the results of the new solution are in better agreement with the exact solution, compared to the results obtained by the corresponding 2 term solution. The accuracy of the new solution depends on the wedge angle, the frequency and the receiver position, while the model remains valid everywhere with the exception of extremely low frequency-distance cases. Subsequently, a model based on the analytical solution of the 4-term mDLSM is developed. The model approximates the mDLSM via a non-linear least squares method, while extensive numerical comparisons have shown almost identical behavior and accuracy between the 4-term mDLSM and the new least squares solution. Note that the new solution consists entirely of mathematically simple functions, resulting in computational times orders of magnitude lower than those of the original 4-term mDLSM. Moreover, measurements of the accuracy and computational time of the least squares solution are made and compared directly with the well-known semi-empirical model Nord2000 (Plovsing-Kragh, 2001), where the accuracy of the new solution is comparable while the computational cost is significantly lower. Finally, a new semi-empirical extension of the least squares solution for very low frequency applications is briefly analyzed.

*Keywords*

Diffraction, Frequency Domain, Wedge, Approximate Solutions

# *SIMULATION OF AIRFLOW AND THERMAL FIELDS IN A RECTANGULAR CROSS SECTION PIPE PRODUCED FROM A CURVED VORTEX GENERATOR WITH AND WITHOUT HOLES FOR DIFFERENT GEOMETRIC ARRANGEMENTS AND DIFFERENT FLOW AND THERMAL BOUNDARY CONDITIONS*

**Student's Name**
Stergiou Petros
**Student Registration Number**
1026955
Email: mead7048@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026955&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this thesis is to investigate phenomena that take place in a rectangular duct where air flows, such as the characteristics of the flow, the heat transfer from the heated walls of the duct to the fluid and the pressure drop. Inside the pipeline, and at a given distance from the fluid inlet cross-section, a Vortex Generator with a curved cross-section is placed, which also includes a hole with a circular cross-section. In general, the effect of the geometric characteristics of the vortex generator is examined, namely the ratio of its height to the height of the pipeline, as well as the ratio of the area of the hole to the total area of the generator. The results where the work focuses concern the heat transfer to the fluid from the heated duct walls and the pressure drop inside the duct with the aim of highlighting the best generator geometries in each case.

The modeling of the problem took place in ANSYS and the simulation of the considered cases took place using computational fluid dynamics in the ANSYS Fluent platform.

The results of the geometry and boundary value cases of the problem are presented both separately and aggregated for better understanding by the reader.

*Keywords*

ANSYS-Fluent, Flow in a Duct, Heat Transfer, Pressure Drop, Vortex Generator, Nusselt Number

# *NUMERICAL INVESTIGATION OF NANOSECOND PLASMA ACTUATOR*

**Student's Name**
Tzirtzilakis Ilias
**Student Registration Number**
1054478
Email: up1054478@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054478&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The scope of this paper is the 2D numerical simulation of a shock wave, in quiescent air, which is created during the generation of a single voltage pulse in an ns DBD plasma actuator configuration, through the usage of OpenFOAM. Concentrating almost exclusively on the fluid-dynamic phenomenon, we tried at first to interpret the way of creation of the shock wave focusing on its distinct geometrical characteristics. We concluded to attributing this to two reasons. The first of them has to do with the rapid transformation of the electric energy to thermal energy connected to the formation and deformation of the plasma which is created after the discharge. The second reason, which is associated with the geometric structure of the induced shock, refers to the use of thermal energy for the heating of a very specific shape of surface. Afterwards, by adopting a technique suggested by Zheng et al. [1], we created a suitable environment in OpenFOAM, which we used to perform numerical simulations and compare our results with other numerical simulations of public literature. Finally, we compared our results with experimental measurements. Through analyzing our results, we came into the realization that the induced shock wave demonstrates characteristics similar to those of a blast wave. Based on this, we present a description and an interpretation of the whole phenomenon, with respect to all the different phenomena which take place, while at the same time proceeding to a characterization of the shock wave dynamics.

*Keywords*

Flow Control, Blast wave, OpenFOAM, CFD, ns DBD plasma actuator

# *COMPUTATIONAL INVESTIGATION OF THE EFFECT ON THE FLOW AND THERMAL FIELD IN A RECTANGULAR TUBE WITH WALLS AT CONSTANT TEMPERATURE, OF TWO VORTEX GENERATORS, TYPE DELTA AND RECTANGULAR WING, FOR DIFFERENT HEIGHTS OF THE WING, IN TURBULENT FLOWS*

**Student's Name**
Floudas Nikolaos
**Student Registration Number**
1047343
Email: up1047343@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047343&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The subject of the present diploma thesis is Vortex Generators, as they are a convenient method of passive heat transfer enhancement. In particular, the effect of Delta Wing and Rectangular Wing on the flow and thermal flow field of a rectangular cross-section pipe is examined. The research has been carried out for six different cases: three considering Delta Wing and three considering Rectangular Wing, which differ in the dimensions of the Wings. The Wings have been studied in terms of their height, while keeping the angle with the plane of the duct constant in all cases. Initially, the fundamentals of Fluid Mechanics and Heat Transfer are presented, and an introduction is provided for Computational Fluid Dynamics using Ansys Fluent, the software used to perform the simulations. In the simulation part, the geometries to be studied are constructed, and the meshing is carried out according to the necessary grid independence study that accompanies it. The optimal number of computational elements required is determined. The k-e Realizable turbulence model is chosen for the solution, and the boundary conditions are defined along with the convergence criteria. The software carries out the simulation. The first simulations took place for a Reynolds number of 5,000 and continued for 10,000, 15,000, and 20,000. Comparing the two Vortex Generator types, the Delta Wing is preferable to the Rectangular case as it provides a more effective combination of increases in the heat transfer coefficient and the friction coefficient. In conclusion, the size of the Vortex Generator is an important parameter, and the case with the lowest height yields the best overall results for each type.

Increasing the Vortex Generator size leads to an increase in the Nusselt number along with a significant increase in the friction factor coefficient and a decrease in efficiency.

*Keywords*

Vortex Generator, Heat Transfer, Turbulent Flow, Computational Fluid Dynamics.

# *STUDY OF DESIGN METHODOLOGIES OF A SOUNDING VOCKET*

**Student's Name**
Frysira Dimitra-Aikaterini
**Student Registration Number**
1059792
Email: up1059792@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059792&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The objective of this thesis is the basic design of a sounding rocket which meets specific requirements. These requirements are to reach an altitude of 1000 to 1200 m and to be able to carry a payload weighing 1 kg, with optimal specific impulse and minimum possible drag coefficient to lift coefficient ratio ($C_D/C_L$). The study is performed using OpenRocket software and the CFD program Ansys Fluent along with literature knowledge. OpenRocket calculates the design characteristics and the flight envelope of the rocket while Ansys Fluent calculates its aerodynamic characteristics. For the final selection of the shape and characteristics of each rocket part, trials of the possible options are carried out and finally the one that meets the requirements as closely as possible is selected. The outputs of the two programs are used in a complementary way to draw a conclusion and make the final choice. In the CFD program, simulations are performed on the discretized, unstructured-mesh, rocket and, structured-mesh, outer domain for six angles of attack and ten flow velocities each, which give a complete flight profile of the given rocket. The various individual parts of the rocket (nose cone, nozzle, fins) are first presented, as well as what each is used for, the various shapes they can take and the characteristics of each shape. The concept of stability in a rocket is also introduced, how it is calculated and how its value affects the flight of the rocket. Regarding the choice of engine, after testing several models in OpenRocket, the greater possible thrust with the lowest propellant mass is chosen. The motor nozzle is a convergent-divergent nozzle. For the nose cone the shape chosen is Von Karman with a fineness ratio of three and for the fins the final shape is trapezoidal with an aspect ratio of 1.33. Based on the dimensions of the engine and literature research, the dimensions of the other rocket components were calculated. Finally, as for the stability of the rocket, it is found to be slightly ultra-stable.

*Keywords*

Sounding rocket, Specific impulse, Drag coefficient to lift coefficient ratio, Nose cone, Fins

# *THE EFFECT OF DEMAND ELASTICITY IN PRODUCTS OF SUCCESSIVE TECHNOLOGIES ON EMPLOYMENT: ANALYSIS USING SYSTEM DYNAMICS*

**Student's Name**
Kallinteri Dafni-Konstantina
**Student Registration Number**
1059793
Email: up1059793@ac.upatras.gr

**Supervisor:**
Adamides Emmanouel, Associate Professor
**Contact Info**
Email: adamides@mech.upatras.gr
Tel.: (+30) 2610 969475

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059793&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present thesis investigates technological unemployment. An optimistic view states that technology, by reducing the production cost, results in higher demand. Thus, a re-employment of employees substituted by automation can occur in order to support the increased demand. The study focuses on the question whether elasticity of demand is appropriate to outweigh the negative impact of automation technology on employment. A model based on the system dynamics methodology has been developed addressing an industrial sector of products at a national level for a relatively short period of time. For the qualitative modeling, the problem is separated into subsystems and the main causality links between the variables of the system are drawn. For the quantitative modeling, a stock and flow diagram is constructed and the dynamic model is simulated using the software program iThink. Validity tests are performed to ensure the compatibility between the qualitative and quantitative models and the independence of the dynamic model from the initial conditions. Different elasticity scenarios are examined, and the results indicate that high elasticity can have a positive effect on employment when implementing automation technology.

*Keywords*

Elasticity of Demand, Employment, Technological Innovation, System Dynamics

# *GREEK PASSENGER AIRLINES' BUSINESS MODELS*

**Student's Name**
Kanakaris Ioannis
**Student Registration Number**
1025740
Email: mead5778@ac.upatras.gr

**Supervisor:**
Adamides Emmanouel, Associate Professor
**Contact Info**
Email: adamides@mech.upatras.gr
Tel.: (+30) 2610 969475

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1025740&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The specific purpose of this thesis is to highlight the importance of the aviation industry in Greece, to identify the problems and opportunities that may arise over time, and to present various analytical tools and modeling methods that help analysts analyze the industries and companies under investigation.

To achieve these objectives, the thesis initially presents Porter's Five Forces Theory (Chapter 1). Porter, an American academic and economist, developed this theory, which analyzes every industry by examining its five basic components. These components are: (1) the power of buyers, (2) the bargaining power of suppliers, (3) the threat of new entrants (barriers to entry and exit), (4) the threat of substitutes, and (5) the competitive rivalry among existing companies.

Next (Chapter 2), some economic data are presented to demonstrate the significance of the aviation industry on a global scale. This is followed by a presentation of general and economic information about the corresponding industry in Greece (Chapter 3).

In the next chapter (Chapter 4), the thesis introduces System Dynamics, programs that utilize mathematical relationships and processes to model industries or businesses and predict their evolution over time by assuming specific parameters and assumptions. One such program is Stella – iThink (Chapter 5).

Specifically, using iThink, we design a model of the aviation industry in Greece (Chapter 6) and simulate its processes over a decade. Based on the results, we can identify the pathologies, risks, and opportunities that may arise over time.

With these results, we examine certain scenarios involving changing conditions, such as fuel prices, customer trends and preferences, the impact of increased expenses due to competition, and the consequences of competition from alternative means of transportation. Taking all these factors into account, we conclude the thesis by presenting the findings derived from the design, decade-long simulation, and study of specific scenarios. By combining these findings with the analysis of Porter's Five Forces, we can determine which factors positively or negatively affect the industry and to what extent.

*Keywords*

Air transport, Porter, iThink, Airplanes, System Dynamics

# *DEVELOPMENT OF INDUSTRIAL APPLICATION USING AI TECHNOLOGIES*

**Student's Name**
Paspaliaris Stamatios-Marios
**Student Registration Number**
1048418
Email: up1048418@ac.upatras.gr

**Supervisor:**
Karakapilidis Nikolaos, Professor
**Contact Info**
Email: karacap@upatras.gr
Tel.: (+30) 2610 969480

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1048418&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this thesis is to develop an AI system to support predictive maintenance decisions in industry. At the core of the implementation of these systems are Machine Learning algorithms. Based on this assumption, at a first level the paper focuses on presenting the implementation techniques, critical parameters and scopes of three main supervised Machine Learning algorithms. In particular, the algorithms chosen are decision trees, the Naïve Bayes classifier and the nearest neighbours (k-NN) algorithm. In addition, emphasis is also placed on the pre-processing stage of the data, which is considered particularly important for the efficient implementation of the algorithms, and the metrics for evaluating the effectiveness of the algorithms are listed. At a second level, the set of techniques is applied to real industry data. The results obtained from the implementation of different combinations, showed that the k - NN algorithm, is the most efficient over the others, achieving efficiency values ranging from 87% to 90%, depending on the choice of implementation parameters. Satisfactory results were also obtained by the Naïve Bayes classifier, while decision trees had significantly lower efficiency in the set of combinations considered.

*Keywords*

Artificial Intelligence, Machine Learning algorithms, Supervised learning, Industrial Equipment, Predictive Maintenance

# DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS (SEPTEMBER 2023)

## *TOPOLOGY OPTIMIZATION OF 3D PRINTED LATTICE STRUCTURES USING MACHINE LEARNING ALGORITHMS*

**Student's Name**
Athinaios-Athinadis Loukas
**Student Registration Number**
1059811
Email: up1059811@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059811&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

The rapid advances in technology in recent decades have resulted in the demand for materials with improved performance and mechanical behavior, as well as properties not found in ordinary natural materials. A new class of materials, lattice structures, provides a solution. The design freedom that distinguishes them gives them a strong element of design flexibility, with the possibility of achieving unusual properties adapted to the application in question.

This freedom, however, also creates the problem of finding the right design model of lattice structure for each case. There are many design variables and thus the possible combinations lead to many different configurations and create a vast picture for the engineer. Machine learning and in particular evolutionary algorithms can largely address this obstacle. Through the examination of possible models, they offer the possibility of optimization and finding the model that best satisfies the requirements of the problem.

In this study, the topology optimization of lattice structures subjected to compressive loads, using the Covariance Matrix Adaptation Evolution Strategy algorithm (CMA-ES), is presented. Two different optimization loops were performed, the first one focusing on the minimization

of the mass-to-compressive-strength ratio while the second one on the mass-to-resilience ratio. The procedure involved the use of the programs nTopology (3D design of the lattice) and Abaqus (compression simulation). The cooperation of the algorithm with the programs was performed using code in Python programming language, thus automating the process. For each optimization 10 iterations were performed, considering 4 candidate models in each one. Finally, the optimal model was 3D printed and subjected to a compression experiment to verify the results.

