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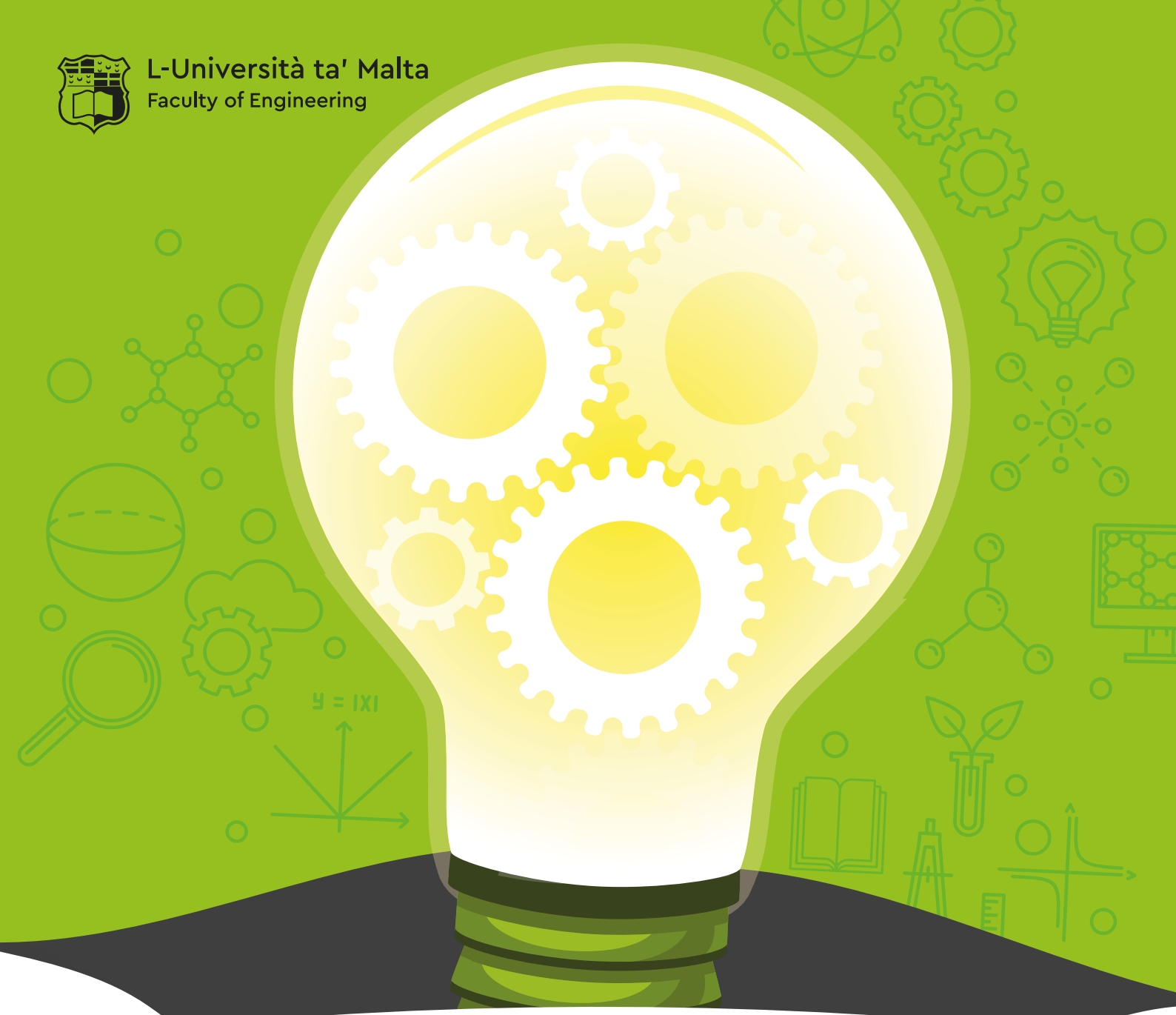
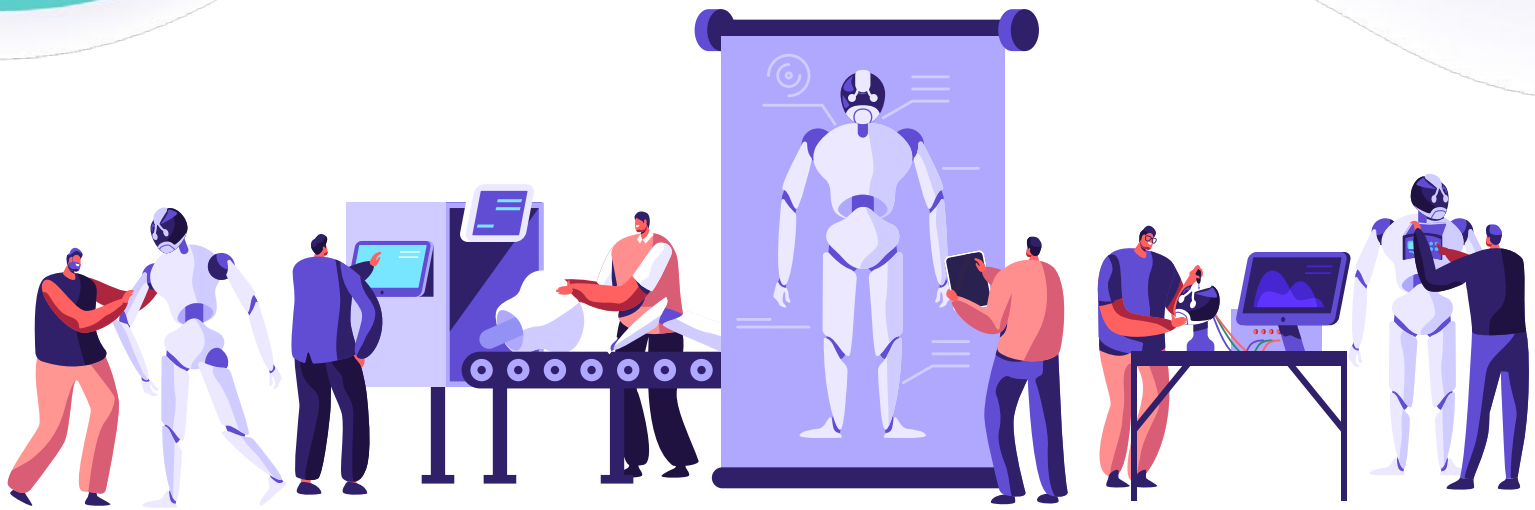


FACULTY OF ENGINEERING EXHIBITION 19

UNIVERSITY OF MALTA, MSIDA

myjourney:
Achieving through different paths

MINISTRY FOR EDUCATION AND EMPLOYMENT



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As part of the My Journey initiative, students in secondary school now have the option to immerse themselves in the fascinating world of design and technology with hands-on experience.

Students are now able to blend relevant and quality academic, applied and vocational subjects in a personalised and inclusive learning environment that enables them to reach their full potential.

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For more information kindly visit **myjourney.edu.mt** or **nextyear.edu.mt**

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engineering
the route to safety and security

18th September 2019 | 08:30hrs - 15:00hrs | Venue to be advised

Chamber of Engineers 26th Annual Conference

The conference entitled "Engineering: The Route to Safety and Security" will focus on engineering aspects related towards providing safety and security in all aspects of life and society. In a world where people are growing accustomed to the ever increasing commodities and realities offered by modern lifestyles, be it the buildings they live or work in, the systems they use on their workplace or to move around, the virtual reality where they store their valuables, from e-mails to bank accounts, the safety and security of such commodities is often overlooked, by all, bar the professionals entrusted with providing it.

Engineering, in all its facets is an accepted route towards providing safety and security. For this reason, this year's conference looks at aspects which in a wide context relate to safety and security. Topics to be addressed include, but are not limited to, fire safety in buildings, cyber security, designing for safety on the workplace, occupational health and safety, safety in road infrastructure, risk management, safety in aviation, security systems, facilities management and insurance.

Papers or any queries are to be addressed to **actsec@coe.org.mt**. Deadline for submission of papers is the **31st July 2019**. The Authors should clearly highlight the objectives, results and outcomes. Formatting rules can be found on the website **www.coe.org.mt** and should be followed strictly. Further details will follow in the coming months.

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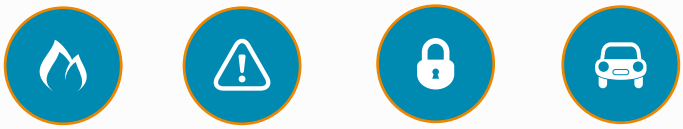

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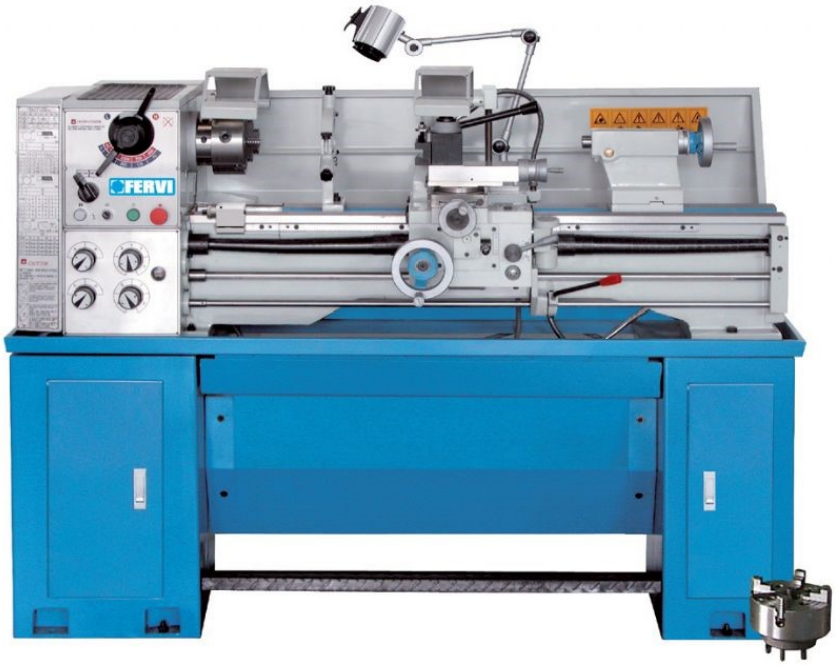

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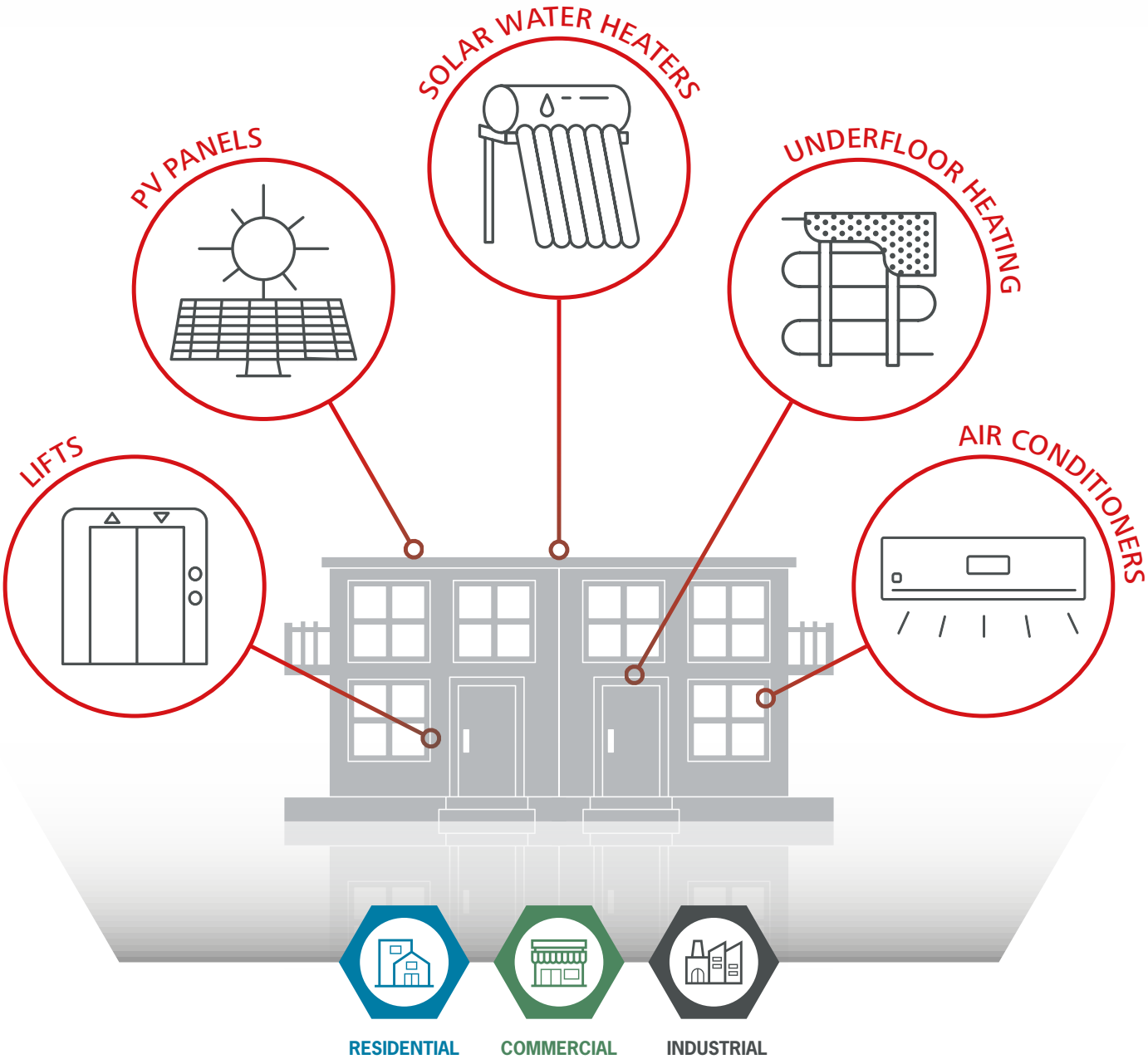

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FOREWORD

On behalf of the staff of the Faculty of Engineering, I welcome you to the 30th edition of the engineering undergraduate final year projects exhibition. This year 90 undergraduate projects will be on display within the various Faculty labs, allowing the general public, as well as our industrial partners, alumni and prospective students the opportunity to appreciate the work that our students have developed over the past year.

I invite you to read carefully through the introductory pages of this brochure, where you will find information on the courses that are offered by the Faculty, on the major facilities of the Faculty, on the ongoing externally funded and postgraduate projects, as well as on staff members of the Faculty. The brochure also contains one-page summaries of each of the undergraduate projects that are on display during the exhibition, explaining the project objectives, the approach and methods taken, and the results obtained. There is also useful information in the form of adverts from a good number of industrial sponsors of the exhibition, without whom this event would not be possible.

I take this opportunity to thank all the Faculty members for their contribution to the Faculty and specifically the members of the Faculty's Public Relations and Outreach committee for the organisation of this year's exhibition and the collation of the information for this booklet. I believe you will find it highly informative.

Andrew Sammut

Dean, Faculty of Engineering

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This degree covers the generation, distribution, application and control of electrical energy. Electrical and electronic engineers can apply their scientific knowledge in the fields of transport, space technology, biomedical technology, control, robotics and automation, communications and machine vision. Optional subjects include microcontrollers, advanced electronic and power circuit design, electrical and renewable energy, advanced drives, signal processing, image processing, control systems and artificial intelligence.

Bachelor of Engineering (Honours) in Mechanical Engineering

This degree covers the design, development and improvement of mechanical components and systems that make our world and lives function. Mechanical engineers can apply their scientific knowledge in the fields of bioengineering, robotics, the production of sustainable and clean energy, access to clean water, aerospace, nano-manufacturing and nano-materials. If you follow this degree, then you will be asked to choose one of three streams namely:

1. Applied Mechanics and Thermofluids Engineering
2. Applied Materials in Engineering
3. Industrial and Manufacturing Engineering

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Applicants must satisfy the General Entry Requirements for admission, namely, the Matriculation Certificate and Secondary Education Certificate passes at Grade 5 or better in Maltese, English Language and Mathematics.

Applicants must also satisfy the following Special Course Requirements:

- passes at Advanced Matriculation Level at Grade C or better in Pure Mathematics and in Physics.

Applicants in possession of passes in the Secondary Education Certificate Examination at Grade 5 or better in Maltese and English Language, and of either the MCAST-BTEC Higher National Diploma in an area deemed by the Board to be relevant to the Course, or the MCAST Diploma in Industrial Electronics, may also be admitted into the course.

If applicants are graduates of a university or have other qualifications considered to be sufficient, they may be exempted by the University Admissions Board, on the advice of the Faculty Admissions Committee, from the whole or part of these special course requirements.

The admission requirements are applicable for courses commencing in October 2019.

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ENTRY REQUIREMENTS

The degree of Bachelor of Engineering (Honours) from the University of Malta or from any other higher education institution recognized by Senate, obtained with at least Second Class (Honours). In exceptional cases the Admissions Board, on the recommendation of the Faculty Board, may admit into the Course applicants not in possession of the qualification listed above, provided that it is satisfied that such applicants are in possession of other relevant academic or professional qualifications and experience that together are deemed to be comparable to the level of a first cycle degree. The admission of such applicants may be made conditional on the results of an interview.

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The programme allows students to build on and integrate prior knowledge and understanding of their engineering discipline at an advanced level to solve a substantial range of practical engineering problems, through individual or group case studies or projects with a specific direction towards the maritime field of study and industry. The programme covers a wide range of engineering disciplines from ship fundamentals, resistance and propulsion and their systems, hydrodynamics, computational fluid dynamics, oceanography, materials for the marine environment, maritime structures, renewable energy generation and water treatment. Furthermore, essential topics covering economic, environmental, ethical, legal, managerial and social issues are also covered.

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b) the degree of Bachelor of Science (Honours) from the University of Malta, or from any other higher education institution recognized by Senate and obtained with at least Second Class (Honours) in an area of study deemed relevant by the Faculty Board; or

c) any other Honours degree in a relevant area which the Faculty Board deems comparable to the qualifications indicated in (a) or (b).

In exceptional cases the Admissions Board, on the recommendation of the Faculty Board, may admit into the Course applicants not in possession of a qualification listed above, provided that it is satisfied that such applicants are in possession of other relevant academic or professional qualifications and experience that together are deemed to be comparable to the level of a first degree. The admission of such applicants may be made conditional on the results of an interview.

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Some subject areas covered in this programme include: Electrical Drives; Electrical Machine Design; Electric Transportation; Control and Grid Integration of Renewable Energy Sources; Energy Storage; Building Services; Electrical Power Systems; Power Electronics; Smart Grids; Microgrids; Power Quality and EMC; Electrical Energy Efficiency; Signal, Image and Biomedical Signal Processing; Computer Vision; Distributed Computational Intelligence; Machine Learning; Automatic Control; Adaptive and Intelligent Control; Robot Control; Spatio-temporal System Modelling; Swarm Robotics; Human-machine Interface Design, Analysis and Evaluation; Aircraft Flight Trajectory; Prediction/Management; Autonomous Navigation Systems; Analogue/Digital Signal Processing; Air/Road Traffic Management; Intelligent Transportation Systems; Biomedical Electronics and Industrial Electronics and Precision Instrumentation.

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a) a Bachelor of Engineering (Honours) degree with at least Second Class (Honours); or

b)a Bachelor of Science (Honours) degree with at least Second Class (Honours) in appropriate subjects as approved by the Faculty Board; or

c) a Bachelor degree with a Third Class (Honours) in Engineering or in a relevant area of study together with other qualifications, including relevant experience following the first cycle degree; or

d) equivalent qualifications approved by Senate on the recommendation of the Faculty Board.

Admission of applicants under (c) and (d) shall be made conditional on the results of an interview and in such cases the Faculty Board may require applicants to successfully complete a preparatory programme.

Master of Science in Mechanical Engineering by Research

Some subject areas covered in this programme include: Applied Mechanics and Biomechanics; Robotics; Strength, Stability and Integrity of the Structures; Applied Multiphysics Modelling; Composite Structures; Mechanics of Welding; Environmental Engineering; Offshore Renewable Energy; Solar Energy, Aerodynamics and Wind Energy; Airconditioning Systems; Heat Transfer in Electrical Machines; Internal Combustion Engines; Naval Architecture; Laser Material Processing; Surface Engineering for corrosion and wear resistance; Nanomaterial Modelling; Biomaterials; Tribology; Tribo-corrosion; Functional Coatings; Diffusion Treatments; Austempered Ductile Iron (ADI); Product Design and Development; Design of Biomedical and Assistive Devices; Artificial Hand Design and Development; Rapid Prototyping; Tooling and Manufacturing (RPTM) using Fused Deposition Modelling (FDM) and Electron Beam Melting (EBM); Polymer Processing (Injection Moulding and Thermoforming); Lean and Agile Manufacturing; Micro and Nano Manufacturing; Sustainable Manufacturing; and Industrial Automation.

ENTRY REQUIREMENTS

a) a Bachelor of Engineering (Honours) degree with at least Second Class (Honours); or

b) a Bachelor of Science (Honours) degree with at least Second Class (Honours) in appropriate subjects as approved by the Faculty Board; or

c) a Bachelor degree with a Third Class (Honours) in Engineering or in a relevant area of study together with other qualifications, including relevant experience following the first cycle degree; or

d) equivalent qualifications approved by Senate on the recommendation of the Faculty Board.

Admission of applicants under (c) and (d) shall be made conditional on the results of an interview and in such cases the Faculty Board may require applicants to successfully complete a preparatory programme.

Master of Science in Integrated Product Development

The Course is built on two fundamental pillars of Product and Process Engineering, and Business. The programme blends these topics together and even allows the student an element of specialisation or focus in any one of these two pillars within the programme itself. This Course is intended to fortify skills and to maximise performance and success in the industry by integrating all the aspects of product development, including product function and design, product materials and manufacturing, product use and environmental impact, product marketing and costing, entrepreneurship and business management.

ENTRY REQUIREMENTS

a) the Bachelor of Engineering (Honours) degree with at least Second Class (Honours); or

b) the Bachelor of Science (Honours) degree with at least Second Class (Honours) in appropriate areas of study as approved by the Faculty Board; or

c) a qualification deemed by Senate, on the recommendation of the Faculty Board, to be equivalent to either of the above degrees.

Master of Science in Signals, Systems and Control

This Course delivers the necessary academic, practical and professional education to acquire high-tech competencies and advanced technological skills in the interlinked areas of signal processing, systems engineering and automatic control systems. Through this course, students will learn the basic theories, design methodologies and implementation techniques relevant to the areas of system modelling, signal processing, dynamics and systems, automatic control, computer vision, and machine learning. The acquired hightech skills would enable graduates to pursue professional careers in several sectors such as system automation, process control, biomedical engineering, transport and robotics to name but a few.

ENTRY REQUIREMENTS

a) the degree of Bachelor of Engineering (Honours) with at least Second Class (Honours); or

b) the degree of Bachelor of Science (Honours) with at least Second Class (Honours) in appropriate subjects as approved by the Faculty Board; or

c) the degree of Bachelor of Science in Information Technology (Honours) with at least Second Class (Honours); or

d) the degree of Bachelor of Science in Information and Communication Technology (Honours) with at least Second Class (Honours); or

e) any other Honours degree with a suitable mathematical and computer programming component which the Faculty Board deems comparable to the qualifications indicated in (a), (b), (c) or (d).

Master of Science in Biomedical Engineering (Biomechanics)

The M.Sc. in Biomedical Engineering provides students with multi-disciplinary scientific knowledge in engineering, biomedical and clinical fields required for the complete understanding, analysis and advancement of Biomedical Engineering with particular emphasis to health care. The heterogeneous cohort of students - engineers, medics, scientist and health care graduate, will be provided with all necessary skills, to augment and advance their capacity thereby providing a platform for collaborative work in the multidisciplinary area of biomedical engineering. The program is based on the expansion of engineering skills applied to biological systems and a solution of medical, pathological or trauma issues that will encourage the innovative and creative approach to problem solving that caters for unique individual patients.