Both optimizations output the same model as optimal (lattice with Iso-truss cell, cell side dimension 8.333mm and 2mm strut thickness). An increase in strength of up to 293% was observed, while the objective functions (mass/strength, mass/resilience) improved by -54% and -64% respectively, compared to the second-best solution. Moreover, it is worth noting the observation that with an increase in structure density, the strength improvement obtained significantly outweighs the simultaneous negative effect of mass increase. Finally, the deviation from the experimental results reached 92%, due to the large number of geometric defects in the samples, which leads to the conclusion that the FDM printing method is inappropriate for manufacturing lattice structures of this scale

*Keywords*

lattice structures, cellular materials, optimization, CMA-ES algorithm, Machine Learning, 3D printing, Additive Manufacturing

# *DEVELOPMENT AND CHARACTERIZATION OF FLAXLEPOXES COMPOSITES WITH STRAIN SENSING CAPABILITIES*

**Student's Name**
Gavathas Prokopios
**Student Registration Number**
1067282
Email: up1067282@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067282&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present diploma thesis has focused on composite materials (CM) and more precisely on CM which are reinforced with ecofriendly flax fibers. Initially, a comprehensive literature review on CM has been performed by categorizing and by providing basic applications of them. Following that, a historical overview of the flax itself is provided, together with scientific description of its microstructure and the chemical composition. Subsequently, an extensive literature review on flax fiber reinforced CM is provided taking into consideration the mechanical properties which are fully affected by the moisture absorption, while the environmental footprint is described. In parallel, the fabrication of such materials having strain-sensing capability are described together with the introduction to the electrospinning process (EP) technique. EP is lately utilized for the fabrication of fibrous structures for strain-sensing applications.

On practical level, in the current work a flax fiber reinforced composite material containing 8 layers of woven flax dry fabric $0^o/90^o$ and epoxy resin as matrix has been fabricated through the infusion process. The main goal of the work was the fabrication of an ecofriendly CM as the curing process took place at room temperature conditions. After fabrication, tensile tests were executed while during the tests the strain value was measured by using strain sensors. Initially, the first concept for these strain-sensors was to be integrated into the composite structure prior polymerization procedure, but this action was proved to be nonfunctional. The precise strain-sensors are electrospun fibrous structures which were fabricated in our laboratory by using the EP process and then immersion of them into suspension which contains single-walled carbon nano-tubes (SWCNTs). The tensile tests were conducted taking into consideration the ASTM D3039/D 3039M-00 standard. Based on this standard, the mechanical properties were determined while the strain values were recorded through the fabricated strain-sensors which were positioned onto the center of each CM. Based on the

obtained results, the strain values arose from the strain-sensors are in good agreement with the recorded ones from the tensile machine. Taking into consideration of the obtained results, this approach can consider a viable solution for strain-sensing applications.

*Keywords*

flax fiber, composite materials, natural fibers, strain, carbon nanotubes, infusion, tensile, strain sensor

# *EXPERIMENTAL INVESTIGATION OF BIOBASED POLYMERS ENHANCED WITH GRAPHENE OXIDE*

**Student's Name**
Gargala Aikaterini
**Student Registration Number**
1071000
Email: up1071000@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1071000&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the present thesis, an experimental investigation was carried out in order to study the effect of graphene oxide on bio-based polymer materials.

Bio-based resin called EnviPOXY 530 and CHS Hardener P11 were used as matrix material. It is a resin made from vegetable glycerin with high levels of environmental friendliness. The hardener is an aliphatic amine that is used worldwide in polymer materials during curing.

Graphene oxide (GO) is often a nanoreinforcement agent in polymeric matrices and can lead to significant changes in mechanical properties. In this thesis, the GO which was used, was prepared in the laboratory by the modified Hummers method (Tour Method). All the steps in its composition are listed in the next section.

For the preparation of the polymeric materials with the addition of GO, the effect of the presence or absence of a solvent was studied to achieve the optimal dispersion as well as on the mechanical properties of the prepared samples. Specifically, the behavior of GO reinforced materials in tensile and brittleness ($G_{IC}$,$K_{IC}$) was studied. Five different types of materials were studied. The five experimental series tested were virgin resin, GO-reinforced resin (without solvent), GO-reinforced resin (with acetone solvent), GO-reinforced resin (with THF solvent), and initial graphite-reinforced resin.

All experimental series were synthesized in the exact same way and under the same conditions. More specifically, the resin was degassed to reduce its viscosity. Then the reinforcing material was injected, in the case of GO and graphite directly inside, while in the case of the presence of a solvent, the step of stirring the solvent with the GO for several minutes was preceded. The reinforced resin was then stirred for one hour at high temperature to evaporate the respective solvent and further reduce its viscosity. This was followed by vacuum stirring at an increased number of revolutions. Then, the hardener was added, the mixture was gently stirred and degassed for a few minutes. Finally, it was

injected into the cleaned molds, cured at a low temperature for 2 hours and the next day post-cured for another 2 hours at a high temperature. All samples had a reinforcement percentage of 0.5% wt.

Tensile tests were performed to determine the tensile strength and modulus of elasticity per ASTM D638 specification. To determine the strain energy ($G_{IC}$) and the stress intensity factor ($S_{IC}$), three-point bending tests with an artificial crack were performed according to the ASTM D5045 standard.

The samples of the materials were analyzed by scanning electron microscopy (SEM), Raman spectroscopic analysis and thermogravimetric analysis (TGA) in order to determine the surface morphology, microstructure and thermal stability of the materials respectively.

In conclusion, from the graphs of the tensile and brittleness experiments, conclusions are drawn about the effect of both nanoreinforcement and solvent on the mechanical properties. While from the spectra of the analyzes the chemical composition of the samples and the chemical connection between matrix and GO nanoparticles are obtained

*Keywords*

Biobased Polymers, Graphene Oxide, Graphite, Preparation of Nanocomposites, Solvent, Mechanical Properties, SEM, TGA, Raman

# *INVESTIGATION OF THE DEPENDENCE OF COMPLIANCE ON THE LOADING RATE DURING MODE I FRACTURE TESTS*

**Student's Name**
Dimakou Georgia-Artemis
**Student Registration Number**
1059730
Email: up1059730@ac.upatras.gr

**Supervisor:**
Loutas Theodoros, Associate Professor
**Contact Info**
Email: loutas@mech.upatras.gr
Tel.: (+30) 2610 969477

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059730&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this study, an investigation of the loading rate dependency of delamination growth on different fracture mechanical parameters in two material systems is conducted. The two materials systems consist of DCB (Double Cantilever Beam) specimens made of carbon fiber reinforced polymers (CFRPs) and glass fiber reinforced polymers (GFRPs). These composite laminates involve unidirectional layers. Initially, Mode I fracture tests are performed at various displacement rates ranging from 0.016 mm/s up to 400 mm/s for the CFRP specimens and from 0.016 mm/s up to 200 mm/s for the GFRP specimens in order to collect important data. Then, data reduction schemes are used to evaluate these data and consequently different fracture mechanical parameters such as the compliance, the strain energy release rate (SERR), the Williams correction term $\Delta$, the loading rate at the crack tip and the strain energy. Finally, the results are depicted in graphs and thus the influence of the loading rate on the fracture behavior of the two material systems is discussed. Moreover, a comparison between the two composite materials, i.e. CFRP and GFRP, is carried out.

*Keywords*

Fracture mechanics, Strain energy release rate, Loading rate, Compliance

# *DEVELOPMENT OF GRAPHENE SUPERCAPACITORS AND THEIR INTEGRATION INTO THE STRUCTURE OF MULTIFUNCTIONAL FIBROUS COMPOSITE MATERIALS*

**Student's Name**
Zisis Dionysios
**Student Registration Number**
1067307
Email: up1067307@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067307&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Given the carbon footprint of human activity due to the necessity of meeting energy needs in modern history, there is strong research interest in fields regarding the transition to a zero-emission future. Part of this research deals with ways to scale up energy storage technologies and integrate multi-functionality into existing systems towards independence from conventional energy sources and reducing energy costs. Against this background, multifunctional graphene supercapacitors in the form of fibrous composite materials are developed in this thesis. Initially, conventional graphene supercapacitors with electrode material of 5 different GNPs products were fabricated in aqueous solvent slurry solution, as an alternative to the organic toxic and at the same time environmentally harmful solvents that have been the status quo so far. A maximum specific capacitance of these cells of 127 F/g was achieved from the electrode product with the highest specific capacitance. As an intermediate stage in the transition to a structural supercapacitor, solid- state supercapacitors were fabricated by replacing the liquid electrolyte with its semi-solid counterpart, and with the most efficient graphene product electrode material from the previous stage. As a result, a maximum specific capacitance of 129 F/g and 29 F/g of supercapacitors with glass woven cloth and thermoplastic fabric separators, respectively, was noted. Finally, the supercapacitors were embedded into the composite plate structure of carbon fiber impregnated with the same electrode and the semi-solid electrolyte acting simultaneously as the matrix subsystem and ion transport medium of the cell. The structural supercapacitors exhibited a maximum specific capacitance of 23 F/g while their mechanical capability is characterized by Young's modulus of 4GPa and failure strength of 60MPa. The final products based on their specific properties are classified in the spectrum of electrochemical double layer capacitors (EDLC) and fibrous composites simultaneously.

*Keywords*

Energy storage, graphene, multifunctionality, supercapacitors, composite materials

# *SURFACE PROPERTIES OF BIOMEDICAL SCAFFOLDS WITH MULTI-FUNCTIONAL PROPERTIES FOR ENHANCED BIO-INTEGRATION*

**Student's Name**
Thampet Maria
**Student Registration Number**
1057782
Email: up1057782@ac.upatras.gr

**Supervisor:**
Mihanetzis George, E.E.D.I.P.
**Contact Info**
Email: gpakm@upatras.gr
Tel.: (+30) 2610 969460

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1057782&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Biomedical engineering and tissue engineering are coming to meet the needs of modern medicine and so, the development of suitable biomaterials is necessary. The creation of three-dimensional artificial microstructures, so-called scaffolds, is based on advanced manufacturing technologies such as 3D printing and electrospinning. A new challenge is the development of biomimetic biomaterials, which are usually porous materials and have properties similar to those of the natural tissues. This can be achieved with the help of the above-mentioned techniques, 3D printing and the electrospinning, respectively. 3D printing, or additive manufacturing, is a method that allows the construction of complex structures by adding materials, layer-by-layer, and it has applications mainly in bone engineering [1]. The electrospinning method is being used to create fibrous scaffolds and it is often preferred for applications in wound healing [2]. The purpose of the present study was to investigate the surface properties of 3D scaffolds manufactured by 3D printing and electrospinning. The employed materials were: bulk polylactic acid (PLA), bulk polyetherimide (PEI), hydroxyapatite (HAp) reinforced PEI, and graphene nanoplateles (GNPs) reinforced PEI, which were previously investigated [3], [4]. The reinforcement percentages were as follows: 1% HAp reinforced PEI, 0.5% GNPs reinforced PEI, 1% HAp&0.5% GNPs reinforced PEI. The main surface properties of biomaterials are roughness, which affects the adhesion quality of the human cells to the material, and stiffness, which affects cells' differentiation, while both play an important role in biorecognition. Specimens were of two types: (i) compact PLA 3D printed and (ii) 3D scaffolds produced by electrospinning (PEI and its composites). Scanning electron microscope (SEM) images were taken to observe the morphology of the materials. In addition, the morphology and the roughness of both types of scaffolds (PLA and PEI) were examined by Atomic Force Microscopy (AFM). Further on, the mechanical properties, such as elastic

modulus and hardness of the scaffolds were studied through the nanoindentation technique. The applied indentation forces in different areas of the scaffolds were: 600, 2000 and 5000 μN.

Some outcomes are: (1) The AFM technique is quite sensitive which makes the observation of such materials difficult and requires the analysis of multiple samples of the same investigated material; (2) The roughness of the double reinforced - HAp and GNPs - PEI specimens was significantly higher comparing to the other substrates. This is expected and is due to conglomerates formation. The compact PLA samples are highly organized at macro level but this is not valid at micro-level. On the other hand, the 3D electrospun scaffolds are fibrous and present empty porous regions due to their nanoarchitecture. It is known that for plastics, the increased roughness results in an improved biointegration rates [5] and finally (3) All materials exhibit singularities and inhomogeneities at nano level, from one point to another of the same sample.

*Keywords*

biomedical scaffolds, electrospinning, 3D printed biomaterials, biomaterials' surface properties

# *REDUCED ORDER DYNAMIC MODELS UPDATE FOR A STRUCTURAL DIGITAL TWIN APPLICATION*

**Student's Name**
Kamilakis Anastasios
**Student Registration Number**
1067290
Email: up1067290@ac.upatras.gr

**Supervisor:**
Chrysohoidis Nikolaos, Assistant Professor
**Contact Info**
Email: nchr@mech.upatras.gr
Tel.: (+30) 2610 996878

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067290&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The idea of Structural Digital Twins is summarized in the interconnection of a real structure with its digital twin, through sensors and actuators. The digital twin represents the behaviour of the real structure in real time based on some state variables, while it can optimise its operation, or even detect possible failures by recording its structural intregrity. The present Diploma Thesis focuses on the Updating of the Structural Digital Twin to keep up with possible changes of the real structure during its operation, and also to reduce the order of the model for Real-time Updating. Towards this direction, the research starts by composing the model of a real structure through the Finite Element Method. Then the order of the model is reduced through the Second Order Arnoldi Iteration algorithm to save computational resources and time. Utilizing the reduced model and frequency domain measurements of the structure, the properties of the digital model are updated to be in better agreement with the real ones. Finally, the damage detection capability of the real structure is highlighted through the final routine developed in the Matlab programming environment.

*Keywords*

Structural Digital Twin, Finite Elements, Model Order Reduction, Finite Element Model Update, Damage Detection

# *DEVELOPMENT OF A PRELIMINARY DESIGN METHODOLOGY OF A COMPOSITE FIXED WING UAV*

**Student's Name**
Kleanthous Zacharias
**Student Registration Number**
1056659
Email: up1056659@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1056659&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this paper the topic that will be analyzed is the design of fixed wing unmanned aerial vehicles (UAV). Design is divided into three main categories: basic design, preliminary design and detailed design. It is also based on a structural diagram, which details each step that must be implemented. In this particular work we will deal more with the preliminary design. Primary stage, with the help of the aircraft specifications, we calculate the weights in detail (take-off weight, payload weight, empty aircraft weight and fuel weight). In the next stage with the help of the criteria we will calculate the Wing Load (W/S) and the Thrust of the Engines (W/P) and then we will be able to calculate the wing area and subsequently the buoyancy needed by the aircraft to all flight phases (required lift) and induced drag (Drag). Another main factor we will deal with is the geometry of the aircraft, which in turn determines its aerodynamic characteristics as well as stability in the various phases of flight (landing, takeoff, normal flight, maneuvers, etc.). After the appropriate calculations have been made, we will move on to the detailed design stage where a 3D model of the aircraft will be built with the help of the Solidworks computer program. Then after the design is completed, the Ansys fluent computer program will be used to perform a detailed aerodynamic analysis using Computational Fluid Dynamics, so as to confirm the required aerodynamic coefficients. Finally, with the help of the results obtained, we will draw the appropriate conclusions.