ENTRY REQUIREMENTS

The Course shall be open to applicants in possession of one of the following qualifications:

(a) the degree of Bachelor of Engineering (Honours) from this University, or from any other higher education institution recognized by Senate, obtained with at least Second Class Honours; or

(b) the degree of Doctor of Medicine and Surgery from this University or equivalent obtained from any other higher education institution recognized by Senate; or

(c) the degree of Bachelor of Science (Honours) from this University, or from any other higher education institution recognized by Senate, obtained with at least Second Class Honours in one of the following areas: Medical Biochemistry, Applied Biomedical Science (or Medical Laboratory Science), Physiotherapy, Chemistry, Biology, Physics, or in another area of study deemed relevant by the Board of Studies.

Doctorate Degree by Research in Engineering

The Ph.D. in Engineering is a 3-4 year doctorate degree based on an innovative research project implemented by the student, supported by the extensive expertise of the departments in the Faculty and using the comprehensive range of equipment and facilities available.

FACILITIES

Department of Electronic Systems Engineering

Embedded Systems Laboratory

A computer network with Labview and Altium licenses to design PCBs and control electronic systems

50MHz Arbitrary programmable function generators

200Mhz Digital Storage Oscilloscopes

Triple Output programmable precision bench power supplies

3GHz Mixed Domain Oscilloscope (includes logic analyzer, spectrum analyzer and protocol analyzer)

National Instruments Data Acquisition Boards

FPGA Development Boards

Microcontroller Development Boards

Electronics Laboratory

20Mhz programmable function generators

100Mhz Digital Storage Oscilloscopes

Various bench power supplies

General purpose soldering stations

Electronics Manufacturing Laboratory

PCB Structuring Laboratory

UV Laser PCB structuring system

CNC PCB structuring system

Multilayer Press

Stereolithographic 3D Printer

Eyepiece-less Stereo Inspection Microscope (21x -120x magnification)

X-ray Inspection facility (up to 5600x magnification)

PCB Finishing Laboratory

Through-hole copper and tin plating facility

Hand operated mechanical through-hole plating facility

Vapour phase Oven

Reflow oven with 8 independently controlled heating zones

Dry film Solder mask Laminator

Brushing machine

Ultrasonic cleaner

PCB Assembly Laboratory

High speed, high accuracy solder paste dispenser

Weller high precision rework station

Advanced soldering/desoldering stations ideal for SMT soldering

Weller Hot air station

Manual pick and place systems

Semi-automatic pick and place systems

Eyepiece-less Stereo Inspection Microscope (10x - 60x magnification)

Department of Industrial Electrical Power Conversion

Energy Conversion and Power Quality Laboratory

- Grid Connected PV and Wind Systems
- Various Electric Bicycles
- Passive and Active Filters for Power Quality Improvement
- High Voltage and Current DC supplies
- Power Electronics, Power Systems and Electrical Machines software packages
- 100kVA Flywheel UPS
- Wave Energy Conversion Emulator Rig
- Linear Motor Rig
- Prototype AC Microgrid
- Various Power and Energy meters

Power Electronics Laboratory

- Induction Motor, Permanent Magnet Synchronous Motor and Switched Reluctance Motor rigs with Variable Frequency Drives
- Machine Loading Units up to 50kW
- Wind Energy Conversion Emulator Rig
- Various Power Electronic Converters
- High Bandwidth Instrumentation for Power Electronic Measurements

Electrical Machines Laboratory

- Various domestic scaled Combined Heat and Power Plant
- DC and AC motor and generator test beds
- Single phase transformer rigs

Electrical Mobility Laboratory

- Electric Car with Lithium Ion Battery Technology
- Electric Boats
- Solar Catamaran
- Electric kart
- Battery Charging Equipment

Department of Industrial and Manufacturing Engineering

CAD/CAM Systems Laboratory

CAD Systems (2D, 3D, Animation)

CAD/CAM Systems

MoldFlow, 3D Studio max, AutoCAD, Autodesk Inventor

Tecnomatix - manufacturing development and simulation package,

Statistical process control and AI software

Picza LPX-250 3D Laser scanner

HP Plotter (up to A1 printing)

Concurrent Engineering Research Unit (CERU)

Concurrent Engineering Research Facilities

Thermoplastic Design Guidelines

DFX Design Guidelines

Industrial Automation Laboratory (IAL)

Six Mitsubishi FX1N-24 PLCs

Various Siemens Simatic S7 PLCs

Sony SRX3CH Robot

Two variable speed dual track conveyors

Reconfigurable 3D Gantry Robot - Cartesian System

Industrial Vision System

Other sundry equipment, oscilloscope, components and tools

Metrology Laboratory

Metrology Equipment Including CMM and Surface Roughness Measurement

Calibration of Metrology Equipment in Roundness, Linear and Angular Measurements

Optical measurement instruments such as autocollimator and engineering microscope, and supported with different type of gauges such as slip, plug and dial gauges

DMA Equipment - Dynamic Mechanical Analysis involves the measurement of the mechanical properties of a viscoelastic material as a function of temperature, time, or frequency when the material is subjected to a periodically oscillating force

DSC Equipment - Differential scanning calorimetry is a thermoanalytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature

CNC Laboratory

CNC Vertical Milling Machine 2 ½ axis

CNC Vertical Machining Centre 3 axis

Advanced Manufacturing Laboratory

CNC Electric Discharge Machining (EDM) with Micro EDM capabilities

Additive manufacturing:

Polymer 3D printer - Fused Deposition Modeling (FDM) - Dimension 1200es

Polymer 3D printer - Stereolithography (SLA) - Form 2

Metal 3D printer - Electron Beam Melting (EBM) - ARCAM EBM S12

Thermoforming machine

2-component micro injection moulding machine (Boy 22E) with a clamping force of 200kN

Thermal imaging camera (Flir E6)

Department of Mechanical Engineering

Sustainable Manufacturing Laboratory

Eco Materials Adviser

Kyoritsu Power/Energy Meters

Design Studio lab

Dedicated workstations for collaborative design and engineering design teamwork

Merkur modelling sets to build functional models of design concepts

Hitachi Smartboard to project presentations, to capture sketchwork generated in engineering design teamwork etc

Fuel 3D handheld scanner for reverse engineering purposes

Formlabs Form 2 SLA 3D Printer to convert 3D CAD models into physical prototypes

Boxford CNC 3D Router to quickly obtain simple physical prototypes using a range of materials, including aluminium, plastics, wood and modelling foam

Rasberry Pi 2 B to develop innovative Internet of Things (IOT) product concepts

Empatica E4 wristband, a wearable wireless device to monitor physiological signals in real-time

University (Engineering) Workshop

Conventional Machine Tools including centre lathes, milling, surface and cylindrical grinding, gear hobbing, drilling and welding

Applied Mechanics Laboratory

Various undergraduate student lab setups

Engineering stress analysis:

Strain gauge instrumentation

PhotoStress® Plus analysis kit from Vishay Precision Group – Micro Measurements for experiments stress analysis

Residual stress hole drilling equipment from Vishay Precision Group – Micro Measurements

Small filament winding machine

Material testing and characterisation of properties:

Quenching and Deformation Dilatometer for metallic alloys – CCT, TTT, expansion, phase transformation, flow stress characterisation

Tensile, compression, shear and flexure testing of materials

Impact testing of materials

Vibration and Acoustic Monitoring:

Vibration monitoring

Human and hand vibration exposure measurements

Machine diagnostics using vibration analysis tools

Sounds/Noise level monitoring

Run-up and run-down vibration testing of rotating machinery

Dynamic balancing of machines/rotary systems

Monitoring of ground borne vibrations

Order analysis

Modal analysis

CAE Lab - Computer Aided Engineering Laboratory

Computer Computer facilities to run the following engineering software:

FEA – Finite Element Analysis – ANSYS

Linear and non-linear structural analysis: predict behavior of structural components for a wide range of materials and loadings (e.g. pressure vessels, biomechanics, modal analysis/ vibration responses etc.)

Thermal and thermo-mechanical analysis: predict the thermal and structural response of components of thermally driven processes (e.g. welding, laser cutting/ forming etc.)

CFD – Computational Fluid Dynamics Fluent – FLUENT/ANSYS

Advanced aerodynamic and hydrodynamic analysis of systems and components including conjugate heat transfer (bounded and unbounded flows, laminar and turbulent flows, subsonic, transonic, supersonic and hypersonic flows, single phase and multiphase flows, combustion, etc.). Typical applications include car bodies, ducting systems, electrical machines, aircraft wings / aerofoil sections, wind turbine blades, offshore wind turbine support structures etc.)

Naval Architecture Simulation – Bentley Academic SELECT:

To design, model, optimise and characterise hull forms

To perform stability (intact/damage) and strength calculations, analyse sea-keeping performance, resistance and powering prediction, sailing performance analysis for yachts

To perform 3D modelling using linear, non-linear and buckling analysis, static and dynamic structural analysis on the ship hull and structure

Maxsurf Enterprise

Multiframe Advanced

SACS Marine Enterprise

SACS Offshore Structure Enterprise

MOSES Advanced

MATLAB/Simulink

CAD – Computer Aided Design

SOLIDWORKS

Microstation

WindPRO (EMD)

WAVE/VALDYN (Ricardo)

FloTHERM (Mentor Graphics) – Electronics cooling package

ESATAN-TMS: ITP Engines UK is kindly sponsoring the Department of Mechanical Engineering of the University of Malta with the software licence for the analysis and simulation software ESATAN-TMS for their undergraduate degree program.

Fluid Mechanics Laboratory

Wind Tunnel Testing, flow measurements using hot-wire anemometry, wind turbine performance and load evaluation

Low wind speed wind tunnel 38 x 38 cm

Wind Tunnel Testing, flow measurements using hot-wire anemometry, wind turbine performace and load evaluation

Low wind speed wind tunnel 900mm diameter

Water wave generator (8m x 0.75m x 0.8m)

Flow measurement equipment (including six-channel hot-wire anemometer and volumetric PIV)

Hydraulic pump/turbine demonstration equipment

Pelton wheel performance testing equipment

Model propeller/wind turbine performance testing rigs

Setup for flow visualisation over aerofoils using smoke generation and PIV.

Thermal management of electrical machines

Particle Image Velocimetry (PIV) and Particle Tracking Velocimetry (PTV)

Heat transfer in pipe facility

Heat Exchanger testing facility

Thermodynamics Laboratory

Laboratory experiments for thermodynamics and heat transfer

Testing beds for internal combustion engines

One electrical dynamometer, two water brakes and other smaller dynos

Demonstration type gas turbine

Testing of air conditioning setups, including variable speed (inverter)

Supersonic nozzle setup

Labview and Keithley data acquisition systems

Robotic Systems Laboratory

Mitsubishi RV-6SL 6-DOF revolute robot, 91cm reach, 6kg payload, with controller upgrade, tracking card, and adjustable gripper, or vacuum gripper. Mounted on a highly reconfigurable table.