*Keywords*

Unmanned aerial vehicles, aircraft preliminary design, dynamic analysis, aerodynamic analysis, Solidworks, Ansys fluen

# *DYNAMIC ANALYSIS OF FLUID EFFECT ON LIQUID FUEL TANK STRUCTURE*

**Student's Name**
Koukoumialos Theocharis
**Student Registration Number**
1059784
Email: up1059784@ac.upatras.gr

**Supervisor:**
Labeas Georgios, Professor
**Contact Info**
Email: labeas@mech.upatras.gr
Tel.: (+30) 2610 969498

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059784&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

A particularly common and interesting phenomenon in nature is the behavior and response of a free surface of a fluid during perturbations of the boundary conditions of the fluid. Also known as sloshing, this phenomenon is the topic of this thesis, focusing primarily on the occurrence of this phenomenon in a liquid fuel tank of an aircraft during its simulated take-off and landing procedures, while also considering what effect does this dynamic behavior have on the structure of the tank. At the same time, we also consider what effect does this have on the insulation that is necessarily needed to be present externally, as we have chosen liquid hydrogen as the existing fuel and a layer of insulation is useful to maintain cryogenic temperatures inside the tank. During the research we will compare two cases of fuel quantity in the tank, the one with 50% and the one with 75% fill rate.

To perform the simulation model we have described, we used two very popular tools in modelling and computational analysis concerning fluids and solid structures: Ansys Fluent and Ansys Transient Structural respectively. These are tools of the academic Ansys Student 2023 R1 Version software through which we computationally simulate the physical model we have explained and to obtain appropriate results that capture both the sloshing phenomenon within the tank and the effect this can have on the structure and insulation of the tank. The governing equations of fluid motion (Navier-Stokes), the multiphase flow modeling based on Lagrange and Euler grids, the Volume of Fluid free-surface capturing method, the Fluid Structure Interaction (FSI) approach we used and many other options and settings we performed to compose the computational analyses are explained and described in detail. Finally, we conclude by presenting the results that capture the phenomena mentioned above and proceed to their evaluation.

*Keywords*

Sloshing, Computational structural analysis, Computational Fluid Dynamics, Multiphase flows, Volume of Fluid Method, Fluid Structure Interaction

# *ANALYSIS OF THE MECHANICAL BEHAVIOR OF FLAX FIBER REINFORCED THERMOPLASTIC COMPOSITES*

**Student's Name**
Lagogiannis Nikolaos
**Student Registration Number**
1026879
Email: up1026879@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026879&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The 21st century and its future generations face threats of pollution and depletion of the earth's resources due to the huge amounts of non-biodegradable plastic and toxic waste that are produced every year. While a small percentage of plastic waste is recycled or incinerated, most of it ends up in landfills in the US. According to the Environmental Protection Agency (EPA), 75.4% of all plastics produced in the US end up in landfills after their beneficial use. Thus, in the last two decades, many researchers have focused on the use of natural fibers as reinforcements in cement-based construction materials and in polymers, although the use of natural fibers for structural applications has been known since ancient times. Currently, natural composite materials have been widely used in the automotive and construction industries. Also, aerospace and marine constructions may be using them in the future. It is difficult to assess the quality of natural fibers, which are generally extracted from nature, so this is a challenge for predicting the structural and mechanical properties of natural composites. In this assay, the advantages and disadvantages and the applications of composite materials are analyzed, as well as various aspects related to the use and properties of natural composite materials. In addition, the mechanical properties of five groups of composites calculated by three-point bending and tensile experiments are studied. Three groups consisted of thermoplastic matrix reinforced with flax fibers, one of thermoplastic matrix reinforced with glass fibers and the last one of thermosetting matrix reinforced with flax fibers. Finally, from the experimental results, the magnitudes of the Young's, and flexure modulus as well as the tensile and flexural strength are calculated and compared.

*Keywords*

composites, natural composites, properties of natural composites, mechanical properties, three-point bending and tensile experiment

# *EXPERIMENTAL STUDY OF PROGRESSIVE FATIGUE IN THERMOPLASTICS BY MECHANICAL TESTS AND ULTRASOUND*

**Student's Name**
Menegos Konstantinos Athanasios
**Student Registration Number**
1067284
Email: up1067284@ac.upatras.gr

**Supervisor:**
Tserpes Konstantinos, Professor
**Contact Info**
Email: kitserpes@upatras.gr
Tel.: (+30) 2610 969439

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067284&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This paper presents an experimental investigation focused on quantifying damage accumulation caused by fatigue in Thermoplastic Carbon Fiber Reinforced Polymers (CFRP). The study employs ultrasonic sound testing to assess the extent of damage development during the fatigue process and subsequently determines the residual strength of the specimens. Additionally, the percentage of the specimen area that undergoes damage at various stages of fatigue is calculated. The study begins with the preparation of Thermoplastic CFRP specimens, followed by subjecting them to cyclic loading in a controlled fatigue testing setup. Ultrasonic sound testing is conducted periodically during the fatigue process to detect internal defects and damage evolution within the material. The detected damage is then correlated with the corresponding number of fatigue cycles to establish a damage accumulation trend. Furthermore, after reaching a predetermined number of fatigue cycles, the specimens are subjected to a residual strength assessment. Tensile or flexural tests are performed on the fatigued specimens to determine their load-carrying capacity and mechanical properties. This analysis provides insights into how fatigue affects the mechanical behavior of the Thermoplastic CFRP. The experimental results reveal the progressive damage accumulation mechanism in Thermoplastic CFRP under cyclic loading. The evolution of internal defects and their correlation with fatigue cycles provides valuable information about the material's durability. Additionally, the residual strength assessment sheds light on the material's ability to withstand loads after fatigue exposure. Finally, the study calculates the percentage of the specimen area that experiences damage at different fatigue stages, providing a spatial understanding of the damage evolution pattern. These findings contribute to a deeper comprehension of the fatigue behavior of Thermoplastic CFRP and offer critical insights into the structural integrity of such composite materials under cyclic loading conditions.

*Keywords*

Thermoplastic CFRP, fatigue, ultrasonic sound testing, residual strength, damage accumulation, composite materials

# *INFLUENCE OF TRABECULAR BONE ARCHITECTURE AND MATERIAL ON ULTRASOUND CHARACTERISTICS USING 3D-PRINTED TRABECULAR BONE MODELS*

**Student's Name**
Belesiotis Panagiotis
**Student Registration Number**
1047303
Email: up1047303@ac.upatras.gr

**Supervisor:**
Apostolopoulos Konstantinos, E.E.D.I.P.
**Contact Info**
Email: apostolkon@upatras.gr
Tel.: (+30) 2610 969488

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047303&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this thesis is to study the effect of the initial structure and the density of trabecular bone on the acoustic parameters of ultrasound, with the goal of understanding better about osteoporosis and developing new diagnostic methods. Specifically, replicas of trabecular bone were created from polylactic acid (PLA), thermoplastic polyurethane (TPU), and polypropylene (PP), with a relative bone volume fraction (BV/TV) of 15%, 21%, and 34%, respectively. Additionally, specimens (PLA) (PP) & (TPU) with a stable controlled structure and the same volume fractions of 15%, 21%, and 34%, as well as a thickness of 0.2, were created. PLA specimens with a stable structure for (Tr.Th) 0.2-0.4-0.5 & 0.6 mm were also prepared for simulating bone and evaluating the results.

All specimens were fabricated using the 3D printing method and were subjected to ultrasound experiments to measure the speed of sound through the specimen (SOS) and the broadband ultrasound attenuation (BUA) using the through-transmission method. Additionally, backscatter using the pulse-echo method for two types of focal and unfocused transducers (Focus-unfocus) was performed only for specimens of trabecular bone. The materials used for constructing the bone specimens were polylactic acid (PLA), polypropylene (PP), and thermoplastic polyurethane (TPU), while the specimens with a stable structure were made from PLA material.

Understanding the architecture of trabecular bone is of great importance as it allows us to predict and address various conditions such as osteopenia and osteoporosis. Comparing the characteristics of trabecular bone specimens with specimens of the same material but different densities will help draw conclusions for the appropriate use of materials and structures in the fields of biomechanics and biomedical technology.

*Keywords*

Cancellous bone, osteoporosis, 3D printing, Ultrasound, Backscatter

# *DRAG COEFFICIENT ANALYSIS OF SATELLITES IN LOW EARTH ORBITS*

**Student's Name**
Nazlidou Panagiota
**Student Registration Number**
1059843
Email: up1059843@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059843&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Within the past decades, very low Earth orbits (VLEO) have been of key interest for a variety of commercial space missions primarily focusing on Earth Observation and Telecommunications. Thousands of satellites have been launched at these altitudes the last few years, taking advantage of the thermospheric environment of these orbits. One of the main characteristics at these altitudes is the low lifespan the satellites due to the magnitude of the drag force as a result of increased atomic oxygen presence. Therefore, drag force takes important part in keeping these orbits clean since it ensures deorbiting of the satellites. However, it can be a disastrous element for a mission if it is not calculated correctly. On the course of this thesis, a review of the thermospheric environment takes place following by drag coefficient estimation using the Moflow+ software. The process of correlating Low Earth Orbits with vacuum applications is described to correctly represent the thermospheric environment. After confirming the conditions which best describe the simulation box as well as the satellite, the drag coefficient of various Cubesat satellites take place.

*Keywords*

Drag coefficient; ATOX; Rarefied Aerodynamics; Molflow+, LEO

# *STUDY OF LEAKAGE DYNAMIC CHARACTERISTICS IN HIGH PRESSURE TRANSMISSION NETWORKS USING PIEZO-ELECTRIC SENSORS - DETECTION AND LOCALIZATION OF LEAKAGE*

**Student's Name**
Oikonomou Ioannis
**Student Registration Number**
1070804
Email: up1070804@ac.upatras.gr

**Supervisor:**
Chrysohoidis Nikolaos, Assistant Professor
**Contact Info**
Email: nchr@mech.upatras.gr
Tel.: (+30) 2610 996878

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1070804&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This thesis deals with leak detection and localization in gas pipelines. The phenomenon of acoustic emission due to leakage is studied, as well as its frequency characteristics. The method that aims to detect and localize the leakage is analyzed and applied at the experimental level to test its performance. The experimental measurements involve data acquisition both in terms of pressure variation and steady-state measurements. Transient type experiments are aiming to study the frequency content excited by the leakage and the way it varies under the corresponding pressure fluctuation. In the steady state, the data recordings were used for the detection method, but also for leak detection. The leakage was modeled as a drilled hole screw attached to the pipe wall, this way easy repeatability in conducting experiments was achieved, but also this enabled studying various sizes of Leaks. Piezoelectric sensors (PZTs) were used, attached to the surface of the pipe using high shear strength epoxy resin. The theoretical background for wave propagation in isotropic cylinders is required for the localization technique. Therefore, the theoretical part of the propagating elastic waves due to acoustic emission is also mentioned. The equations of motion in three dimensions are derived, the Navier equation is then solved by the field method, the dispersion equation is obtained and the dispersion curves for the main families of propagating waves are plotted.

*Keywords*

Gas Leakage, Acoustic emission, Wave propagation, Piezoelectric sensors, Dispersion

# *STRUCTURAL ANALYSIS OF ELASTIC MEMBRANE UNDER AERODYNAMIC LOADING: APPLICATION ON SAIL DEFORMATION OF A RACING YACHT*

**Student's Name**
Pilichos Georgios
**Student Registration Number**
1026931
Email: mead7022@ac.upatras.gr

**Supervisor:**
Philippidis Theodore, Associate Professor
**Contact Info**
Email: philippidis@mech.upatras.gr
Tel.: (+30) 2610 969450

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026931&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This research investigation is centered around the examination and forecasting of sail deformations when subjected to varying aerodynamic loads, employing structural simulations and finite element analysis. The study encompasses a range of geometric parameters, sewing techniques, and material combinations commonly utilized in sail production. The simulation models are constructed using ANSYS [1] software, incorporating sail cut designs generated by Sailcut CAD [2]. The analysis encompasses the assessment of nodal displacements, the inverse Tsai-Wu failure criterion, and the distribution of the first principal stress.

The outcomes of this investigation offer insights into the behavior of different sail configurations. Comparisons are drawn between jib sails and main sails experiencing dissimilar aerodynamic loads, thereby demonstrating the impact of the angle of attack and distinctive sewing techniques. Moreover, the study examines the influence of various materials, such as Dacron and laminated carbon, on sail performance.

The findings illustrate that the selection of materials and sewing techniques plays a key role in sail deformation and structural integrity. The combination of laminated carbon material with Radial sewing exhibits superior performance in terms of shape holding and minimal displacement. However, for enhanced longevity and durability, it is advisable to employ Radial sewing with Dacron material.

The predictions of this study are verified by comparing them with existing literature and empirical observations. Furthermore, the research delves into the latest trends in sail design, emphasizing the utilization of moulded sails and the significance of aligning yarn paths with the orientation of the material's first principal stress.

In conclusion, this research study yields insights into the optimization of sail performance and durability through the careful selection of suitable materials and sewing techniques.

*Keywords*

Finite element analysis, Aerodynamic load, Sail deformation, Sewing techniques, Sailcloth Material

# *ADAPTIVE REFINEMENT TECHNIQUES FOR FASTER WAVE PROPAGATION SIMULATIONS IN RODS AND BEAMS VIA THE MULTIRESOLUTION FINITE WAVELET DOMAIN METHOD*

**Student's Name**
Samara Aikaterini
**Student Registration Number**
1067321
Email: up1067321@ac.upatras.gr

**Supervisor:**
Saravanos Dimitrios, Professor
**Contact Info**
Email: saravanos@mech.upatras.gr
Tel.: (+30) 2610 969437/ 2610 962753

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067321&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The Multiresolution finite wavelet domain method (MR-FWD) is a numerical technique that employs Daubechies wavelet and scaling functions as basis functions for the approximation of the structure's displacement field. The method provides a hierarchical representation scheme involving an initial, zero-scale approximation, while finer, higher-scale components are superimposed to improve the solution's accuracy.

In the present Diploma Thesis, adaptive refinement techniques are presented to accelerate wave propagation simulations in rods and beams via MR-FWD method. The fundamental idea lies in separating the solution into high- and low-wavenumber components and approximating each component with an appropriate level of resolution. Smooth low-wavenumber variations are accurately represented through low-scale approximations, whereas abrupt high-wavenumber oscillations require advanced computational effort and as such, they are handled with higher resolution levels. A heuristic indicator is employed to assess the quality of the solution and localize areas that need solution enrichment in the displacement field. Accordingly, a dynamic refinement domain is formed to define regions where increased precision is required.