Epson E2S651S 4-DOF SCARA robot, 65cm reach, 5kg payload

Two Cognex/DVT smart image sensors (machine vision)

Two flat belt conveyors (one with variable speed)

Machine vision lighting (ring light, strobe)

Other sundry equipment, components and tools

Various robot hands and glove devices, built in house

Department of Metallurgy and Materials Engineering

Process Equipment

- Plasma Assisted Physical Vapour Deposition (PA-PVD)
- Ion Beam-Assisted Deposition
- Gas Nitriding Furnace
- Vacuum Furnace
- Laser Added Manufacture Centre
- Box Furnaces
- Tube furnace
- Foundry induction furnace
- Martempering/ Austempering salt bath
- 3-axis CNC machining station
- Planetary ball miller

Mechanical Testing Equipment

- Charpy Impact tester with digital acquisition
- 10 ton bend testing centre
- 25 ton multipurpose dynamic testing centre
- Brinell/ Vickers Macro hardness tester
- Knoop/ Vickers Micro hardness tester
- IRHD/ Shore polymer hardness tester
- Pin-on-disk wear tester
- Reciprocating sliding tribo-corrosion tester
- Universal tribology testing system
- Rotary bending fatigue tester
- Gear tribological tester

Calibration Equipment

- Load cell calibration system
- Temperature calibration system

Sample Preparation Equipment

- Precision cut off saw
- Thermosetting cold mounting station
- Hot mounting phenol sintering station
- Manual and automatic sample polishing stations
- Automatic electropolishing station

Characterisation Equipment

- Optical microscopy with real time image acquisition
- Incident light metallographic microscopes
- Confocal microscope with 3 excitation lasers and multispectral analyser
- Micro RAMAN Spectroscope
- Potentiodynamic wet cell corrosion testers
- Laser Induced Breakdown Spectrocopy (LIBS)
- Dilatometer with inert gas chamber
- 3D stylus surface profilometer
- Optical surface profilometer
- Nano-mechanical Indentation Testers

Scanning Electron Microscope (SEM) with:

- In-lens backscattering detector
- In-lens secondary electron detector
- External secondary electron detector
- Solid state angular selective backscatter detector
- Energy dispersive spectroscope (EDS) detector

Wavelength dispersive spectroscope (WDS) detector

Electron Backscatter Diffraction (EBSD) detector

Ultra high vacuum Integrated Characterisation Facility including:

SPECS UHV non contact characterisation chamber

150mm mean radius 9-channel electron hemispherical analyser

X-Ray Photoelectron Spectroscopy (XPS)

Secondary electron detector for electron imaging (SEM)

Auger electron detector for compositional mapping (SAM)

Low energy electron diffraction (LEED)

Large area ion source for sample cleaning

Secondary ion mass spectrometry (SIMS)

Electron flood gun for charge compensation of non conductive samples

Quadrupole mass spectrometer

RHK UHV scanning probe microscopy:

Atomic force microscope

Scanning tunneling microscope

X-ray diffractometers

Department of Systems and Control Engineering

Biomedical Engineering Laboratory

- Vicon Optical Motion Analysis System
- Tekscan Body Pressure Measurement System
- Biopotential (e.g. EEG) Acquisition System
- Non-invasive Biomedical Data Acquisition System
- Diagnostic Ultrasound System
- Haptic Feedback System
- Rehabilitation Robotic Manipulator
- Thermal Imaging System
- Spectral Camera
- Signal Processing Boards
- Data Acquisition Boards
- High-end servers and computing equipment
- Matlab and Simulink Research Licences

Control Systems Engineering Laboratory

- Programmable Logic Control (PLC) units with state of the art Human Machine Interfaces (HMIs)
- Various mobile robot teams and other high end mobile robots
- Robotic manipulators
- Force, torque, laser and inertia sensors for robotic applications
- Embedded and tablet PC for real time computer control of mobile systems
- Fingerprint/palm and iris biometric scanners
- Stereo cameras with pan/tilt actuation
- Analogue and digital area scan cameras and smart cameras with LED illumination
- Various digital and analogue video grabbers and camera multiplexers
- Electronic test and measurement instrumentation
- PC interfaced servos and process control units
- Various PC interface units for computer control
- A computer network with various licenses for simulation and real-time control of systems

DEAN'S AWARD

In December 2018, Mr George Cauchi and Mr Matthew Aquilina were awarded the Dean's Award for best students graduating in the Mechanical and Electrical and Electronic Engineering Degrees respectively, offered by the Faculty of Engineering and sponsored by the Farsons Foundation.

Mr George Cauchi and Mr Matthew Aquilina consistently proved to be hard-working students of high capability in the engineering discipline, and achieved a 1st class Honours degree in their respective streams, with the highest average score in this degree in their year of graduation.

Dean Dr Ing. Andrew Sammut together with Mr Kenneth Pullicino from the Farsons Foundation presented these awards.

Dr Ing. Andrew Sammut and Mr Kenneth Pullicino presenting awards to Mr Matthew Aquilina (left photo) and Mr George Cauchi (right photo)

ONGOING EXTERNALLY FUNDED RESEARCH PROJECTS

Biodegradable Iron for Orthopaedic Scaffold Applications (BioSA)

Funding Body: **Malta Council for Science and Technology through the Fusion: R&I Technical Development Programme**

Project Fund: **€ 194,960**

UM Workshare Value: **€ 146,209**

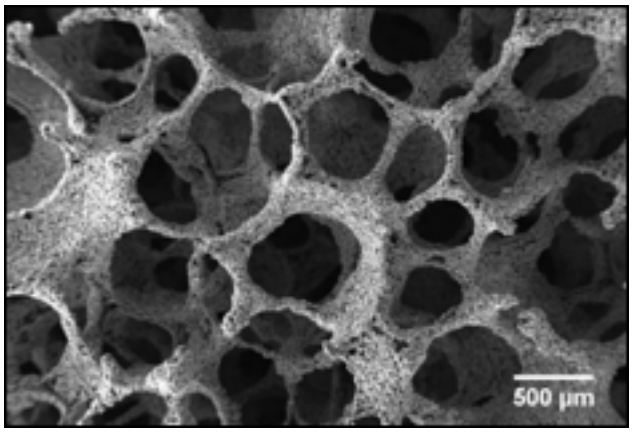
Principal Investigator: **Prof. Ing. Joseph Buhagiar**

Co-Investigators: **Ms Christabelle Tonna, Prof. Ing. Maurice Grech, Dr Arif Rochman, Prof. Pierre Schembri Wismayer MD, Prof. Christian Scerri MD, Mr Ray Gatt MD, Mr Ryan Giordimaina MD, Mr Luke Saliba MD, Mr Matthew Sultana & Mr Karl Borg**

Consortium/Partners: **Department of Industrial and Manufacturing Engineering, the Department of Anatomy and the Department of Physiology and Biochemistry at the University of Malta, in collaboration with the Department of Trauma and Orthopaedics at Mater Dei Hospital**

Project Start Date: **July 2018**

Project Duration: **3 Years**



Scanning Electron Microscopy micrograph of initial Fe-based scaffold prototype

Clinically, trauma patients often require the implantation of porous implants known as scaffolds, in order to stimulate the healing of persisting fractures or other sizeable bone defects. Current research is addressing the issues presented by existing bone scaffolds on the market, through the development and study of Fe-Mn-Ag porous structures. Researchers working on the BioSA project are making use of powder metallurgy techniques for the fabrication of Fe-based foams with customisable geometry. Moreover, the use of the ternary alloy system is expected to contribute to the achievement of adequate mechanical and corrosion behaviour for load-bearing orthopaedic systems. The group will also be evaluating the cytocompatibility of the implants developed and performing an in vivo study to assess the suitability of the implant for clinical application.

Development of a Low-Wearing Novel Hip Joint Prosthesis for a Longer Lifespan (MALTAHIP)

Funding Body: **Malta Council for Science and Technology through the Fusion: R&I Technical Development Programme**

Project Fund: **€194,594**

UM Workshare Value: **€ 145,674**

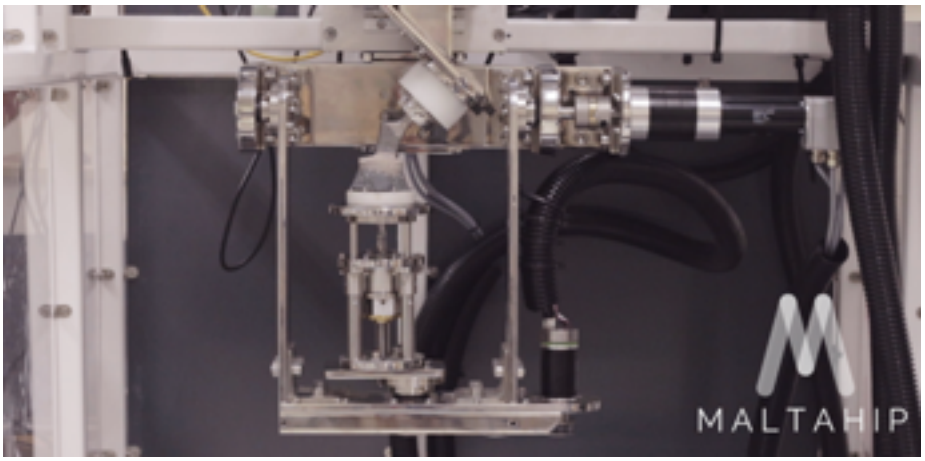
Principal Investigator: **Prof. Pierre Schembri Wismayer MD**

Co-Investigators: **Mr Donald Dalli, Prof. Ing. Joseph Buhagiar & Prof. Ing. Pierluigi Mollicone,**

Consortium/Partners: **Department of Metallurgy and Materials Engineering, Department of Anatomy, Department of Mechanical Engineering at the University of Malta, in collaboration with MCL Components Ltd.**

Project Start Date: **September 2016**

Project Duration: **3 Years**



MaltaHip Project: Hip joint simulator designed to mimic the in vivo conditions

The lifespan of a prosthetic hip joint is mostly limited by its vulnerability to wear. To eliminate the dire effects induced by the formation of wear debris, the patient may be required to undergo revision surgery, which unfortunately could further increase clinical complications. Motivated by the notion of reducing revision surgery, this project intends to develop a new prosthetic hip design with reduced wear rates, in order to improve its lifetime when compared to current commercially available implants. The wear performance of the prototype implant will be tested in two phases; initially using a hip joint simulator that was developed in-house, and later on at an accredited implant testing company. To better understand the practicality of the new design during surgery, orthopaedic surgeons will implant the prosthesis prototype inside a cadaver. The overall study will provide better insight on the novel design of the implant during *in vivo* conditions.

Micro Wastewater Treatment System using Photocatalytic Surfaces (MicroWATTS)

Funding Body: **Interreg V-A Italia-Malta**

Project Fund: **€ 2,415,048**

UM Workshare value: **€ 914,689**

Project Leader: **University of Malta (UM)**

Project Coordinator: **Prof. Ing Maurice Grech**

Co-Investigators: **Dr Stephen Abela, Dr Paul Refalo**

Consortium: **Dept of Metallurgy and Materials and Dept of Industrial and Manufacturing Engineering, UM, Consiglio Nazionale delle Ricerche, Malta College of Arts Science and Technology, Universita` degli Studi di Catania, Econetique Ltd, Plastica Alfa Srl**

Project start date: **15th May 2018**

Project duration: **3 years**

MicroWATTS shall develop a solar greywater treatment system, using surface engineered photocatalytic materials. This would be a step in the right direction when it comes to tackling the problem of water shortage that Malta and Sicily face.

Short term distinctive aspects include: cross border collaboration, transfer of technology, cross border mobility, adoption by SMEs of technology developed and non-financial assistance to SMEs. Long term objectives include: generation of green jobs, reduction of carbon and water footprint and better use of natural resources.

Development of Functional Coatings for Corrosion-Resistant, Low-Impedance and Bioactive Implantable Electrode Surfaces

Funding Bodies: Endeavour Scholarship

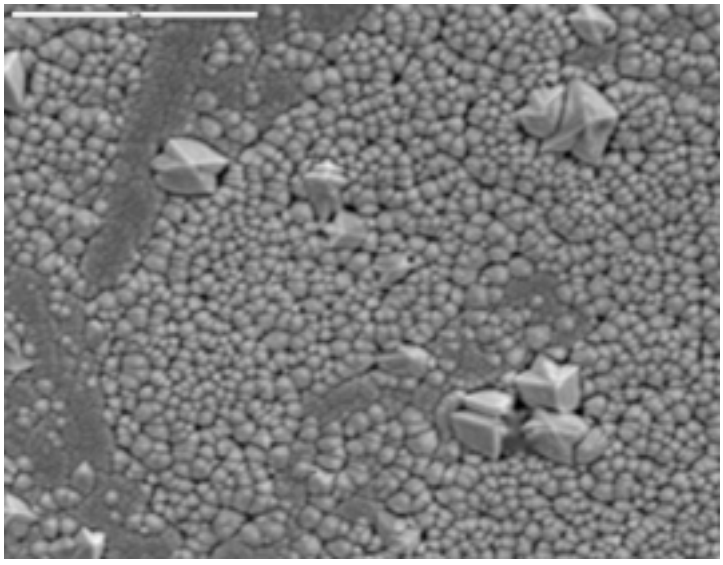
Project Fund: approx. € 30,000

Project Investigators: Prof. Ing. Bertram Mallia (Supervisor), Prof. Pierre Schembri Wismayer (Co-supervisor), Ms Jeanelle Arpa (Ph.D. student)

Consortium: Department of Metallurgy and Materials Engineering and Department of Anatomy, UM; The Danish Technological Institute (DK)

Project Start Date: December 2018

Project Duration: 3 years



Topographic secondary electron image of a PVD coated polished biomedical alloy. Coating deposition conditions influence surface topography and its charge transfer characteristics

Disease or trauma affecting the peripheral nervous system may result in debilitating conditions such as impaired motor function, pain, and loss of sensation. Neural electrodes are typically employed as part of a chronically implanted device to counter these effects and operate by delivering coulombic charge to stimulate the target nerves. Corrosion, high impedance, and biofouling are common problems associated with these electrodes. This ongoing project deals with the development of novel, multi-component coatings designed to improve electrode performance by optimising their electrical properties, minimising electrochemical attack, and preventing fibrous encapsulation.

Tribocorrosion Testing of Surface Modified Biomaterials

Funding Bodies: **Internal Research Grant, Endeavour Scholarship and Student bench fees**

Project Fund: **approx. € 65,000**

UM Share value: **approx € 50,000**

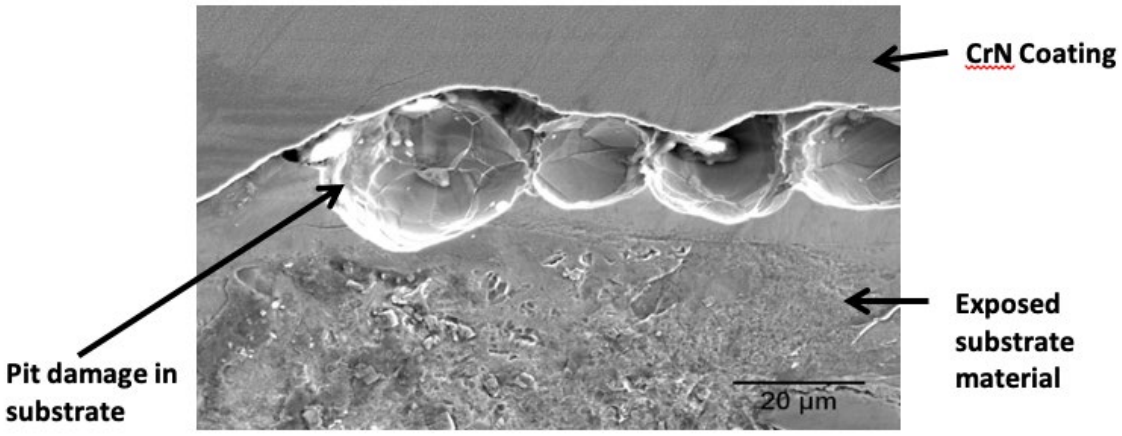
Principal Investigator: **Prof. Ing. Bertram Mallia**

Co-Investigators: **Prof. Ing. Joseph Buhagiar, Mr Antonino Mazzonello, Ms Raisa Chetcuti, Mr Luke Scicluna and Mr Dylan Abela**

Consortium: **Department of Metallurgy and Materials Engineering, UM; Boride Services Ltd. (UK); Bodycote Hardiff GmbH (DE); The Danish Technological Institute (DK); University of Leeds, UK.**

Project Start Date: **October 2016**

Project Duration: **Ongoing**



Interface corrosion between Cr(N) coating and 316LVM substrate leading to severe pitting corrosion of the substrate following tribocorrosion in simulated body fluid

This project aims to develop novel surface treatments for the tribocorrosion protection of biomedical grade 316LVM stainless steel and CoCrMo alloys. Physical vapour deposition and low temperature diffusion treatments are being applied to produce surface modified layers to mitigate tribocorrosion damage of articulating biomaterials used inside the body. This work is contributing to better the current understanding of tribocorrosion mechanisms exhibited by surface engineered materials tested in a simulated body environment under controlled electrochemical conditions. This research shall lead to enhance the performance and success rates of permanent metallic implants.

RIDE+SAFE: Rider-Centred Product+Service System for Designing Safer Motorcycles

Funding Body: **Malta Council for Science and Technology through the National Research and Innovation Programme 2018**

Project Fund: **€ 194,861**

UM Workshare Value: **€ 142,902**

Principal Investigator: **Dr Ing. Philip Farrugia**

Co-Investigators: **Prof. Ing. Simon Fabri, Ing. Sean Agius, Mr Adrian Vella, Ms. Denise Baldacchino**

Consortium/Partners: **Department of Industrial and Manufacturing Engineering, the Department of Systems and Control Engineering at the University of Malta, in collaboration with WKD-Works Ltd.**

Project Start Date: **September 2018**

Project Duration: **3 Years**

Customisation of a motorcycle for a more comfortable, hence safer ride

In this project, a User-Centred Design (UCD) approach is adopted, which places product users at the centre of the design process. Motivated by the alarming increase in motorcycle fatalities in Malta, this proposal is inspired by a UCD to develop safer motorcycles. A novel motorcycle jig immersed in a Virtual Reality environment will be developed and used to capture rider's postures.

SPEECHIE: Development of a Novel Device to Support Children with Language Impairment in a Bilingual Context

Funding Body: **Malta Council for Science and Technology through the National Research and Innovation Programme 2016**

Project Fund: **€ 194,960**

UM Workshare Value: **€ 146,175**

Principal Investigator: **Dr Ing. Philip Farrugia**

Co-Investigators: **Prof. Ing. Simon Fabri, Prof. Helen Grech, Dr Daniela Gatt, Dr Ing Owen Casha, Mr Emanuel Balzan, Mr James Attard, Mrs. Louisa Frendo Wirth, Ms. Lorridana Buttigieg and Mr Anthony Demanuele**

Consortium/Partners: **Department of Industrial and Manufacturing Engineering, the Department of Systems and Control Engineering, Department of Communication Therapy, Department of at the University of Malta, in collaboration with Flying Squirrel Games Ltd.**

Project Start Date: **July 2016**

Project Duration: **3 Years**

Typical scenario of 'Olly Speaks' being used during a speech therapy session

The project's goal is to develop a novel, multi-modal device, nicknamed Olly Speaks, to facilitate language therapy for children with language impairment both within and beyond the clinical setting. Olly Speaks will be developed as a smart therapeutic device that entices children to engage with the designated exercises by creating a more rewarding and motivating environment. At the time of writing, the research team has produced a physical prototype of Olly Speaks.

MEMENTO: Multi camEra high fraMe ratE syNchronisaTiOn

Funding Body: **MCST R&I Fusion 2015 (R&I-2015-024-T)**

Project Fund: **€ 195,000**

UM Workshare Value: **€ 150,000**

Principal Investigator: **Dr Ing. Marc Anthony Azzopardi**

Co-Investigators: **Mr. Andre Micallef**

Consortium Lead: **Dept. of Electronic Systems Engineering at the University of Malta**

Consortium Partners:**MST Audio Visual Ltd.**

Project Start Date: **April 2016**

Project Duration: **3 Years**

High speed vision equipment design for exacting scientific applications

MEMENTO is the Electronic Systems Engineering Department's first initiative at commercialisation of home-grown electronics hardware technology. After two successful rounds of research into high frame-rate vision hardware, and the completion of detailed commercial feasibility studies, the time has come to offer the technology with a range of products, and a sound business proposition that fills an existing gap in the high performance vision market. This product will address the problem of high precision synchronisation that arises between coupled cameras working at thousands, or even millions of frames per second. This will enable capturing transient events from multiple angles. The University of Malta already holds intellectual property in this domain (WO/2010/029040). However, through this project the technology will be polished to a high technology readiness level (TRL) and brought in line with market expectations. The ability to synchronize multiple cameras precisely enables a wide range of technical possibilities such as high speed 3D reconstruction, multi-camera resolution-augmentation, frame interleaving, and real-time stitching of video footage.

Electrical Energy System Optimisation for the More Electric Aircraft

Funding Body: **University of Malta 2017**

Project Fund: **€ 60,000**

Principal Investigator: **Prof. Ing. Cyril Spiteri Staines**

Co-Investigators: **Prof. Ing. Maurice Apap, Dr. Ing. Christopher Micallef,**

Consortium/Partners: **Department of Industrial Electrical Power Conversion and Department of Mechanical Engineering**

Project Start Date: **2017**

Project Duration: **2 Years**

The More Electric Aircraft

Recent advances in power electronics applied to commercial aircraft technology has brought about an increase in aircraft electrical systems (actuation, wing ice protection, environmental control and fuel pumping). The study in this project shall focus on the simulation of a More Electric Aircraft (MEA) power system to determine the optimal configuration in power generation, distribution (energy management) and end use. The research shall be concerned with both the generation systems and the electrical loads (power converters and electrical machines) and shall look into AC and/or DC distributed power systems or a hybrid combination allowing for flexible system reconfiguration aimed at achieving efficient operation. The study shall analyse the aircraft's electrical power operation for different flight mission scenarios with the aim to achieve stable and efficient operation whilst meeting the relevant power quality standards.

A Smart Micro Combined Heat and Power System

Funding Body: **Malta Council for Science and Technology through the FUSION R&I Technology Development Programme 2016**

Project Fund: **€ 194,956**

UM Workshare Value: **€ 146,207**

Principal Investigator: **Prof. Joseph Cilia**

Co-Investigators: **Ing. Matthew Schembri, Ing. Eryl Vella**

Consortium/Partners: **Department of Industrial Electrical Power Conversion, in collaboration with ABERTAX KEMTRONICs LTD.**

Project Start Date: **February 2017**

Project Duration: **3 Years**

A Smart Micro CHP with a Smart Home Energy System

Cogeneration or combined heat and power (CHP) is the use of a heat engine to simultaneously generate electricity and useful heat. In separate production of electricity, some energy must be discarded as waste heat, but in cogeneration this thermal energy is put to use. This system increases the overall energy efficiency of the generator from about 40% to more than 85%.

A micro-CHP has been designed at the University of Malta. Small enough for households, which would increase the amount of renewable energy used as well as the attractiveness of using other renewable energy devices such as photovoltaic panels. The key design feature of the system is the fact that it treats the grid as an option and not as a compulsary source in meeting the energy needs of a household. The other advantage is that the micro-CHP using an asynchronous machine and the PV panels can be used to generate electricity during a power cut, which is not currently possible.

HDMS–Smart Single-Phase Motor Soft Starter without Starting Capacitor

Funding Body: MCST Fusion

Project Fund: € 194,988

UM Workshare Value: € 94,900

Principal Investigator: Dr Ing. Reiko Raute

Consortium/Partners: Department of Industrial Electrical Power Conversion

Project Start Date: July 2019

Project Duration: 2 Years

Single phase induction motors are widely used in domestic applications such as heat pumps. Problematic during the switch on of these motors is the large inrush current that can reach levels of 8 times the nominal motor current. This high current can disturb the electric voltage supply. This disturbance of the electric power supply causes voltage dips or flickering to neighboring customers. To reduce this effect soft starting devices have been developed. Their circuit is mostly based on thyristor semiconductors in combination with a starting capacitor. Practical experience has shown that these capacitors are the weakest link in the design and are susceptible to fail. Failure can result in small explosions, damaging surrounding installations and causing risk of fire. A novel single-phase induction motor soft starting technique was recently researched at the R&D department at Carlo Gavazzi Ltd. Malta that results in superior motor starting without any use of a starting capacitor. This technique uses more advanced power electronic semiconductor devices and a sophisticated, but easy to implement control algorithm. The research funded by the MCST Fusion scheme focuses on the development of a market ready product. The 2 research packages investigated by the University of Malta analyze theoretical and practical the stability of the complex control system, and investigate the overloadability and robustness of the used IGBT power semiconductors.