The efficiency of the proposed refinement process is evaluated through numerical results for the prediction of wave propagation phenomena in aluminium rods and composite beams. The results demonstrate substantial reduction in computational effort compared to the solution using uniform refinement, while maintaining a high level of accuracy. However, it is essential to meticulously define an appropriate threshold for the indicator to accurately locate the refinement region while ensuring computational efficiency.

*Keywords*

Adaptive Refinement, Multiresolution Analysis, Wavelet Analysis, Transient Response, Wave Propagation, Daubechies Wavelets

# *PREDICTION OF THERMOMECHANICAL PROPERTIES, THERMAL STRESSES AND FAILURE IN UNIDIRECTIONAL FIBER COMPOSITES SUBJECT TO LARGE TEMPERATURE VARIATIONS*

**Student's Name**
Sarmas Georgios
**Student Registration Number**
1070599
Email: up1070599@ac.upatras.gr

**Supervisor:**
Saravanos Dimitrios, Professor
**Contact Info**
Email: saravanos@mech.upatras.gr
Tel.: (+30) 2610 969437/ 2610 962753

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1070599&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This study is carried out to predict the stiffness properties, thermal expansion coefficients, thermal residual stresses and failure of unidirectional (UD) fiber composites. The prediction is performed by two micromechanical models, a 2D Repeated Unit Cell (RUC) and a 3D Representative Volume Element (RVE) in the finite element program ABAQUS, by simultaneous comparison with the results from Chamis' micromechanical equations.

Chapter 1 provides introductory information on composites, their classification, and some important advantages and disadvantages. Then, in Chapter 2, the basic concepts of macroscopic mechanics (macromechanics), the types and elasticity matrices of elastic media, and the basic mechanics of the hygrothermal behavior of elastic composites are presented. Therefore, by completing Chapter 2, the reader will be able to enter Chapter 3, where the transition from the macroscopic level (macroscale-layer level) to the microscopic level (microscale-component level) is made. Chapter 3 describes the field of micromechanical modeling, multiscale modeling, homogenization, and important micromechanics concepts such as the RUC and the RVE. Then, in Chapter 4, observations on the behavior of UD composites in low temperature environments under various conditions (tensile, compression, shear, etc.) and also some data on the experiments of composites under these conditions are reported through a literature review. Next, in Chapter 5, the methodology (discretization, periodic boundary conditions) and the relevant results of the analyses of the two modeling methods are presented and compared with available results from the literature (where possible) and with predictions of the micromechanical equations of Chamis. Finally, in Chapter 6, we report the main conclusions about the low temperature behavior of the composites obtained from the modeling, disadvantages and advantages of the modeling, and suggestions for future research.

*Keywords*

Composite material, properties, low temperatures, micromechanics, thermal stresses, failure

# *FABRICATION OF FABRIOUS THERMOPLASTIC POLYURETHANE STRUCTURES USING SOLUTION ELECTROSPINNING FOR STRAIN SENSING APPLICATIONS*

**Student's Name**
Syrmpopoulos Nikolaos
**Student Registration Number**
1070135
Email: up1070135@ac.upatras.gr

**Supervisor:**
Kostopoulos Vassilis, Professor
**Contact Info**
Email: kostopoulos@mech.upatras.gr
Tel.: (+30) 2610 969443

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1070135&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In today's era, more and more researchers are using the Electrospinning Process (EP) technique, having an aim to fabricate composite materials with fibrous structure. EP technique is a simple and low-cost set-up which provides a wide range of fibrous structures made by different type of polymeric materials and in different variations. In addition, despite these advantages, human interests in understanding, analyzing, and monitoring biological signals have lately created the need to fabricate thin sensors that are friendly to the human body. Based on literature and as demonstrated below, one of the easiest and most convenient ways to make these sensors is by using the EP technique.

Based on these, in the current investigation electrospun Thermoplastic Polyurethane (TPU) and modified ones with Single-Walled Carbon Nano Tubes (SWCNTs) fibrous structures were fabricated by using the solution EP. The fabricated structures are intended to be used for strain-sensing applications. Taking into consideration initial trials on the electrospun samples containing SWCNTs at the rate of 0.5-2 wt%, it was shown that no conductive paths were created. This behaviour is mainly attributed to the SWCNTs aggregates that were created within the electrospun material during the EP process. Micro-tensile experiments on these type of samples showed an increase of the apparent mechanical properties for the samples containing 0.5% SWCNTs, while a decrease of these properties for the samples containing 2 wt% SWCNTs. The main reason behind this behaviour is the increase of the SWCNT aggregates when the quantity of the SWCNTs into the solution is increased. Based on the obtained results, a different way of nanomodification was further utilized by immersion of TPU samples for 2 hours into a suspension containing distilled water and SWCNTs at the rate of 0.3 wt%. The utilized suspension prior the immersion process was positioned into an ultrasonic bath to prevent SWCNTs aggregation. After immersion process, the obtained TPU

samples were dried by using a conventional oven for 30 minutes at 80$^{o}$C. After drying it was shown that a better bonding of the SWCNTs with the TPU fibers was achieved while a conductive network was created. Afterwards, micro-tensile tests were conducted and combined with electrical resistance measurements. The experiments showed an increase of the electrical resistance during the tensile tests (when the strain increases) while the mechanical properties were significantly enhanced. Finally, a successful demonstration of the achievement was performed by positioned of the fabricated strain-sensor onto a finger to monitor potential movements.

*Keywords*

Electrospinning – SWCNTs – Film Sensors – TPU – Fibrous Nanostructure

# DIVISION OF DESIGN AND MANUFACTURING (SEPTEMBER 2023)

## *DESIGN OF POWER LOSSES AND CONTROL OF A LONG SLENDERNESS RATIO ACTIVE MAGNETIC BEARING (AMB) AND COMPARISON WITH AN EQUIVALENT SYSTEM CONSISTED OF SMALLER AMBs*

**Student's Name**
Andrikopoulos Andreas
**Student Registration Number**
1067287
Email: up1067287@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067287&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

Journal bearings are the most popular machine component for bearing and shaft support. Factors such as their simple and economical design and their high load lifting capacity in comparison with their radial grace are the cause of their extensive study and use. However, high sliding friction values lead to significant energy losses and the required use of lubricants has a negative environmental impact. These disadvantages of journal bearings have led researchers to study a different way of supporting the shafts, Active Magnetic Bearings (AMB). The serious advantage of the AMB over conventional journal bearings lies in their ability to support the moving shaft contactless. This means that any mechanical losses and wear that may have existed are currently absent. As a result, a significant amount of energy is saved, considerably higher rotational speeds are allowed and no maintenance or replacement of equipment is required at the same rate. Furthermore, the fact that no lubricant is used makes the application of AMB environmentally friendly.

The above advantages of Active Magnetic Bearings have made them applications of enormous appeal and a pole of research interest. So we will deal with this modern application in the context of this thesis. The work will move in between two separate contexts. Initially, the first objective is to perform a power loss study for a long-length AMB

and at the same time compare it with a corresponding shorter-length AMB system. However, this requires the analysis of the fundamental principles of electromagnetism, the creation of a simulation model of an AMB in ANSYS WORKBENCH, a detailed study and analysis of the power losses, and then the desired comparison of power losses is carried out. The second part of the paper deals with a nerve-wracking and essential part of the AMBs, the automatic control. First a static automatic decentralized control is performed in MATLAB and SIMULINK which is then extended to a dynamic model for a rigid shaft. Finally, we create a new and modern automatic control model called decoupled, we will analyze its principles and then perform a comparison with respect to the performance of decentralized control where we will derive the appropriate conclusions.

*Keywords*

Active Magnetic Bearings (AMB), Magnetic Force, Decentralized control, Cooper losses, Decoupled control

# *WINDAGE EFFECTS ON BEVEL GEARS DESIGN FOR AERONAUTIC APPLICATIONS*

**Student's Name**
Avgerakis Spyridon
**Student Registration Number**
1026828
Email: mead6914@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026828&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the following work an extensive investigation is conducted on the windage power losses (WPL), which occur in gear pairs during the engagement process in a gearbox of a turbofan aircraft engine. The study around WPL is a subject that is being developed especially in the aeronautical industry to improve the design of turbofan engines used in modern aircraft. The windage power losses (WPL) may only represent 10% of the total losses of an aircraft turbofan engine, but considering the amounts of energy expended by an aircraft, it becomes clear that studying around this type of loss can save an aircraft from large amounts of fuel required to operate them and make them more environmentally friendly. The work focuses on investigating the geometric characteristics of the gears to present the least aerodynamic power loss during engagement process. The design of the geometric model was executed in CATIA environment, utilizing parametric design, enabling the design of the gears in a 3D drawing, while the geometry can be modified, depending on the model and the geometry of the gears being simulated. Typically, in a gearbox of a turbofan engine the gears used are bevel gears, while the WPL produced within it can be divided into peripheral power losses and power losses on toe/ heel. Our study focuses on the windage power losses occurring on the toe/ heel of the gear. For this reason and to reduce the computational power, the pairs studied are spur and helical gear pairs. The study around the windage effects is completed with the CFD (Computational Fluid Dynamics) analysis of the gear pairs in ANSYS Fluent environment, examining the losses in the region of the gear teeth by changing the geometry at the toe of the gear. The geometry was modified in terms of the chamfer at the toe tip (0 mm, 0.2 mm, 0.4 mm, 0.6 mm) and the pressure angle (15o, 20o, 25o) using five different rotational speeds (10000 rpm, 15000 rpm, 17500 rpm, 18500 rpm and 20000 rpm). The results obtained helped to correlate WPL with various changes in gear geometry and rotational speed, to develop methods for its reduction of WPL and design improvement of the gears that make up a gearbox of a turbofan aircraft engine.

*Keywords*

Windage power losses (WPL), Turbofan engine, Gears, CFD simulation, parametric CAD.

# *DESIGN OF ROLLING BEARINGS UNDER THE INFLUENCE OF ELECTRIC FIELD AND APPLICATIONS ON ELECTRIC VECICLES*

**Student's Name**
Vokolos Georgios
**Student Registration Number**
1059746
Email: up1059746@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059746&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Demands for environmentally friendly means of transport have led to the increasing popularity of electric and hybrid vehicles. It is therefore of great industrial and scientific importance to study and understand the effects of an electric environment on mechanical parts in the light of 'Ecological Tribology'.

In this diploma thesis, a brief introduction to the history of electric vehicles is first given and the critical parts are listed. Furthermore, the novelty of this work is presented.

In the next two chapters the theoretical background on lubricants and lubrication regions is presented, and the focus is on the elastohydrodynamic region in which rolling bearings operate.

In the fourth chapter, tangential solids contact theory is discussed through Hertz's theory and how it applies to rolling bearings. More specifically, the theory of the contact line is presented, as well as the stresses and strains generated in it in an elastohydrodynamic contact.

In the fifth chapter there is an in-depth study of elastohydrodynamic lubrication in rolling bearings and the equations governing this complex problem are given. First, the fundamental equations of fluid motion, such as the continuity equation, the Navier Stokes equation and the momentum conservation equation are listed. Next, the equations relating the density and dynamic viscosity of a lubricant to pressure and temperature are discussed.

Chapter six introduces the theory of electromagnetism, and more specifically electrostatic theory, so that in the next chapter they can be applied to describe the electrical phenomena in rolling bearings. Among other things, definitions of the electric field, resistance and

capacitor are presented, fundamental terminology for understanding the subsequent calculations.

Chapter seven discusses the mode of failure generation and the results of problems due to electrical phenomena. In particular, the way currents and voltages are generated, and the different types of damage caused by them are presented.

Finally, the last three chapters present the methodology followed in this work and its results, using MATLAB and Ansys, while conclusions are drawn and ideas for future work are proposed.

*Keywords*

Eco-Tribology, Electromagnetism, Electric Vehicles, Rolling Bearings, Elastohydrodynamic Lubrication

# *EFFECT OF NANO-PARTICLES ADDITIVES IN LUBRICANTS ON TRIBOLOGICAL PERFORMANCE OF COMPRESSION RING (ICE) UNDER THE INFLUENCE OF COMBINED OVALITY AND WAVINESS OF THE CYLINDER LINER*

**Student's Name**
Dimitrakopoulos Michail
**Student Registration Number**
1067243
Email: up1067243@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067243&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present research aims to approximate the actual shape of an internal combustion engine cylinder liner and examine how the axial and radial deformations of the cylinder liner, in combination with the rapidly developing lubricants with nano-particles additives, influence the design criteria of the compression's ring tribological behavior. The current model approaches the effects of axial and radial deformations and ring conformability through Tomanik's criterion, under the regime of boundary to mixed lubrication, through modeling using computational fluid dynamics (CFD) methods, by solving the Navier-stokes equations and under the assumptions of a 2D axisymmetric model representing the in-plane motion of the ring. To achieve greater accuracy, the boundary friction was calculated by Greenwood and Trip's model for asperity contact. The axial deformation profiles of the cylinder were modeled using sine wave series, while experimental measurements from existing literature were used for the radial deformation profiles. To model the viscosity behavior of non-Newtonian lubricants with nano-particles additives, the "Power Law" was implemented, and seven cases of nano-particles additives were modeled based on the data found in the current known bibliography. The effect of the combined deformations on the compression's ring wear rate was determined using Archard's model regarding wear depth rate and material volume loss. Finally, a blow-by model was fitted to approximate real engine operating conditions. Predictions for compression ring friction and minimum lubricant film thickness were accomplished for various operating conditions, with emphasis mainly on the point of maximum combustion pressure, where the maximum contact of the compression ring surface with the cylinder liner is observed. The present study has shown

that when the combustion pressure increases, the different cylinder deformation profiles significantly affect the characteristics of the compression's ring friction behavior, especially since the number of sine waves is the most important parameter for all lubricant cases. Finally, through the modeling that was carried out, the great importance of the addition of nano-particles to the lubricant base oil was highlighted, as a reduction of the friction force up to 64.74% was observed for the case of ZnO/MWCNT type additives, compared to lubricant without any additives.

*Keywords*

Compression ring, Ovality, Ring conformability, Wear, Non-Newtonian lubricants

# *DESIGN AND CONTROL OF AN ACTIVE MAGNETIC AND HYDRODYNAMIC BEARING SYSTEM ON A MULTI-DISC ROTATING SHAFT*

**Student's Name**
Kortesis Georgios
**Student Registration Number**
1067286
Email: up1067286@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067286&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Magnetic bearings are a type of bearing that use magnetic fields to suspend and support a rotating shaft or other load. Unlike sliding or rolling bearings, which use physical contact to support the load, magnetic bearings use electromagnetic forces to create a gap between the bearing and the load, resulting in frictionless rotation and improved performance.