Heat pump system with scroll compressor and softstarter

ARIES: Accelerator Research and Innovation for European Science and Society

Funding Body: **European Commission in Call, Horizon 2020**

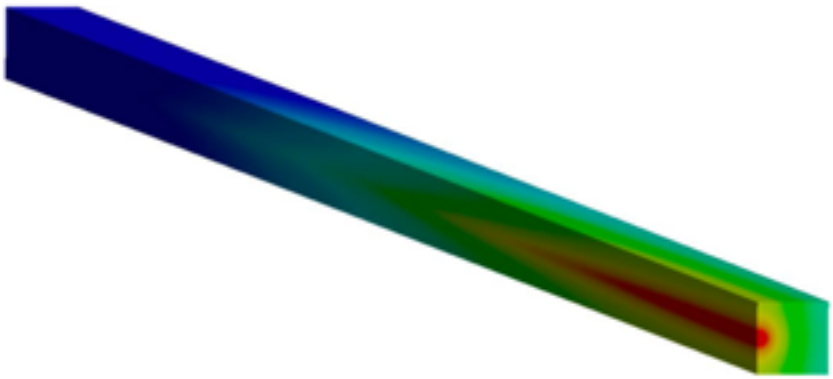
Investigators at UM: **Prof. Ing. Pierluigi Mollicone and Dr Ing. Nicholas Sammut (Faculty of ICT)**

Ph.D. Student: **Mr Marcus Portelli**

Consortium/Partners: **Department of Mechanical Engineering, Department of Micro and Nanoelectronics (Faculty of ICT) at the University of Malta, Coordinator: CERN The European Organisation for Nuclear Research, Geneva, Switzerland; full partners list on https://aries.web.cern.ch/**

Project Start Date: **2017**

Project Duration: **4 Years**



Advanced thermo-mechanical analysis of collimator components

Project title at UM: Constitutive Models of Advanced Materials Subjected to High-Energy Particle Beam Impacts

Advanced experimental campaigns conducted at the European Centre for Nuclear Research (CERN) are a source of a large amount of data which can be used to derive constitutive models for advanced materials tested. These models, once verified in simulations and additional experiments, can be subsequently implemented in numerical analysis of full-scale components in nominal and accidental scenarios, such as in the modelling of collimators and other beam intercepting devices in CERN's largest facility, the Large Hadron Collider (LHC), the Future Circular Collider (FCC), and other high-energy particle accelerators and experiments.

MAProHand: Development of the Mechanical and Control Framework for a Minimal Anthropomorphic Prosthetic Hand

Funding Body: **Malta Council for Science and Technology through FUSION: The R&I Technology Development Programme 2018.**

Project Fund: **€ 194,992**

UM Workshare Value: **€ 146,128**

Principal Investigator: **Prof. Ing. Michael A. Saliba**

Co-Investigators: **Prof. Ing. Kenneth P. Camilleri, Dr Jesmond Attard, Prof. Alexiei Dingli, Mr Emanuele Aliotta.**

Consortium/Partners: **Department of Mechanical Engineering, and Department of Systems and Control Engineering at the University of Malta, in collaboration with Orthopaedic Centre Malta**

Project Start Date: **March 2019**

Project Duration: **3 Years**

Technician fitting a prosthetic upper limb (shutterstock), and an early prototype prosthetic hand developed at the Department of Mechanical Engineering

A major issue in the development of commercial prosthetic hands is the trade-off between simplicity, dexterity and usability. The primary research objective of this project is to carry out a systematic exercise, based on extensive and innovative experimental, analytical, simulation, and design work, to for the first time seek a practical solution that optimizes this classical trade-off within a single device, by extracting an acceptable and optimum dexterity out of the simplest possible architecture while maintaining high usability of the device.

Advanced Revolutionary Manufacturing Solutions and Development of Novel GFRP Composite Poles – ARM-D-COP

Funding Body: **Malta Council for Science and Technology Fusion Research & Innovation Technology Development Programme 2018 – R&I-2017-039-T**

Project Fund: **€ 194,968**

UM Workshare Value: **€ 110,503**

Principal Investigator: **Prof. Ing. Duncan Camilleri**

Co-Investigators: **Prof. Ing. Martin Muscat, Dr Brian Ellul**

Consortium/Partners: **Department of Mechanical Engineering at the University of Malta, in collaboration with SilverCraft Products Ltd**

Project Start Date: **September 2018**

Project Duration: **2 Years**

Street lighting and electricity poles are generally made from steel, yet steel poles are subject to corrosion, require extra insulation and stronger ground foundations. Recent advances in composite materials triggered interest in the manufacturing of Glass Fibre Reinforced Composite Poles (GFRCP), but are currently limited in length due to the fabrication procedure adopted. ARM-D-COP aims to design, develop and commission a novel fabrication process for GFRCP ultimately leading to poles that are: (1) longer than 16m, (2) withstand larger loads, (3) insulators, (4) corrosion and wear resistant and (5) lighter and thus less rigid foundation requirements. A prototype machine that encapsulates new revolutionary manufacturing technologies will be developed. A modular design approach will be adopted paving the way towards the manufacture and production of long tapered GFRCP. The prototype machine will focus on optimising and testing the modular design concepts of the new revolutionary manufacturing method.

Project FLASC: Development of a Hydro-Energy Storage System for Offshore Multi-Purpose Floating Platforms

Funding Body: **Malta Council for Science and Technology through the National Research and Innovation Programme 2015**

Project Fund: **€ 198,206**

UM Workshare Value: **€ 142,545**

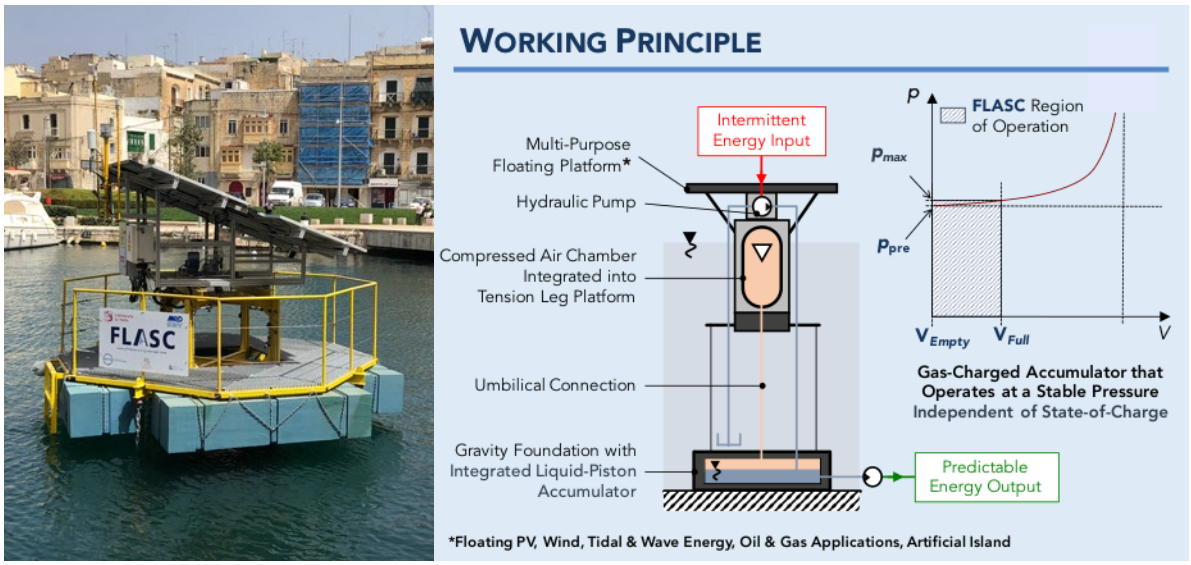
Principal Investigator: **Prof. Ing. Tonio Sant**

Co-Investigators: **Dr Ing. Daniel Buhagiar, Dr Ing. Robert N. Farrugia**

Consortium/Partners: **Department of Mechanical Engineering at the University of Malta, in collaboration with MedServ plc., and with support from the Institute for Sustainable Energy.**

Project Start Date: **July 2016**

Project Duration: **3 Years**



FLASC small-scale prototype (left) and working principle (right)

Despite its advantages, use of offshore renewable energy is hindered by numerous challenges, particularly the mismatch between renewable energy supply and consumer demand. FLASC is an interface between offshore renewables and the grid. It smoothens out the intermittent output of renewable sources by storing surplus energy and dissipating it in periods of higher demand. FLASC is a hydro-pneumatic energy storage system that integrates into an offshore floating platform. It has a unique design with a high efficiency and a stable operating pressure. Since it stores energy as pressurised, cold, deep seawater, it can also be integrated into LNG liquefaction and Water-Injection Oil Wells.

FLASC is patented in the EU, America & China. It is patent pending in Japan.

VENTuRE - A Virtual & Physical ExperimeNtal Towing CentRe for the Design of Energy Efficient Sea-Fairing Vessels

Funding Body: **The project has received funding from the European Union's Horizon 2020 research and Innovation programme. Project No. 856887**

Project Fund: **€ 799,904**

Principal Coordinator: **Prof. Ing. Claire De Marco**

Co-Investigators: **Prof. Ing. Tonio Sant, Dr Ing. Simon Mizzi**

Consortium/Partners: **Department of Mechanical Engineering, University of Malta, University of Strathclyde, UK, Universita degli Studi di Genova, Italy, Naval Architectural Services, Malta**

Project Start Date: **January 2020**

Project Duration: **3 Years**

The Maltese maritime industry is seeing rapid development with a view to adhere to all international standards and regulations whilst at the same time adopt the latest novel and state-of-the-art engineering techniques to adequately support this vision. As part of building such capability, the University of Malta is forging ahead with plans to set up virtual and experimental towing facilities that are fundamental for the design of energy efficient sea-faring vessels. The Twinning action will enable the transfer of essential knowledge from two internationally-leading research institutions, namely the University of Strathclyde (UK) and the University of Genoa (Italy) to Malta and a leading local Naval Architectural company, Naval Architectural Services, NAS, to enhance the local capabilities and build tomorrow's maritime professionals and innovators.

R&I-2015-032-V - Brain Controlled Application (BrainApp)

Funding Body: **FUSION R&I Technology Development Programme 2016, MCST**

Project Fund: **€ 181,793.22**

UM Workshare Value: **€ 136,335.72**

Principal Investigator: **Dr Tracey Camilleri**

Co-Investigators: **Ing. Rosanne Zerafa, Dr Owen Falzon, Prof. Kenneth P. Camilleri**

Consortium/Partners: **Department of Systems and Control Engineering, and Centre for Biomedical Cybernetics at the University of Malta, and Idox Health.**

Project Start Date: **July 2017**

Project Duration: **36 months**

Brain controlled application based on steady-state visually evoked potentials (SSVEPs)

This project proposes the development of a novel application controlled directly with brain signals, opening up accessibility to individuals suffering from motor disabilities, and providing alternative access methods to healthy individuals.

BCIs acquire the electrical brain activity using electroencephalography (EEG) electrodes, relying on brain phenomena such as those evoked by flickering visual stimuli, known as steady state visually evoked potentials (SSVEPs). In the proposed system, stimuli are associated to commands, and EEG signals are processed to detect the intent associated to the brain pattern. A BCI challenge is to have BCIs operating in real environments amidst the nuisance signals generated by normal user actions. The project proposes solutions to this challenge, operating in real-time at the user's will. It also aims at addressing the annoyance factor of the flickering stimuli, ensuring that the system can be used comfortably for long periods of time.

R&I-2016-010-V WildEye - Eye-Gaze Tracking in the Wild

Funding Body: **FUSION R&I Technology Development Programme 2016, MCST**

Project Fund: **€ 193,943.38**

UM Workshare Value: **€ 141,312.67**

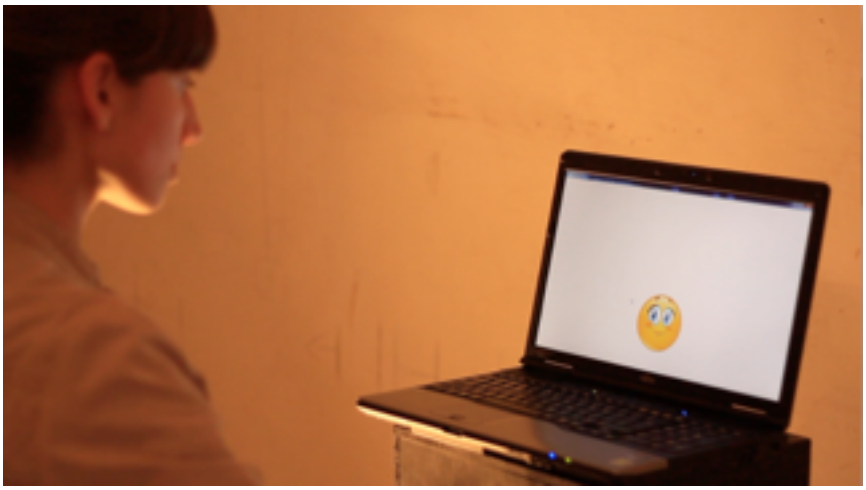
Principal Investigator: **Prof. Kenneth P. Camilleri**

Co-Investigators: **Dr Ing. Stefania Cristina**

Consortium/Partners: **Department of Systems and Control Engineering at the University of Malta, and Seasus Ltd.**

Project Start Date: **July 2017**

Project Duration: **30 months**



Controlling the mouse cursor by the eye movements alone, demonstrated by an interactive game that requires the user to hover the cursor over randomly appearing smileys

This project proposes a passive eye-gaze tracking platform aimed to provide an alternative communication channel for persons with physical disabilities, permitting them to perform mundane activities such as to operate a computer, or for normal individuals as an additional access method.

In the proposed platform, eye and head movement are captured in a stream of image frames acquired by a webcam, and subsequently processed by a computer (and possibly mobile devices) in order to estimate the gaze direction according to the eye and head pose components. Mapping the eye-gaze to a computer screen permits commands to be issued by the selection of icons on a suitably designed user interface. This project addresses challenges associated with eye-gaze tracking under uncontrolled daily life conditions, including handling of head and non-rigid face movements, and reduction or elimination of user calibration for more natural user interaction.

Thermo-Mechanical Studies of Novel MEMS Microgrippers for Manufacturing in Malta

Funding Body: **Reach High Post doc scholarship, Malta**

Principal Investigator: **Dr Ing. Marija Demicoli (née Cauchi)**

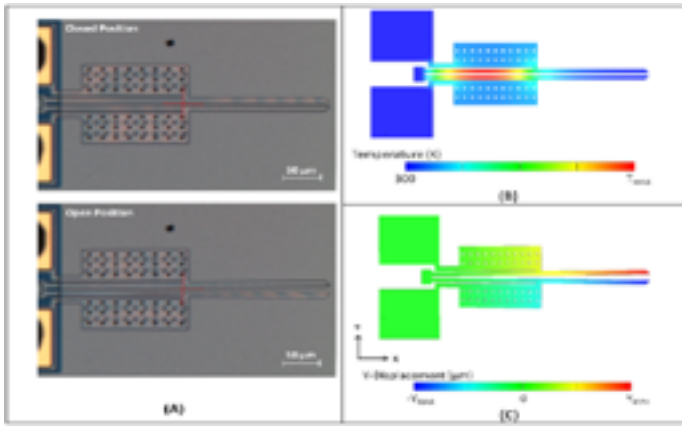
Main Academic Mentor: **Prof. Ing. Pierluigi Mollicone**

Co-Investigators: **Dr Ing. Nicholas Sammut, Prof. Ivan Grech, Prof. Ing. Bertram Mallia,**

Consortium/Partners: **Department of Mechanical Engineering, Department of Metallurgy and Materials Engineering, Faculty of Engineering and Department of Microelectronics & Nanoelectronics, Faculty of ICT, University of Malta; ST Microelectronics, Malta**

Project Start Date: **April 2016**

Project Duration: **3 Years**



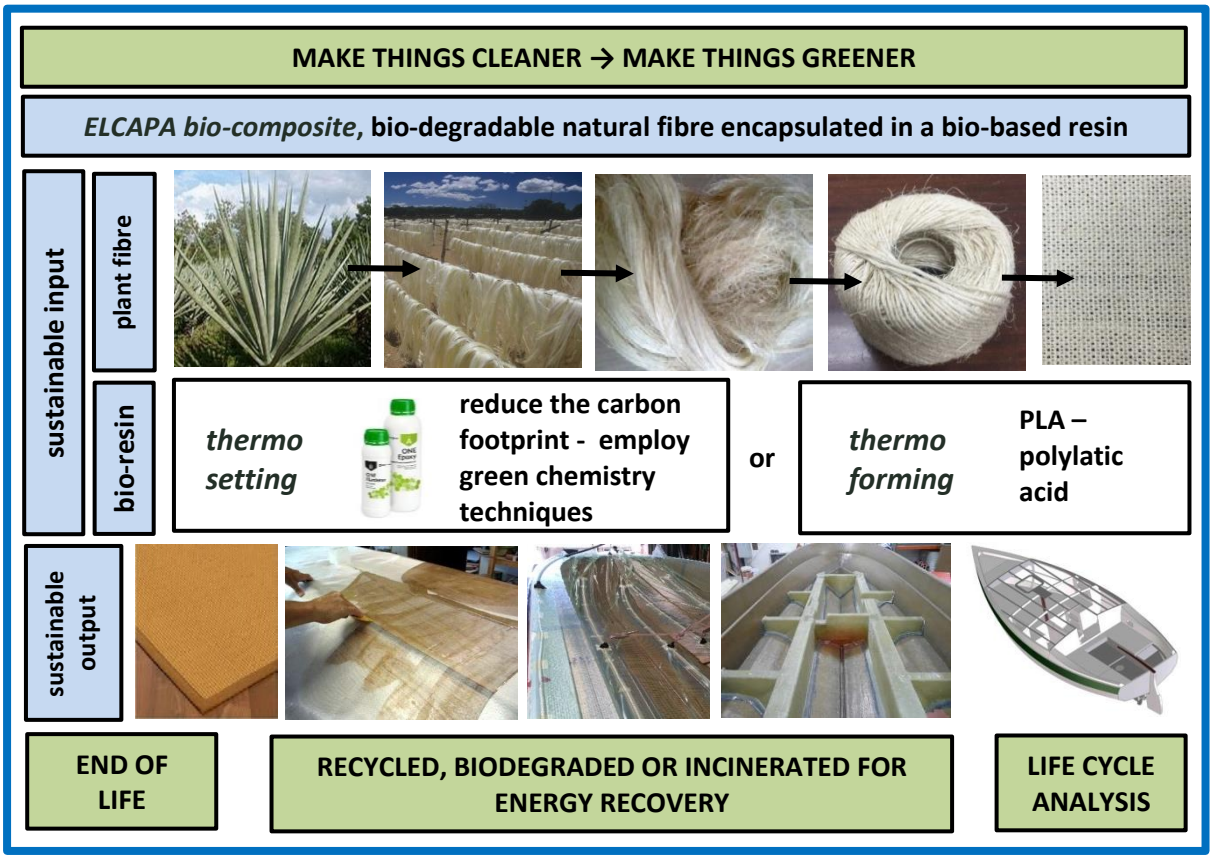
MEMS-based electrothermal microgripper. (A) Optical images showing the fabricated polysilicon microgripper when not actuated (closed position) and when each arm is actuated under an applied potential (open position). (B),(C) Simulated steady-state temperature and displacement plots of the designed microgripper at an applied potential in CoventorWare®

Micro-electro-mechanical systems (MEMS) are advanced commercial microchips currently available on the market. These devices are composed of a microelectronic part and a miniaturised mechanical sensor/actuator that are embedded on the same semiconductor microchip using the techniques of microfabrication. The advances in MEMS technology have been instrumental in the development of new devices and applications, as well as in the creation of new fields of research and development. This project deals with research on MEMS microgrippers which is a relatively new field for Malta. Microgrippers are typical MEMS devices whose compact size, low power consumption and low cost make them ideal tools in microassembly and micromanipulation fields. The primary function of microgrippers is to handle and manipulate micro-objects, such as micromechanical parts and biological cells, without causing damage. The focus of this research project is the design, modelling, fabrication and experimental testing of a silicon-based electrothermal microgripper for the deformability characterisation of human red blood cells.

ELCAPA – Exploiting Local Agave Plants for Maritime Applications

Funding Body: Maritime Seed Award (MarSA) a joint initiative between Malta Marittima Agency (MMA) and the University of Malta, supported by the TAKEOFF Business Incubator, Knowledge Transfer Office and the Centre for Entrepreneurship and Business Incubation (CEBI).

Project Fund: **€ 20,000**
Principal Investigator: **Prof. Inġ. Claire De Marco**
Co-Investigators: **Prof. Inġ. Martin Muscat, Prof. Inġ. Duncan Camilleri, Dr Sandro Lanfranco, Mr Aaron Meilaq**
Consortium/Partners: **Department of Mechanical Engineering, Department of Biology**
Project Start Date: **January 2019**
Project Duration: **1 Year**



ONGOING MASTERS and Ph.D. RESEARCH PROJECTS

Ongoing Master's and Ph.D. Research Projects

Projects supervised by members of the Department of Industrial and Manufacturing Engineering

M.Sc. by Research

Abela Kyle	Performance Analysis and Improvement of Compressed Air through the use of a Compressed Air Test Bed
Caruana Luca	Development and Analysis of a Floating Solar Distillation Device
Fenech Alec	Investigating Kansei Engineering in Industrial Product Development
Magro Ryan	An Approach for Implementing Cyber-Physical Production in Legacy Machines

M.Sc. IPD

Bonello Dilan	An IPD approach to Safety and Security Implications of Designing Cyber – Physical Production Systems (CPPS)
Calleja Giulio	Maturity Assessment of IPD activities
Chetcuti Karl	Sustainability Analysis of Heat Recovery from Plastic Injection Moulding
Sciberras David James	An IPD Based Framework supporting Design for Additive Manufacturing

Ph.D.

Agius Sean	Rider-Centred Design Support Framework for Improved Emotional and Ergonomic Experiences in Motorcycles
Balzan Emanuel	A User-Centred Design Framework for Speech and Language Therapeutic Devices

Projects supervised by members of the Department of Metallurgy and Materials Engineering

M.Sc. by Research

Abela Dylan	Tribocorrosion Response of DLC-Coated 316LVM and Co-Cr-Mo alloys
Attard Marlon	Study of Shot-Peened and PVD Coated Aerospace-Grade Titanium Alloy
Debono Matthias	PIRAC Nitriding of a NiTi Shape Memory Alloy: Augmentation of Degradation Resistance
Scicluna Luke	Tribocorrosion of PVD Coated Bio-Medical CoCrMo Alloy

Ph.D.

Agius Anastasi Anthea	Molecular Simulation and Atomic Probe Studies of Graphene
Arpa Jeanelle	Development of Functional Coatings for Corrosion-Resistant, Low-Impedance and Bioactive Implantable Electrode Surfaces
Dalli Donald	Development of a Low-Wearing Novel Hip Joint Prosthesis for a Longer Lifespan
Farrugia Clayton	Synthesis and Functionalisation of Photocatalytic Surfaces
Grima Matthew	Archaeological glass and raw material trade routes: An archaeometric investigation of Phoenician, Punic and Roman glass found in Malta
Kusova Cini Diana	Protective Coatings for Heritage Metals
Magro Maria	Graphene and graphene oxide for nanostructured membranes
Micallef Mary Grace	Solar Wastewater Treatment Unit
Mozzanello Antonino	Surface Engineering of Biomedical Orthopaedic Implant Alloys: A tribological study
Saliba Eleanor	The Effect of Heat Treatment Parameters on the Microstructure & Magnetic Properties of X46Cr13, a Martensitic Stainless Steel
Tonna Christabelle	Development of a Patient-specific Iron-based Biodegradable Scaffold for Orthopaedic Applications

Projects supervised by members of the Department of Electronic Systems Engineering

M.Sc. by Research

Dalli Mark	Development of a Magnetic Measurement Bench for insertion Devices of a Free electron Laser
Debattista Darren	Design on an Attitude Determination and Control System for the UoM Sat 1 Pico-Satellite
Grech Charles	Design of a UHF Passive Phased Array Ground Station for the UoM BSat1 Pico-Satellite
Sammut Matthew	Electric Propulsion for Small Satellites
Vassallo Oliver	Design of a Software Radio for a Pico-Satellite
Willoughby Jamie	Power Optimization of a Multi-Dimensional Thermoelectric System

Projects supervised by members of the Department of Industrial Electrical Power Conversion

M.Sc. by Research

Ellul Racquel	Droop Control for Electric Springs Used for Voltage Stabilization
Lendi Daniel	Stability and Optimisation of a High Dynamic Motor Starter Prototype's current control algorithm
Palombi Jonathan	Design of an Electric Power Train for Malta's FSAE Team
Vella Eryl	Micro Combined Heat and Power Engine
Xuereb Justin	Investigation of IGBT devices for the HDMS project

Ph.D.