This thesis explores the incorporation of hydrodynamic bearings as backup systems for active magnetic bearings (AMB). AMBs are known for their excellent accuracy and maintenance-free operation, but may face challenges during, power loss, or unexpected system failures. Hydrodynamic bearings, with their proven reliability and load carrying capabilities, serve as an ideal complement to AMBs, enhancing system reliability. The synergistic combination of active magnetic and hydrodynamic bearing technologies offers a promising solution for achieving high performance and fail-safe systems.

In the beginning of the paper the static analysis and modelling of an active magnetic bearing on a shaft and its automatic control with conventional PID controllers and with the help of fuzzy logic are presented. Firstly, the mathematical models of electromagnetism used in an EME (active magnetic bearing) system are presented in order to understand the simulation in finite element computer packages of ANSYS type which is used in this paper. Specifically, the magnetic field under static loading is modeled in the ANSYS Workbench environment where the constituted magnetic force on the ferromagnetic rotor material is calculated. Then the theory of automatic control under both static and dynamic loading on the electromagnets of the bearing is analyzed and the appropriate transfer functions are extracted where using them the control is done in Matlab and Simulink computer program to design the appropriate controller and to correct any geometric and operational parameters of the bearing. The dynamics of the rotor-bearing system are then examined in

the Ansys APDL computer program with both magnetic and hydrodynamic bearings to enable us to subsequently set up closed control loops to simulate the system under sinusoidal inertial forces. Finally, a hybrid control system is created that supports a rotating multi-disk shaft under unbalance forces so that when there is a failure in the magnetic bearing, the safety bearing of the installation (hydrodynamic bearing) is able to support the load imposed.

*Keywords*

Active Magnetic Bearing, Electromagnetism, Hydrodynamic back-up bearing, PID controller, Rotating multi-disc shaft

# *DESIGN OF A MECHATRONIC SYSTEM FOR THE AUTOMATED ADJUSTMENT OF EXOSKELETON'S ASSISTANCE LEVEL*

**Student's Name**
Maniatis Alexandros
**Student Registration Number**
1059808
Email: up1059808@ac.upatras.gr

**Supervisor:**
Mourtzis Dimitrios, Professor
**Contact Info**
Email: mourtzis@lms.mech.upatras.gr
Tel.: (+30) 2610 910150

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059808&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Exoskeletons are wearable robotic devices that provide external support and augmentation to the user's body. They play a significant role in the context of Industry 5.0, an emerging concept that combines automation and advanced technologies while focusing on human-machine collaboration and worker well-being. By integrating exoskeletons into industrial processes, companies can optimize productivity, reduce workplace injuries, and create a more inclusive and supportive working environment. Exoskeletons offer different levels of assistance to users, depending on their design and intended purpose. The Comau MATE-XT exoskeleton specifically provides a passive level of assistance to the user. The level of assistance of this particular exoskeleton model can be manually adjusted by the user, potentially reducing his productivity. This diploma project involves the design and development of a mechatronic system for the automated adjustment of the MATE-XT's assistance level. Additionally, an IoT-based project for system control was created. Finally, the system was constructed and assembled directly onto the exoskeleton, where its functionality was tested.

*Keywords*

Exoskeleton, Mechatronic system, Level of assistance, Servo motor, Torque

# *KINEMATIC STUDY AND DEVELOPMENT OF CONTROLLERS (PID AND NEURAL NETWORK) FOR A LINE-FOLLOWING ROBOT USING THE EV3 MINDSTORMS EDUCATIONAL PLATFORM*

**Student's Name**
Maninos Amfitryon Fotios

**Student Registration Number**
1059741
Email: up1059741@ac.upatras.gr

**Supervisor:**
Dermatas Evangelos, Professor
Panagiotis Koustoumpardis, EDIP

**Contact Info**
Email: dermatas@upatras.gr,
koust@mech.upatras.gr
Tel.: (+30) 2610 996476, (+30) 2610 969491

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059741&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This thesis is about the kinematic study and development of controllers (PID and Neural Network) for a line following robot using the EV3 Mindstorms educational platform. Line following robots already occupy a significant part of autonomous vehicles, so research on them is of major importance.

A reference to the uses and importance of line following robots and a study of the literature is conducted. Functional layouts with different approaches are presented and then conclusions and guidelines for the construction of the robot are made and also the development of the controllers is presented.

Experiments are then performed to create the most efficient arrangement of those tested about the robot's kinematics. By using the Lego EV3 Mindstorms platform, all the layouts could be completely disassembled without any component wear. The assembly as well as the list of parts used is shown in detail.

In the next chapter, simulation is used as an initial approach to the PID parameterization process, which greatly helped to make the process of parameterization easier to understand. In addition, a track was designed based on line following competitions. Some improvements were made regarding its stability and size and then the robot showed better control behavior. Then, the preferable arrangement for the sensors was studied experimentally. With the improvement of the layout and the correct positioning of the sensors for the needs of the robot, the final parameterization of the PID was done.

Next, the development of the neural network controller was carried out. The training was done on the computer. The robot only used the final trained neural network to do the control and was not loaded with libraries. The robot successfully followed the line approaching the PID time, although it followed the line using only one sensor. Finally, the conclusions of the thesis are presented and approaches for future research are suggested.

*Keywords*

Line following ρομπότ, PID controller, neural network controller, Lego EV 3

# *DYNAMIC RESPONSE OPTIMIZATION OF A PORTABLE ROBOTIC CELL FOR HYBRID MANUFACTURING PROCESSES*

**Student's Name**
Manitaras Dimitrios
**Student Registration Number**
1054564
Email: up1054564@ac.upatras.gr

**Supervisor:**
Stavropoulos Panagiotis, Associate Professor
**Contact Info**
Email: pstavr@lms.mech.upatras.gr
Tel.: (+30) 2610 910160

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054564&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Hybrid Manufacturing (HM) is defined as the combination of two or multiple manufacturing processes in a single machine tool. The most common combination is the integration of additive manufacturing with machining, enabling manufacturing of unique complex components but most importantly allowing repair of components in a single machine. Such approaches can be integrated on top of robotic cells, offering flexibility and allowing them to be easily transported, allowing repair in the field. However, the design of the load-bearing structure is a challenge because the weight of the structure limits its transportability. On the other hand, the stiffness of the frame plays a crucial functional role under dynamic loads and affects the product quality. Finding the right balance between weight and stiffness requires accurate boundary conditions and an effective design.

Of the processes involved in HM, machining is the one that has the greatest impact on the load-bearing structure. The cutting forces are determined through a machining process model and, through a multi-body simulation of the robot arm, the vibrations at the base of the robot are defined and used as boundary conditions in the dynamic finite element analysis. The increase of the stiffness on the supporting structure will change its natural frequencies inorder to reduce the likelihood of resonance. Since the platform consists of beams, the layout optimization method is used to find the arrangement of beams with the smallest volume. Layout optimization is a numerical approach that is used by a powerful software tool. Then by analyzing the response, the best responding structure is selected as the final design.

The proposed method achieved approximately an order of magnitude reduction in the displacement along the cutting frequency in the y-axis of the cell, as well as better accuracy for the drilling process and a 17% weight reduction compared to the non-optimized design. At the end of this thesis, the reader will have an overview of the design stages of a robotic

cell with optimization, which is based on a closed-loop design, because it uses the forces generated by the machining operations as input to the final dynamic response analysis.

*Keywords*

Hybrid Manufacturing, Mechanical Design, Layout Optimization, Machine Frame Design, Dynamic Analysis

# *ADAPTIVE PERFORMANCE CONTROL FOR THE LONGITUDINAL DYNAMICS OF FIXED-WING UAVS WITH INPUT SATURATION AND COMPERATIVE SIMULATION RESULTS*

**Student's Name**
Miaoulis Vasileios

**Student Registration Number**
1047312
Email: up1047312@ac.upatras.gr

**Supervisor:**
Sakellariou Ioannis, Assistant Professor
Mpechlioulis Charalampos, Associate Professor

**Contact Info**
Email: sakj@upatras.gr, chmpechl@upatras.gr
Tel.: (+30) 2610 969494, 2610 996453

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047312&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Unmanned aerial vehicles (UAVs) have emerged as versatile platforms with a wide range of applications in various domains, including mapping, agriculture, and transportation. Achieving precise and reliable control of UAVs is essential for ensuring safe and efficient operations. This thesis focuses on the development of an adaptive prescribed performance control (PPC) approach for the longitudinal dynamics of fixed-wing UAVs, specifically addressing the challenges posed by saturated control inputs.

The introduction provides an overview of the growing significance of UAVs and their diverse applications. It highlights the need for advanced control techniques to tackle the inherent complexities associated with UAV dynamics and control systems. Then, the modeling of the UAV is discussed, capturing the essential dynamics and constraints that influence its longitudinal behavior.

The thesis explores the concept of adaptive control and its relevance in the context of UAVs. Adaptive control strategies offer the ability to handle uncertainties in system parameters, making them well-suited for UAV applications. Additionally, the prescribed performance control (PPC) methodology with saturated input is introduced as an effective framework to achieve desired system performance and stability guarantees.

An APPC scheme is proposed to address the challenges of controlling the longitudinal dynamics of a fixed-wing UAV with saturated input. The control algorithm is designed to regulate the UAV's longitudinal states, ensuring that specified performance objectives are met while accounting for input saturation constraints, which are present in real-world UAVs because of external environment's constraints and mechanical limitations. Theoretical

analysis and design considerations are presented to illustrate the effectiveness and robustness of the proposed control approach.

To evaluate the performance of the APPC scheme, a comparative simulation study is conducted, contrasting it with a traditional cascaded PID control approach for the longitudinal dynamics of the UAV, which was proposed in a previous project. The simulation results demonstrate the superiority of the adaptive PPC method under the influence of input saturation.

In conclusion, this thesis contributes to the field of UAV control by presenting an adaptive prescribed performance control approach for the longitudinal dynamics of fixed-wing UAVs with saturated input. The proposed control strategy offers robustness against uncertainties and input saturation, ensuring precise and stable maneuvering of the UAV. The comparative simulation study highlights the advantages of the adaptive PPC method over cascaded PID control, supporting its potential for practical implementation in real-world UAV systems.

*Keywords*

UAVs, UAV modelling, Longitudinal dynamics, Adaptive control, Prescribed Performance Control, Saturated Input, Comparative simulation

# *DESIGN OF SURFACE TREATED JOURNAL BEARINGS UNDER CAVITATION AND ELASTIC EFFECTS*

**Student's Name**
Paidousis Aristeidis-Markellos
**Student Registration Number**
1059767
Email: up1059767@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059767&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

For many years journal bearings have been one of the most common engineering components, with wide use in every machine that uses rotational movement to operate. Every journal bearing consists of a rotating shaft, that rotates in an eccentricity inside a steady shell, while there is lubricant in the space between the two parts of the system. The rotational movement of the shaft inside the bearing leads to a pressure distribution. Every engineer that designs a journal bearing aims to minimize the friction between the rotating shaft and the shell.

In this thesis a study of the distributions of the pressures, the deformations and the stresses that are developed during the function of a journal bearing, for different operating conditions is performed, as it will be explained below.

Firstly, the Navier-Stokes and Reynolds equations are derived and then the boundary conditions are presented. Secondly, the cavitation models are displayed with the related theory. Then, the theory of elasticity and the theory of cylindrical shells are quoted, and additionally in the last chapter of the theory, the theory of platings is presented.

As far as the modeling of a journal bearing with the use of the of Ansys software, firstly, the geometry of the bearing, the mesh, the boundary conditions, and the convergence criteria that was used are presented. In addition, the data of the problem and the results of the initial FSI analyses for two different L/D ratio are shown. Then, the results of some additional analyses for the two lubricity ratios, with the addition of a cavitation model are displayed. Next, the results of the journal bearing model that has the addition of a thin layer of planting with the consideration or not of the effect of cavitation are presented. Finally, the results are compared and the conclusions that are derived from them are demonstrated.

*Keywords*

Computational fluid mechanics, Structural mechanics, Elasticity, Cavitation, Planting

# *EXPERIMENTAL INVESTIGATION AND OPTIMIZATION OF DED-LB/W ADDITIVE MANUFACTURING PROCESS*

**Student's Name**
Papamavros Andreas
**Student Registration Number**
1059769
Email: up1059769@ac.upatras.gr

**Supervisor:**
Stavropoulos Panagiotis, Associate Professor
**Contact Info**
Email: pstavr@lms.mech.upatras.gr
Tel.: (+30) 2610 910160

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059769&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this thesis, an experimental process window development for the Laser-based Directed Energy Deposition Additive Manufacturing (AM) process (DED-LB/M) will be investigated as well as an investigation of the influence that the process parameters have on the clad dimensions. Using a coaxial wire feeding system, Stainless steel (316L) wire is deposited on the same material plates.

The goal of this thesis is to identify a suitable set of the key parameters (laser power, scan speed, wire feed rate) by examining the width, height and the penetration depth of the produced clads, as well as the generation of process related knowledge so as to be used in the creation of reference geometries (Single Tracks, Single Walls and Multi-Walls) and for process control. To achieve the minimal number of single-track experiments a factorial design technique and ANOVA based regression modeling are employed to relate the process parameters with track's geometric characteristics. Finally, the overall acquired knowledge is implemented towards the fabrication of a functional demonstration part.

*Keywords*

Metal based Additive Manufacturing, process window optimization, experimental work, laser-based process, statistical analysis

# *DAMAGE DIAGNOSIS IN AN OPERATING OFFSHORE WIND TURBINE VIA VIBRATION SIGNALS AND MULTIPLE MODEL (MM) TYPE METHODS*

**Student's Name**
Roussos Matthaios
**Student Registration Number**
1059757
Email: up1059757@upnet.gr

**Supervisor:**
Fassois Spilios, Professor
**Contact Info**
Email: fassois@mech.upatras.gr
Tel.: (+30) 2610 969495

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059747&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In the current Diploma thesis, remote structural health monitoring is performed on an operating offshore fixed-bottom wind turbine blade using normal operation vibration signals under real environmental conditions. The signals are obtained from a wind turbine model created using OpenFAST software in the bachelor thesis. Structural health monitoring is achieved through statistical time series and Multiple Model methods. The ultimate goal is to apply the initial part of the diagnosis of three types of damage, i.e. to detect them, which are introduced into the wind turbine using an accelerometer, thus reducing the complexity of the detection and maintenance system, making it more economical and easier to operate. To achieve the above objective, the appropriate location and direction that the sensor needs to be installed on the wind turbine is investigated to provide the desired detection. The data are acceleration responses at four measurement locations on one wind turbine blade in the x and y directions in real environmental and operational conditions. The damages, which are examined, are associated with an increase in mass in the last 10% of the 1st blade distance, a decrease in stiffness in the first 10% from the root of the 1st blade, and a decrease in damping and stiffness factor in the low-speed shaft rotor located inside the hub. Early damage detection is carried out for each of the above damages and under different levels of those. Unsupervised parametric Multiple Model (MM-AR and MM-PCA-AR) methods based on AutoRegressive (AR) models are used to detect the three types of damage. The detection is performed under two varying operating conditions, wind speed and wind direction, which are first considered individually and then varied simultaneously. The final results for each case give different levels of detection. In particular, in the case where only the wind speed is varied, perfect detection of all damages is obtained by applying the U-PCA-MM-AR method, in contrast to U-MM-AR, whose results are unsatisfactory. The U-MM-AR method achieves perfect detection in the case of changing only the wind direction, whereas for changing both

operating conditions simultaneously, it is found that the U-MM-AR method does not give satisfactory detection for any of the considered damages, unlike the U-PCA-MM-AR method which detects each type and level of damage perfectly.

*Keywords*

Structural health monitoring, vibration signals, varying environmental conditions, early damage detection, Multiple Model Method

# *GEOMETRICAL MODELING AND OPTIMIZATION USING GENETICS ALGORITHM, SURFACES FOR NAVAL APPLICATIONS*

**Student's Name**
Strongylos Antonios
**Student Registration Number**
1067288
Email: up1067288@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067288&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The design of a ship's hull, which constitutes the core component and structural unit of the system, represents a task of research and development within the field of naval engineering. With the advent of electronic computers, the design process has been accelerated and made more efficient. The discovery of parametric curves Bezier, B-Splines, and NURBS has provided even greater flexibility to naval designers in shaping their designs and achieving desired forms within the hull's complex geometries and topologies. In this work, our focus was on the parametric design of the ship's hull, both in terms of curves and surfaces, as well as dimensional parameters. Utilizing empirical tables, analytical expressions, shape coefficients, and making assumptions for specific dimensions, we managed to establish a mathematical framework describing the hull's geometry. The design was executed using the Catiav5R20 design software. This program employs the aforementioned parametric curves and surfaces, enabling us to create intricate and demanding surfaces, such as those found in a ship's hull. We input the geometric parameters into the software spreadsheet and linked them to their corresponding variables in the design program. This effort provided us complete control over the design, as a simple alteration in a value within the spreadsheet allowed modification of our three-dimensional model. The result of this process is a fully parametric and adaptable model, serving as a template for the creation of various ship types. Subsequently, artificial intelligence, an integral part of the contemporary world that has permeated various domains, was employed. Its influence has been significant in technological advancement. One of the primary applications of artificial intelligence is optimization in design, finding wide-ranging application and driving considerable progress in numerous fields. Design optimization necessitates the exploration of an extensive solution space to identify the optimal solution for a problem. This is where genetic algorithms come into play, a robust category of artificial intelligence techniques that emulate natural selection's evolution for the pursuit of optimal solutions. Genetic algorithms excel in

handling problems with numerous variables and intricate constraints, effectively approximating optimal solutions through a thoughtful approach involving multiple levels of optimization. Finally, the results of the hull's design are comprehensively illustrated, with the goal of optimizing its hydrodynamic performance.

*Keywords*

Parametric Design, Ship Hull, NURBS/Bezier/B-Splines Curves, NURBS/Bezier/B-Splines Surfaces, Ship Dimensions, Genetic Algorithms.

# *PARAMETRIC MODELING AND ANALYSIS OF EXPERIMENTAL VIBRATION SIGNALS FOR WHEELED VEHICLES ACCOUNTING FOR WHEELBASE FILTERING EFFECTS*

**Student's Name**
Schoinas Ioannis
**Student Registration Number**
1059810
Email: up1059810@upnet.gr

**Supervisor:**
Fassois Spilios, Professor
**Contact Info**
Email: fassois@mech.upatras.gr
Tel.: (+30) 2610 969495

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059810&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This study addresses the problem of identifying and modeling the dynamic characteristics of the suspension-chassis system of road vehicles using parametric time series analysis methods. The excitation of the system is due to the roughness of the road surface, and only response signals from two accelerometers mounted on the chassis along the wheelbase and on the one side of the vehicle are used for the analysis. The response of the system depends on both the roughness of the road surface and the speed of the vehicle, which in the literature is known as the Wheelbase Filtering (WF) effect. Wheelbase Filtering occurs in all wheeled vehicles and is due to the time delay between the excitation of the front and rear wheels on each side of the vehicle from the road surface and results in: a) the appearance of periodic troughs, and b) masking of the dynamic characteristics of the system, in the estimated PSD of each signal. At the same time, two important structural conditions, which should be considered during the parametric modelling of the system: a) the order of the excitation is larger than the order of the response and depends on the vehicle speed, and b) at low speeds intermediate zero terms may appear in the excitation. Acceleration signals are obtained for speeds: 45, 52, 65 and 72 km/h, from two different categories of roads: a) a highway with good pavement quality, and b) a country road, which is dominated by both high roughness and steep potholes. In the first part of this study an extensive study of the effect of the two main uncertainties during the experiment, on the vehicle speed and on the dynamic characteristics of the road surface, is addressed. It is shown that due to these the system exhibits a) non-stationary, and b) non-Gaussian behavior for signals obtained from the country road. In the second part of the study parametric modelling of the system is attempted using AR, ARMA and the special case of WF-ARMA models. The results show that all models show relatively large deviation with respect to the actual signal values, while

predicting the data, nevertheless the convergence of AR and WF-ARMA models spectra with the non-prametric PSD seems to be satisfactory. At the same time, it is also attempted to extract the dynamic characteristics (poles and zeros) of the system using the estimated WF-ARMA models, from which it is concluded that only the poles of the system at the lowest frequencies can be obtained, which correspond to the basic chassis' degrees of freedom (bounce, pitch and roll) and the vertical motion of the wheels.

*Keywords*

Surface Vehicles, Wheelbase Filtering, Speed & Road Uncertainties, Parametric Modelling, WF-ARMA, Pavement Quality.

# *EFFECT OF TEMPERATURE FIELD ON LIFE CYCLE OF ROLLING BEARINGS*

**Student's Name**
Sotirkos Christos
**Student Registration Number**
1067343
Email: up1067343@ac.upatras.gr

**Supervisor:**
Nikolakopoulos Pantelis, Professor
**Contact Info**
Email: pnikolakop@upatras.gr
Tel.: (+30) 2610 969421

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067343&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The machine components used to transfer loads and rotation speeds are the most critical parts of a machine. In these components, the direct or indirect interaction between the parts in relative motion increases friction and causes wear of the surfaces. Lubrication is the most common way of reducing this friction and protecting contact surfaces. A type of these lubricated engine components are rolling bearings which are mainly operated under the elastohydrodynamic lubrication (EHL) regime. The life of these bearings depends on many factors, one of which is the heat generated due to viscous heating and the compression work of the lubricant when they are placed in a temperature field. Increases in temperature can accelerate oxidation and degradation of the lubricants, potentially leading to premature bearing failure. Excessive heat can also cause thermal expansion, altering the distances between rolling elements and bushings, which can further contribute to wear and shorten bearing life. In this thesis , therefore, the effect of temperature on the life of rolling bearings is studied. In particular, the modelling of lubrication for rolling bearing will be developed with the help of computational fluid dynamics. The aim is to solve both the isothermal and thermal problem of elastodynamic lubrication and to observe their differences in terms of the variation of pressure, lubricant thickness as well as viscosity potential in the course of time, so that the bearing life can then be calculated. This behaviour of rolling bearings in typical EHL contact is studied and the appropriate diagrams of its simulation are given. Specifically, the thesis will be divided into nine chapters. At the beginning, there is an introduction to rolling bearings, a review of their history and their advantages and disadvantages. In the second chapter, the categorisation of lubricants into liquid, solid, gas and grease groups is described, followed by a few words on the degradation mechanisms of lubricants. The third chapter analyses the different lubrication mechanisms, namely marginal, mixed, elastohydrodynamic and hydrodynamic lubrication. The next chapter describes Hertz's theory of contacts and the analysis of elastic deformation and pressure distribution. Chapter five discusses the wear mechanisms in rolling bearings and the

formulas for calculating their life. The sixth chapter describes the equations relating to elastohydrodynamic lubrication, namely those for density, viscosity, heat source, lubricant film thickness and the equilibrium of forces in the cylinder. This is followed by the modelling in ANSYS Fluent and the presentation of the geometry, the mesh created, the initial and boundary conditions and the results of the simulation. Finally, these results are analysed and the conclusions of this thesis are drawn.

*Keywords*

Elastohydrodynamic lubrication, rolling bearings, lubricant film thickness, temperature, service life, wear, pressure distribution, elastic deformation

# *MANUFACTURABILITY BASED DESIGN OPTIMIZATION FOR DIRECTED ENERGY DEPOSITION PROCESSES*

**Student's Name**
Terzakis Michail-Angelos
**Student Registration Number**
1067311
Email: up1067311@ac.upatras.gr

**Supervisor:**
Stavropoulos Panagiotis, Associate Professor
**Contact Info**
Email: pstavr@lms.mech.upatras.gr
Tel.: (+30) 2610 910160

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067311&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Additive manufacturing is the process of joining materials by selectively depositing them layer upon layer for the purpose of constructing parts or assemblies which are based on a 3D digital model. The nature of this process results in the morphing of complex component geometries which possess increased performance, a high degree of design freedom, and a lightweight structure. This is also the reason that AM has been growing rapidly nowadays and a great number of industrial sectors are implementing it. Furthermore, AM components can be manufactured by a variety of materials such as metals, plastics, ceramics, composites, that are ecologically friendly and exhibit an insignificant amount of material waste over conventional manufacturing technologies. Although AM offers significant benefits as mentioned above, there are manufacturing limitations that are imposed such as low productivity rate, poor surface quality, need for support structures and there is a level of uncertainty regarding the mechanical properties of the final part. These limitations derive from the nature of the specific technology and must be taken into great consideration whenever AM processes are being utilized for a particular task. The aim of this study is to mention the buildability limitations of AM that are attributed mainly to overhanging geometries and specifically overhanging angles, as well as study existing design, orientation optimization and mesh manipulation approaches that confront these issues in order to evaluate a proposed design optimization-based method which is implemented for the generation of a component with increased AM manufacturability and zero required support structures for DED processes. A workflow of topology optimization, orientation optimization, material addition and G-code generation of the final mesh is going to be described and all these steps are going to be realized inside the environments of Rhinoceros 3D and Grasshopper 3D. The extracted results of the fully optimized generated component related to crucial AM manufacturability characteristics are then compared to these of an optimized component that has occurred from a conventional design optimization workflow in order to evaluate and validate the advantages of the proposed method.

*Keywords*

Additive Manufacturing, Manufacturability, DED processes, Topology Optimization, Orientation Optimization, Material addition

# *DEVELOPMENT OF A SARRUS LINKAGE MECHANISM FOR SPACE ROBOTIC DEPLOYABLE MANIPULATORS*

**Student's Name**
Tsironis Dionysios
**Student Registration Number**
1067258
Email: up1067258@ac.upatras.gr

**Supervisor:**
Panagiotis Koustoumpardis, EDIP
**Contact Info**
Email: koust@mech.upatras.gr
Tel.: (+30) 2610 969491

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067258&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The exploration and understanding of space are becoming increasingly important, especially in our time. Although our technology and knowledge have advanced, space remains a dangerous field for astronauts and crews undertaking missions in it. A large portion of space travel requires human efforts, but their long durations can be challenging for the human body. Therefore, the use of robotic systems is vital, whether working in collaboration with humans or working autonomously. Two major challenges are prevalent in space missions: the cost of missions and the limited space on the spacecraft.

The purpose of this thesis is to develop a deployable robotic link that is intended for such missions. Initially, bibliographic research and analysis is reviewed from my student thesis on robotic arms in space, deployable mechanisms, and deployable robots. Then, design concepts are proposed and the most suitable one is selected. The link is designed in detail from the module stage, static and kinematic analyses and simulation of its motion are performed and finally a prototype model is manufactured using 3d printing technology.

The mechanism uses a combination of springs, rope motors and electromagnets for its actuation and closing and provides a lightweight, small volume unit with a high magnification ratio that can be part of a robotic link, and by extension, a robotic arm.

*Keywords*

Robot, Robots in space, Foldable mechanisms, Robotic arms in space, Origami robots

# *DEVELOPMENT OF A PNEUMATIC GRIPPER FOR CUTTING/GRASPING FRUITS TOWARDS ROBOTIZED GRAPE HARVESTING*

**Student's Name**
Christopoulos Athanasios
**Student Registration Number**
1070597
Email: up1070597@ac.upatras.gr

**Supervisor:**
Panagiotis Koustoumpardis, EDIP
**Contact Info**
Email: koust@mech.upatras.gr
Tel.: (+30) 2610 969491

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1070597&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The global agricultural industry is marked by its continuous pursuit of innovation and efficiency. The development of specialized robotic systems for tasks such as grape harvesting holds potential. This thesis presents a comprehensive exploration of the design, development, and testing of a pneumatic gripper tailored for robotized grape harvesting.

Starting with a meticulous review of the existing literature, delving into grape characteristics, prior research efforts, and the diverse gripper designs employed in similar applications. This foundational research presents the concept design of our gripper and provides insights into the specific challenges faced in grape harvesting.

Gripper's design and development process is based on a flowchart developed to address the specific problem. Proposed gripper is based on the selection of a commercial actuator as the adaptive design method is used for the development. After evaluating several options, the actuator is a commercial copy of the MHC2-25S pneumatic angular actuator. This choice aligns with the goal of achieving optimal gripping and cutting performance while maintaining cost efficiency.

The subsequent chapters delve into the detailed design methodology, covering aspects such as configuration design, parametric analysis, kinematic analysis, and static stress analysis.

The prototype development phase achieved with the use of a regular low-cost 3D printer with PLA+ filament to fabricate the gripper components. Essential equipment, including an air compressor and various tools, facilitate the assembly and testing processes. Challenges encountered during development found in assembly procedure.

Operational experiments validate the gripper's performance, in an effort to laboratory simulating the real-world conditions of a vineyard. The gripper demonstrates a high success

rate in harvesting grapes and exhibits stability when subjected to acceleration forces. Considering gripper’s performance on other fruits, the proposed gripper shows success that makes it capable of broadening its scope.

Future improvements includes refining the gripper's design, adding functions, and developing an adaptor for the chosen manipulator.

The proposed design, development, and testing lay the foundation for further advancements in this field, ultimately contributing to automating agricultural harvesting procedures.

*Keywords*

Robotized grape harvesting, Robotic gripper, Soft gripper, Design theory, End effectors

# DIVISION OF ENERGY, AERONAUTICS AND ENVERONMENT (SEPTEMBER 2023)

## *NUMERICAL STUDY OF FLOW IN A "U" SHAPED SQUARE DUCT*

**Student's Name**
Angelopoulos Marios
**Student Registration Number**
1054476
Email: up1054476@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054476&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

In this paper, a computational study of turbulent flow in a square curved "U" type duct is carried out using the Openfoam computer program. Three Rans turbulence models (k epsilon, RNG k epsilon and k omega) will be used in the study, the results of which will be compared with the experiment from the existing literature. The part we are mainly concerned with in this study is the axial velocity and the comparisons will be made at 0, 90, 180 degrees in the curved part of the duct. The aim of the work is to select the most suitable turbulence model, which will give the best possible results compared to the experimental setup, with the lowest possible computational cost. The results are presented through comparative diagrams which are studied both qualitatively and quantitatively.

*Keywords*

Computational fluid dynamics, curved ducts, turbulent flow, RANS models, OpenFoam

# *COMPUTATIONAL ANALYSIS OF AIR FLOW FROM VENTS OF DIFFERENT SECTIONS WITH GRILLES OF DIFFERENT CONFIGURATIONS*

**Student's Name**
Anagnostopoulos Athanasios
**Student Registration Number**
1054545
Email: up1054545@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054545&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

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

*Keywords*

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

# *EARTH-TO-AIR HEAT EXCHANGERS: A SENSITIVITY ANALYSIS OF THE SYSTEM BASED ON ITS CONFIGURATION PARAMETERS*

**Student's Name**
Kalogiannaki Eudoxia Emmanouela
**Student Registration Number**
1067355
Email: up1067355@ac.upatras.gr

**Supervisor:**
Michalakakou Giouli, Professor
**Contact Info**
Email: pmichala@upatras.gr
Tel.: (+30) 2610 969478

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067355&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The ongoing energy crisis and climate change have brought up the demand for alternative methods to meet energy needs in the building sector. The energy conscious design of buildings is more than ever popular and necessary in order to cope with energy and environmental emerging problems. It aims at the smooth operation of the buildings, by consuming the minimum possible power and offering a comfortable indoor climate to the occupants, using mainly passive methods. These lead to the need to use ground cooling methods, such as earth-to-air heat exchangers systems, an indirect form of ground cooling. They take advantage of the nearly constant annual ground temperature at a depth of up to four meters underground, to drop the temperature of the ambient air and regulate the indoor temperature through the piping system. It is considered an indirect method because the building is not in direct contact with the ground, but the piping arrangement buried in it exchanges heat through convection from its walls. A great number of studies described and modelled the thermal performance of the system mainly based on heat transfer equations of conduction in soil and convection inside the tube. The majority of models include a parametric sensitivity analysis in order to assess the impact of the main design configuration parameters on system's thermal efficiency. Scientific literature revealed that the most significant configuration parameters are: (a) pipe length, (b) pipe radius, (c) air velocity inside the tube, and (d) burial depth below ground surface.

In this diploma thesis, extensive reference is made to these parameters and to the way they affect the system, but also to the categories of models that have been developed by the researchers, in order to predict the operation of earth-to-air heat exchangers. Moreover, in the following pages a model for the evaluation of the performance of an earth-to-air heat exchanger system under various circumstances is studied, especially in what way does the burial depth of the system affects the overall performance but also the pipe grant. The

evaluation process is performed for three cities in Greece, Athens, Patras, and Heraklion, and results are obtained. Obtained results performed well with scientific principles. Finally, an estimation of the EAHE system contribution to the cooling load of a typical non-insulated building is presented based on a successfully validated theoretical approach Based on balance temperature and cooling degree hours theory.

*Keywords*

Earth-to-Air Heat Exchangers, Sensitivity Analysis, Cooling Load, Burial Depth, Pipe Grant

# *COMPUTATIONAL STUDY OF AIR-FUEL MIXTURE STRATIFICATION EFFECTS ON THE PROPERTIES OF METHANE FLAMES, UNDER LOW INLET REYNOLDS NUMBER*

**Student's Name**
Kantzavelos Antonios
**Student Registration Number**
1067253
Email: up1067253@ac.upatras.gr

**Supervisor:**
Koutmos Panayiotis, Professor
**Contact Info**
Email: koutmos@mech.upatras.gr
Tel.: (+30) 2610 997244

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067253&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Stratified flames, which we will examine in this paper, are a category of flames of great theoretical and practical interest. More specifically, flames of this type can prove to be particularly useful in the study of the optimization of the combustion phenomenon, both in terms of its efficiency and its stabilization. At the same time, the detailed and correct study of stratified flames can provide us with important results in terms of the emission of pollutants during the combustion phenomenon, with a view to reducing them. This could make a decisive contribution to limiting the greenhouse effect, which is largely sustained by the gaseous products of combustion.

In this paper, the effect of the fuel-air mixture injection height with respect to the axis of symmetry of the layout on the equivalence ratio at the inlet of a given flame stabilizer geometry will be investigated. The effect of the injection height on the most characteristic combustion parameters will then be studied. In particular, we will study four (4) different injection heights, using methane as fuel and distinguishing two (2) sub-cases: initially taking the effect of gravity into account and then ignoring it. The fuel-air mixture is drained under ambient conditions, while the flame stabilizer's shape is conical.

Finally, all simulations were carried out using the Laminar model, while the model that was chosen for mixing and combustion was the Species Transport model, which contains a mechanism with 3 and 35 chemical elements respectively. For the implementation of the computational simulations, the commercially available software Fluent within the Ansys suite was used.

*Keywords*

Flame stabilization, stratified flames, injection height, laminar flames, methane

# *EXPERIMENTAL STUDY OF AIR FLOW FROM VENTS WITH GRILLES OF DIFFERENT SECTIONS AND CONFIGURATIONS*

**Student's Name**
Katsarakis Zacharias
**Student Registration Number**
1044519
Email: up1044519@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1044519&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The primary goal of indoor air conditioning is to design a comfortable and healthy environment. The development of advanced air conditioning systems with a very low environmental footprint has been under continuous research in recent years, for this reason the aim of the present study is the evaluation of ventilation devices. The most basic characteristics of the air grille ventilation devices are throw, rise, drop, spread, noise level, pressure drop and critical velocity.

This study takes place in the laboratory room of the Fluid Mechanics Laboratory of the University of Patras, in the Department of Mechanical and Aeronautical Engineering. The room has dimensions (10 m x 5.5 m x 2.75 m) and replicates a working space, that is comparable to an office environment. Initially, two different grilles of a similar design are studied and compared, and then one more grille is measured and compared with measurements from a computational model by colleague A. Anagnostopoulos. The upper limit of critical velocity from the free surface of each grille is defined as Vc = 10 m/s. The experimental procedure followed is based on taking measurements of air velocity in all three axes with a constant step for each axis, until air velocity equal to 0.5 m/s is found in all three axes of the space. Velocity measurements are made for different air flows to form a profile for the grille under study, while for each flow the noise level of the grille is also measured. The achievement of this process is done with the help of measuring instruments (anemometer and sound level meter).

In conclusion, the results of the two initial grilles are similar as they are quite similar in design, nevertheless there are reasonable differences which are justified. Finally, the results of the experimental and computational study carried out for the third grille are compared and it is observed that the convergence between both the experimental results and the computational model is excellent.

*Keywords*

Air grille, air distribution, ventilation system, experiments, air quality

# *A SOFTWARE FOR CALCULATION OF PRELIMINARY DESIGN PARAMETERS OF A JET ENGINE AND ITS MAJOR COMPONENTS*

**Student's Name**
Kouvaras Georgios
**Student Registration Number**
1059812
Email: up1059812@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059812&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Gas Turbine engines are the most common types of engines used for civilian and military purposes. They operate with the same basic principles as the open-circuit Brayton cycle. For all the cases that are mentioned the same principle applies with little changes regarding the number of spools and the existence of a fan. The air enters the inlet of the engine and is pressurized on the compressor. After that, the air enters the combustion chamber where fuel is ejected and mixed with the air. The mixture is then burnt and goes to the turbine where work is produced and used to rotate the spool of the compressor. In the end, the air is expanded in the nozzle or burnt once again (after it's mixed with fuel again) before is expanded in the nozzle (afterburner). The basic components of Aircraft Engines are the Compressor, the Turbine, the Combustion Chamber and the Nozzle. The air enters the inlet of the engine and is pressurized on the compressor. The Compressor has Rotors and Stators where both of them have a specific number of blades with a specific geometry so that the air in each stage (Rotor-Stator) is compressed with a specific pressure ratio.

The preliminary design of a gas turbine engine is a complex and time-consuming procedure. The purpose of the current study is to automate this type of design with the use of Matlab GUI. The application we design only needs basic parameters often seen in aircraft propulsion systems (such as the height of flight) and after calculations the application exports the basic thermodynamic variables needed for detailed design (pressure, temperature, velocity of exhaust fumes, and entropy) and also exports the basic thermodynamic variables needed for detailed design (pressure, temperature, velocity of exhaust fumes, and entropy).

*Keywords*

Gas Turbine Engine, Compressor, Preliminary Design, Application Design, Matlab GUI

# *EXPERIMENTAL STUDY OF REACTION TO FIRE OF WOOD USING THE CONE CALORIMETRY METHOD*

**Student's Name**
Mitropoulos Nikolaos
**Student Registration Number**
1057436
Email: up1057436@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1057436&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

To prevent accidents, safeguard persons and property, and protect individuals, fire safety is crucial. The industry is continually looking for innovative approaches to improve fire safety. To guarantee that structures are fire-safe, there are stringent laws and regulations. The kind of materials used in the structure may have a significant impact on safety in the case of a fire.

Based on the ISO-5660 standard, the aim of this research was to investigate the burning characteristics of various species of wood. This standard assesses factors characterizing materials in relation to their reaction to fire properties, including heat release, igniting time and smoke production. These characteristics were measured using a cone calorimeter, a small-scale fire test technique, following the abovementioned standard.

We can classify materials and learn how they respond to fire by using data from ignition experiments. The results are used to assess the suitability of wood products as building materials that will have the required fire behaviour.

*Keywords*

Cone Calorimeter, Wood, Reaction to Fire, Fire, Fire Safety

# *SPRAY COOLING OF ELECTRONIC COMPONENTS*

**Student's Name**
Moschovos Nikolaos
**Student Registration Number**
1054456
Email: up1054456@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054456&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

Spray cooling is considered a promising and innovative cooling method, capable of meeting the ever-increasing thermal management requirements of high-power electronic devices, with favorable characteristics such as high heat dissipation capacity, low coolant overheat and maintaining uniform surface temperature. An experimental closed-loop spray cooling system was constructed to investigate the parameters affecting the performance of the method, with R410a refrigerant as the working fluid. The response of the method is investigated under varying operating conditions at coolant flow rates of 4.5, 5.5, 6.5 and 7.5 gr/s and spray heights of 25 and 30 mm. In addition, two different spray nozzles with spray cone angles of 45° and 60° are investigated, as well as the effect of oil coating on the heating surface caused by a defective operation of the oil separator of the system for a prolonged period of time. In this study, the evolution of the critical variables, the heat flux and the heat transfer coefficient, and the trends highlighted in them are evaluated. Their variations under the different operating parameters of the device are examined and the conditions presenting the optimal results of the spray cooling method are sought, in terms of its performance and efficiency.

*Keywords*

Spray cooling, Closed-loop cooling system, Heat transfer performance, Oil surface coating, Spray cone angle

# *EXPERIMENTAL STUDY OF BUILDING MATERIALS' REACTION TO FIRE BY CONE CALORIMETER MEASUREMENTS AND DEVELOPMENT OF A CORRELATION MODEL WITH RESULTS OF SINGLE BURNING ITEM METHOD*

**Student's Name**
Balaras Angelos
**Student Registration Number**
1067276
Email: up1067276@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1067276&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present Diploma Thesis deals with the study of reaction to fire of building construction products. The experimental part of this work is performed using the Cone Calorimeter. This bench-scale apparatus offers the possibility to measure important quantities of a burning material (heat release, smoke production etc.). Based on this data, all building materials are classified in the European system (EUROCLASS). The most widespread testing method for such classification is the Single Burning Item (SBI), which specifies FIGRA (maximum Fire Growth Rate) and SMOGRA (maximum Smoke Growth Rate) indices. Ultimately, this work aims to predict the class of certain materials (pine wood, polyethylene foam and cable sheath) in the SBI, using data obtained from the Cone Calorimeter. To achieve this, selected prediction models are used including the ConeTools model, the One–Dimensional (1D) Thermal Flame Spread model and Computational models for Smoke Production.

This Diploma Thesis focuses on elaborating the fundamental principles regarding fire phenomena, flame spread on surfaces and materials reaction to fire. This work consists of ten chapters.

❖Chapter 1: offers a general overview of the topic, setting the goals of this work.

❖Chapter 2: presents fire and combustion phenomena accompanied by the main principles of heat transfer.

❖Chapter 3: describes the reaction to fire testing methods, focusing on Cone Calorimetry and SBI.

❖Chapter 4: provides an overview of EUROCLASS and its categorization criteria.

❖Chapter 5: includes the theory of flame spread on surfaces.

❖Chapter 6: presents selected methodologies of prediction models.

❖ Chapter 7: specifies the behavior of the testing specimens under fire conditions as observed during the Cone Calorimeter tests.

❖ Chapter 8: collects the experimental results derived from the Cone Calorimeter and outlines the developed computational tool.

❖Chapter 9: presents the computational findings resulted from the tool.

❖ Chapter 10: summarizes the main achievements and presents the evaluation of the findings of this work.

Concluding, this work provides all the data necessary to make the Euroclassification prediction of the tested products. The final results enable the possibility to evaluate the models' accuracy and make suggestions for future studies.

*Keywords*

Reaction to fire tests, Cone Calorimeter measurements, Single Burning Item method (SBI), Euroclassification Prediction Models, Evaluation of Computational and Experimental Findings

# *ACTIVE FLOW CONTROL ON A WING*

**Student's Name**
Papakostas Panos
**Student Registration Number**
1056658
Email: up1056658@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1056658&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The present dissertation deals with flow control of a wing with active dimples which shape the surface of the airfoil and aim to reduce drag, prevent flow detachment, and improve the aerodynamic performance of the wing. First, a reference is made to the aerodynamic quantities that will be used and are needed for the experimental process. Then existing technologies for flow control are presented and the analysis of the active morphing of the airfoil is described which uses cavities and dimples for flow control. The types of actuators available for the control of the dimples and the description of the pneumatic mechanism selected for the experimental device are also analyzed. The experimental setup is then described as well as the calibration and optimization of the aerodynamic force balance with different strategies so that we receive correct indications of the aerodynamic loads of the wing. After the calibration of the aerodynamic force balance is done, we analyze the experimental data that we obtained and present observations about the effectiveness of the cavitations.

*Keywords*

Flow control, active morphing, active dimples, experimental aerodynamics, boundary layer control.

# *COMPUTATIONAL INVESTIGATION OF THE EFFECT OF A VORTEX GENERATOR OF FLAT BLADE TYPE WITH A SHAPE OF CROSS-SECTION IN INCINATION FOR DIFFERENT DIMENSIONS ON THE FLOW-THERMAL FLOWFIELD OF A RECTANGULAR PIPE IN TURBULENT FLOW*

**Student's Name**
Poulakis Konstantinos
**Student Registration Number**
1026732
Email: mead6814@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026732&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This study aims to investigate the effect of a vortex generator (VG) on the flow-thermal flowfield of a rectangular pipe in turbulent flow. The main objective is to enhance the heat transfer in the pipe with as low pressure drops as possible. In the context of this research, different ratios between the dimensions of the pipe and the width of the Vortex Generator were tested, as well as different Reynolds numbers at the inlet of the pipe.

The study starts by introducing the fundamental principles of fluid dynamics and heat transfer, discussing the different types of flow, the boundary layer, and vortices, leading to the concept of Vortex Generators. It also provides an overview of computational fluid dynamics and the Ansys Fluent simulation software used in the study.

The study then proceeds with presenting the process of the construction of the pipe and VG geometry and the generation of the mesh. The VG used in this study is of a flat blade type, cross-section shape, inclined. Specifically, the study was carried out for 6 different ratios between the dimensions of the pipe and the width of the VG. (Pipe aspect ratio: eight/width: 3/2, 2/2, 1/2, with a blade width to pipe width ratio equal to 0.1 and 0.05.) For the discretization of the geometry, a mesh independence study was conducted.

The solution was then determined. Here, the k-e Realizable turbulence model was selected, and the boundary conditions were defined. The walls of the pipe are at a constant

temperature, transferring heat to the fluid. Four different Reynolds numbers were tested at the inlet of the pipe: 5.000, 10.000, 15.000, 20.000.

Finally, the results were analyzed, conclusions were drawn and recommendations were made for future studies. In all of the investigations, the corresponding diagrams were constructed for better understanding of the results.

*Keywords*

Vortex Generator, Heat transfer, Reynolds number, Computational fluid dynamics, Turbulent flow

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

**Student's Name**
Serepisos Nikolaos
**Student Registration Number**
1070586
Email: up1070586@ac.upatras.gr

**Supervisor:**
Souflas Konstantinos, Assistant Professor
**Contact Info**
Email: souflask@mech.upatras.gr
Tel.: (+30) 2610 997249

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1070586&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The writing of this Diploma Thesis is based on the study of the mixing field of a prototype experimental burner setup, which can stabilize aerodynamically stratified gas mixture flames using a bluff body. This experimental setup was designed and constructed in the Laboratory of Applied Thermodynamics of the University of Patras.

The bluff body burner setup is surrounded by a duct, through which primary combustion air is supplied into the combustion region. A fuel injection tube (injector) is located centrally inside the duct. Through this injector the fuel (propane) is supplied into the burner. The fuel injection height is not fixed but can be varied by using extensions. At the duct's exit plane, the bluff body is located. This is conical in shape and the cone is facing inside the burner. This setup ensures stabilization of stratified turbulent flames and achieves stable combustion of lean propane-air mixture.

In the present Diploma Thesis, the basic theoretical background of the combustion process and the partial premixing of mixtures is initially presented. Then, the operating principle of bluff body flameholders is analyzed and the effect of preheating on such setups is pointed out. Following, the experimental setup used for this study is extensively described and a detailed description of the entire measuring equipment is given.

By using Fourier Transform Infrared Spectroscopy (FTIR), the mixing field is studied and the distributions of the equivalence ratio Φ (Phi) over the exit plane of the burner are obtained. Different fuel injection heights are used to record how they affect the stratification of the mixture upstream of the flame stabilization region. Finally, by keeping

the fuel supply constant, the air supply of the incoming mixture is varied and the way in which these variations affect the partial premixing is recorded.

Keywords

Combustion, FTIR, Bluff Body Flameholders, Mixture Stratification, Equivalence Ratio

# *CONTIRBUTION OF CONSTRUCTION MATERIALS IN THE ENERGY EFFICIENCY OF BUILDINGS*

**Student's Name**
Sofikitis Argyrios
**Student Registration Number**
1064356
Email: up1064356@ac.upatras.gr

**Supervisor:**
Michalakakou Giouli, Professor
**Contact Info**
Email: pmichala@upatras.gr
Tel.: (+30) 2610 969478

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1064356&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

It is a fact that over the last decades, climate change combined with intense urbanization, has caused the development of the Urban Heat Island (UHI) phenomenon in Greek cities and in wider urban areas across the Mediterranean. The increase in the temperature of city structures (buildings, pavements, etc.), especially during the summer months, leads to an increasing consumption of energy with serious consequences for environmental degradation, depletion of natural resources and, consequently, for the quality of life. In order to address all the above impacts, energy saving, which is achieved through proper energy planning, is of primary importance. The use of efficient building materials and the application of cold coatings to the structure and shell of buildings are key elements of energy design. The aim of this thesis is, firstly, to examine the energy requirements and consumption of an existing house and then to analyse different cases of energy-saving interventions, as well as a combination of these, mainly in the field of heating and cooling. The technical study of the selected interventions was carried out with the help of the TEE-KENAK software used for energy studies in Greece. The purpose of the analysis of the proposed energy-saving interventions is to find out the optimal choice of intervention that will lead to the minimum possible energy consumption and the improvement of the energy efficiency of the study building.

*Keywords*

Urban Heat Island (UHI), Energy Conscious Design of Buildings, Constructive Materials, Energy Conservation in Buildings, Cool Materials

# *THE AERODYNAMIC BEHAVIOUR OF A SYMMETRICAL AIRFOIL IN AIR-SOLID PARTICLES FLOW: COMPUTATIONAL INVESTIGATION*

**Student's Name**
Tampas Michail
**Student Registration Number**
1047322
Email: up1047322@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1047322&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

This thesis aims at the computational study of the aerodynamic behavior of the airfoil NACA 0012 operating in a discreet air-solid sand particles two-phase flow for a wind speed equal to 25.7 m/s. This airfoil is used in various aerodynamic studies and applications. To begin with, a review of the literature on problems concerning the behavior of airfoils in one-phase and multi-phase flow conditions, such as air-sand particle two-phase flow, is presented. Then, basic aerodynamic nominations, such as aerodynamic quantities, airfoils as aerodynamic bodies and dimensionless aerodynamic coefficients, are presented. Next, more information about two-phase flow is given, with particular emphasis on the behavior of the dispersed phase, i.e. sand particles. This is followed by some information on computational fluid dynamics (CFD) concerning the turbulence model and the modelling of the two-phase flow. In order to study the behavior of the NACA 0012 airfoil in two-phase flow, the behavior of the airfoil in one-phase airflow is first investigated, and then the Discrete Phase Model (DPM) is used to introduce sand particles into the flow field. From the present study, the aerodynamic lift and drag coefficients of the airfoil, the contours of static pressure, velocity magnitude and particle concentration around the airfoil are obtained, and the distribution of the pressure coefficient, the erosion rate and the accretion rate on the upper and lower surface of the body are plotted as well for a number of angles of attack. From the present investigation it is concluded that the airfoil has lower performance when operating in multiphase flows.

*Keywords*

Two-phase flow, NACA 0012 Airfoil, Computational fluid dynamics, Pressure distribution, Sand particle concentration, Accretion rate, Erosion rate

# *COMPUTATIONAL SIMULATION OF COMBUSTION OF BUILDING MATERIALS IN A CONE CALORIMETER*

**Student's Name**
Fragkias Vasileios
**Student Registration Number**
1026973
Email: mead7066@ac.upatras.gr

**Supervisor:**
Panidis Thrassos, Professor
**Contact Info**
Email: panidis@mech.upatras.gr
Tel.: (+30) 2610 969436

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1026973&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In this thesis, the data and results of a small-scale experiment of simulated combustion of materials in enclosed spaces are used for modelling in the open-source program Fire Dynamic Simulation (FDS).

This experiment is applicable to aircraft cabin covert zones and therefore studies materials suitable to be used in these spaces. In particular, the combustion behavior of a structural material widely used in aircraft construction in the hidden zones, as roof panels, is investigated through computational simulation. The combustion characteristics and properties of the material under consideration were obtained from experimental procedures carried out in a Cone Thermometer. The thesis focuses on fire modelling by simulating fire in actual conditions, in order to verify the factors affecting fire propagation. The verification of the properties of the experimental material is done by creating a computational model of the Confined Fire Apparatus (CFA).

The device includes a radiant heat source and a burner used for pilot ignition. The air inlet and outlet is simulated with free flow. Due to the imposed heat flow from the panel to the test specimen, its thermal decomposition begins. Ignition starts when the burner is placed on the sample. The above energies allow the examination of two main factors, the preheating time and the effect of radiant heat from the panel. The issues of interest are the rate of flame spread, the rate of pyrolysis of the material and duration of flame propagation on the surface of the material, and the smoke release.

*Keywords*

Cone Calorimeter, CFA, FDS, simulation of combustion, building material.

# *EFFECT OF HAIL ON THE AERODYNAMIC BEHAVIOR OF THE S809 AIRFLOW*

**Student's Name**
Chalil Aikout
**Student Registration Number**
1054572
Email: up1054572@ac.upatras.gr

**Supervisor:**
Papadopoulos Policarpos, Associate Professor
**Contact Info**
Email: ppapadopoulo@upatras.gr
Tel.: (+30) 2610 997564

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1054572&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

The aim of this thesis is the computational study of the aerodynamic behavior of airfoil S809 in hailstorm conditions, when the wind speed is 14.6m/s. This airfoil was chosen because it is used for the construction of wind turbine blades. Initially, a literature search was conducted for studies on the behavior of airfoils when operating in severe weather conditions, such as rain and hail, and when operating in areas where sand is present, since wind turbines operate in a variety of weather conditions. Next, basic aerodynamic nominations were presented, i.e. characteristics of airfoils and aerodynamic coefficients. Following is some information about hail, which are necessary to know for the simulations. The basic structure of the Computational Fluid Dynamics (CFD) programs is then presented. In order to study the operation of the S809 airfoil under hailstorm conditions, simulations were first performed for the operation of the airfoil under airflow conditions. Then, the Discrete Phase Model (DPM) was activated, and raindrops and hailstones were injected into the computational domain. The results of this work are the aerodynamic coefficients of the airfoil, the distributions of pressure, velocity and diameters of raindrops and hailstones near the airfoil, the distribution of pressure coefficient, water film height and erosion rate on the upper and lower surfaces of the airfoil for different angles of attack. Finally, the power coefficient of a three-bladed wind turbine with blades constructed from airfoil S809 was estimated. In general, it was found that the performance of the airfoil and ultimately the wind turbine decreases under hail conditions.

*Keywords*

Hailstorm, S809 Airfoil, Pressure Distribution, Water Film, Erosion Rate, Raindrops Distribution, Distribution of Hailstones

# DIVISION OF MANAGEMENT AND ORGANIZATION (SEPTEMBER 2023)

## *ERP SYSTEMS: STATE-OF-THE-ART AND BEYOND*

**Student's Name**
Kotzamanidis Nikolaos
**Student Registration Number**
1059752
Email: up1059752@ac.upatras.gr

**Supervisor:**
Karakapilidis Nikolaos, Professor
**Contact Info**
Email: karacap@upatras.gr
Tel.: (+30) 2610 969480

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1059752&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

### ABSTRACT

This thesis examines the impact of emerging technologies such as artificial intelligence and machine learning on enterprise resource planning (ERP) systems. The discussion starts by introducing Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) systems, explaining their precise definitions and elucidating their respective roles within a company. Subsequently, we delve into an examination of the primary machine learning methodologies and a selection of machine learning-driven strategies that hold significant use in the integration of novel technologies within Enterprise Resource Planning (ERP) systems. A more comprehensive discussion is provided regarding the distinction between supervised and unsupervised machine learning. The primary distinction lies in the training process of these two models. Supervised machine learning models are trained using labeled input data and their corresponding output tags. On the other hand, unsupervised machine learning models are trained with unlabeled data, which lacks output labels. Additionally, the challenges associated with each approach are also addressed. Ultimately, the authors elucidate the various methods by which these emerging technologies can be integrated into enterprise resource planning (ERP) systems, thereby presenting a plethora of opportunities for the organizations that employ them. Notably, the primary applications are the integration of chatbots into customer relationship management (CRM) systems, the implementation of dynamic pricing mechanisms, and the enhancement of production planning capabilities.

*Keywords*

ERP systems, CRM , Machine learning , chatbots, Production planning

# *THE TRANSITION OF THE INDUSTRIAL SYSTEM TOWARDS REMANUFACTURING*

**Student's Name**
Panagopoulos Dimitrios
**Student Registration Number**
1057609
Email: up1057609@ac.upatras.gr

**Supervisor:**
Adamides Emmanouel, Associate Professor
**Contact Info**
Email: adamides@mech.upatras.gr
Tel.: (+30) 2610 969475

**Poster:** https://www.mead.upatras.gr/diplomatikes-spoudastikes-ergasies/?filter_8=1057609&filter_4=%CE%94%CE%B9%CF%80%CE%BB%CF%89%CE%BC%CE%B1%CF%84%CE%B9%CE%BA%CE%AE&filter_1=&filter_2=&filter_12=&mode=all

---

## ABSTRACT

In recent years, global interest in remanufacturing has grown dramatically as an imperative response to growing concerns about resource depletion and environmental degradation. As stakeholders from various industries and governments recognize the urgent need for, and are constantly seeking, sustainable alternative solutions, remanufacturing is offered as a promising way to reduce the environmental impact of product production and consumption. The circular economy approach inherent in remanufacturing aligns with global efforts to promote responsible consumption and production, making it an increasingly attractive option for businesses, governments, and consumers. The adoption of remanufacturing goes conjointly with the collective effort to promote a greener and more efficient future where economic prosperity and environmental stewardship go together. In this diploma thesis, a study on the transition from traditional manufacturing practices to remanufacturing in the context of socio-technical systems is carried out. A comprehensive literature review on the topic is conducted, and a simulation of the transition across various scenarios is performed using system dynamics. The iThink 9.1.4 software is employed for the simulation. The outcoming results reveal that the transition can be achieved when used product acquisition is significantly increased, while marketing strategies are implemented for both remanufactured and new products. Also, a fine balance needs to be maintained with the increase of applied regulations. If these conditions are satisfied, the market is expected to see a significant growth in remanufactured products, outnumbering new products by a considerable margin, thus leading to a decrease in the growth rate of discarded products over time.

*Keywords*

Remanufacturing, socio-technical systems, transition models and theories, transition, Multi-level Perspective (MLP), activity theory, system dynamics