Scicluna Kris	Sensorless Control in Steer-by-Wire Application
Zammit Daniel	Control of Microgrids for Distributed Generation including Energy Storage

Projects supervised by members of the Department of Mechanical Engineering

M.Sc. by Research

Aquilina Yesenia	Towards Robot-Assisted Living through Universal Design of the Environment
Bartolo David	An Investigation of Different Welding Manufacturing Procedures to Minimize Distortion
Bezzina Ryan	Investigating the Aeordynamic Wake Evolution of Floating Wind Turbines
Cutajar Charise	Loads and Motion Analysis of Floating Offshore Wind Turbine with Integrated Hydro-Pneumatic Energy Storage System
El Sadi Yasmine	Thermal Analysis of a Hydro-Pneumatic Energy Storage System Integrated in a Floating Offshore Wind Turbine
Gerada Joseph	Design, Development and Optimisation of Fibre Reinforced Composite Poles
Meilak Aaron	Fibre Extraction from Local Agave Plants
Saliba Anthony	Investigating the Aerodynamic Characteristics of Small-Scale UAV Propellors with Vortex Generators
Scicluna Leo	Investigation of Wind Flow Conditions on the Flight Endurance of UAV in Hovering Flight
Tabone Miguel	Analysis of Vehicle Crash Data from event data records

Venkata N. Nallapati	Autonomous Navigation for a Domestic Mobile Robot in a Robot-inclusive Space

M. Phil.

Azzopardi Jean Paul	Dual Fuel Internal Combustion Engines – Alternative Fuels for Diesel Engines
Portelli Marcus	Constitutive Models of Advanced Materials Subjected to High-Energy Particle Beam Impacts

Ph.D.

Almehat Mahmoud Ayad	Development of Benefits accruing from Implementation of Environment Management Systems in Wasteserv Malta Ltd.
Caruana Carl	Incylinder Heat Transfer and Friction Analysis in PressurisedMotored Compression Ignition Engine

Projects supervised by members of the Department of Systems and Control Engineering

M.Sc. by Research

Cutajar Lucianne	Combined Visual and Thermal Imaging for Non-Contact Physiological Signal Measurement
Mangion Jeanluc	EEG based control of a home automation system

Ph.D.

Azzopardi Carl	Quantifying Atherosclerosis Using Freehand 3D Ultrasound Imaging
Barbara Nathaniel	Gaze Angle Estimation using a Dense Multi-Channel EOG Electrode Configuration with Varying Head Pose Compensation
Borg Mark	Automatic Video-based Sign Language Recognition
Chetcuti Zammit Luana	Autonomic Control for Road Network Management
Darmanin Rachael N.	Coordination and Control of Multi-Robot Systems
Garba Idris	CT Radiation Doses in Nigeria: Establishment of Diagnostic Reference Levels and Radiation Dose Optimisation
Gauci Jean	Analysis of Temperature Transient Patterns using Dynamic Infrared Thermography
Okkalidis Nikiforos	An Enhanced Wearable System for Kinematic and Kinetic Gait Analysis
Tanti Marc	Visual Object Recognition based on Textual Descriptions
Zerafa Rosanne	Switching Multiple Models for SSVEP-based Brain-Computer Interfaces

FINAL YEAR ENGINEERING PROJECTS

ELECTRICAL STREAM

Design of the Radio Front End of a UHF Phased Array System

Student: Ryan Agius / Supervisor: Dr Ing. Marc Anthony Azzopardi / Co-Supervisor: Dr Ing. Owen Casha

Introduction

In recent years, there has been considerable interest in the deployment of large constellations of small satellites. Traditionally used base stations employ actuators to move several highly directional antennas to track the satellites as they pass overhead. In contrast, a phased array consisting of many individual antenna elements utilises electronic beamforming techniques to create a steerable, highly directional beam of radio waves.

Project Objectives

The aim of this project was to design, assemble and test a functional radio front end prototype for use with an icosahedral antenna array. The system had to be scalable, entirely referenced to a stable atomic clock and allow for fast and precise phase changes to all the antenna elements.

Project Methodologies

The first stage of the project involved the selection of a suitable architecture to enable accurate beamforming while also keeping the system cost to a minimum. This led to the selection of a software radio architecture with hybrid beamforming, which divides the array into several sub-arrays each containing four elements. Direct Digital Synthesisers (DDS) are then utilised to generate precise phase-controlled signals, which in turn drive each element's mixer to achieve beamforming, as shown in Figure 1.

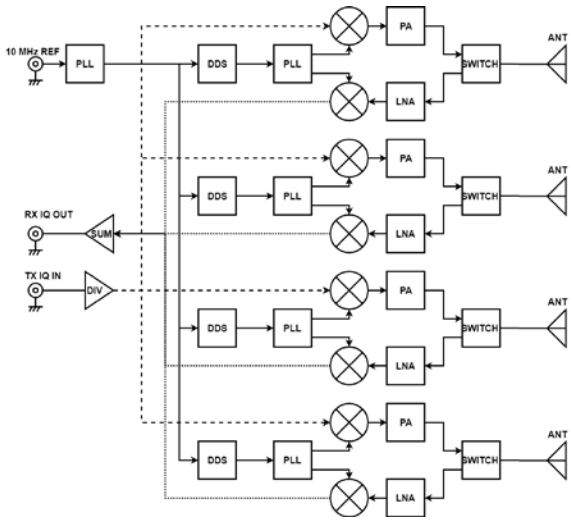


Figure 1: System Block at Sub-Array Level

In the second stage, each of the individual blocks in Figure 1 was realised in hardware through the selection of appropriate integrated circuits and the design of a suitable development board, in order to fully characterise the implemented modules.

Various circuit blocks were then integrated into a single system, which again required the use of appropriate components and PCB routing techniques to ensure synchronisation between the outputs.

Results and Achievements

The designed transceiver consists of four PCB layers, connected together through three backplanes as shown in Figure 2. The modular approach adopted in the system's design improves the system's flexibility in numerous ways. Firstly, it relegates narrowband modules such as the imaging filters to separate interchangeable PCBs, preserving the large operating frequency range offered by the mixers. More importantly, it protects the more expensive components on the central board in the event of lightning striking the antenna array.

While being fed from a single 10MHz source, the system is designed to interface with 32 individual elements over a frequency ranging between 80MHz and 2.7GHz, with an output power of 33dBm and a receiver sensitivity of -127 dBm.

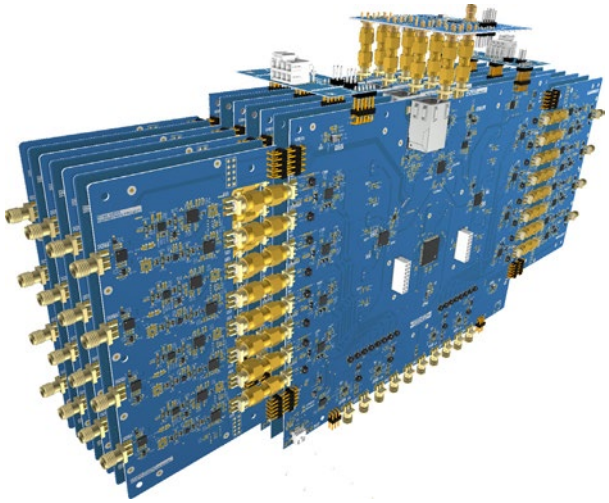


Figure 2: Model of the Finalised System Hardware

Autofocus using an MFT Motorized Lens

Student: Michael Brockdorff / Supervisor: Mr Andre Micallef / Co-Supervisor: Dr Ing. Marc Anthony Azzopardi

Introduction

Ever since the invention of film by Kodak in 1888, the popularity of photography has steadily grown, spurring rapid technological advancements [1]. However, the simplicity involved in taking photos is not uniformly distributed throughout all the different fields of photography. As opposed to the mass-produced point and shoot products, scientific vision instruments still rely on manual focus adjustments made by the user. Given the absence of motorised lenses and matching algorithms in industrial cameras, adding such capability will definitely increase the potential of such instruments.

Project Objectives

This project focuses on the design and implementation of both the hardware and software components of an autofocus system for the MEMENTO project. MEMENTO aims to construct a high-bandwidth camera which consistently produces high frame rate video at high resolutions to serve both the industrial and scientific markets.

Project Methodologies

The design of the implemented autofocus system began with an in-depth review of current existing autofocus algorithms, lens search methods, and lens mount standards. The shortlisted algorithms where then validated through specifically designed tests using MATLAB. After confirming the correct operation of the chosen algorithms, work on the communication between the chosen lens and a suitable processor began.

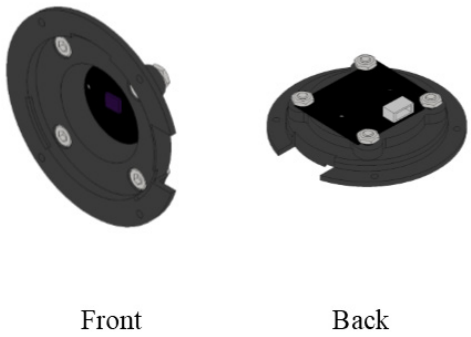


Figure 1: 3D Printed Components

This process consisted of the design and manufacturing of custom made three dimensionally (3D) printed parts as to provide a suitable interface between the image sensor, the motorized lens and the chosen processor. Figure 1 shows a 3D representation of the manufactured components. With all the necessary communication links in place a printed circuit board (PCB) was designed, with the purpose of hosting all the relevant interface and communication related circuitry. The PCB and all other relevant mechanical parts were then assembled after a rigorous testing procedure.

Results and Achievements

The resulting autofocus system repeatedly returned successful results when tested on its ability to obtain a fully focused image when initially presented with an out of focus image. The performance of the overall system was then improved by the introduction of a region selection process. This allowed the system to focus one part of the image while leaving the rest of the image out of focus when multiple focal points are available within the same image. A sample of the results obtained can be seen in Figure 2.

References

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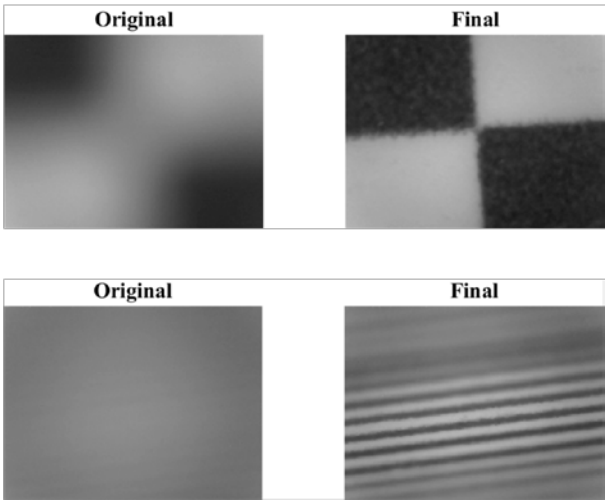

Figure 2: Unfocused vs Focused Images

Control of a 3-axis Helmholtz Chamber

Student: Matthew Camilleri / Supervisor: Dr Ing. Marc Anthony Azzopardi

Introduction

Helmholtz coils consist of two parallel coils placed at a specific distance apart. The interaction of the two separate fields results in a near uniform magnetic field in the center between the two coils. This principle can also be applied in three dimensions by connecting three orthogonal pairs of Helmholtz coils producing what is known as a Helmholtz chamber.

Project Objectives

The aim of this project was to design and manufacture a controller for a 3-axis $1m^3$ cubic Helmholtz chamber shown in Figure 1. This is interfaced with a geomagnetic field model (IGRF) and an orbital propagator and used to conduct experiments in precision controlled magnetic fields while negating the background geomagnetic field.

Project Methodologies

The underlying principles behind Helmholtz coils were studied and the construction of the chamber in Figure 1 verified with the associated mathematics [1]. A review of existing models and magnetometers was also conducted to gain a better appreciation of the equipment needed, final product functionality and limitations.

A single axis controller was first constructed to test out the principles of operation and the proposed circuitry. Once a satisfactory single axis controller was achieved, the design was expanded to cater for 3 individual axes of the Helmholtz coil.

Figure 1: Helmholtz chamber at the University of Malta

Results and Achievements

A 3-axis controller board was designed to control the magnetic field in the X, Y, Z planes producing a directional magnetic field vector as desired within ±1mG of the requested field with respect to the 3-axis magnetometer used [2]. Plotting the percentage error for the magnetic field values as illustrated in Figure 2, it can be observed that while the percentage error is within 1 per cent for all values, those closer to zero exhibit a higher error. This can be attributed to small variations in magnetic field readings due to surroundings and sensor inaccuracies which remain constant regardless of the field but are more comparable to requested values when these are small. Closed loop control is achieved by placing a magnetometer at the center of the coil, a digital integrator on the error adjusts the current in the coils to obtain the desired field. The controller can then be interfaced with an orbital propagator making use of the IGRF model to obtain the required magnetic field simulating a satellite's orbital path.

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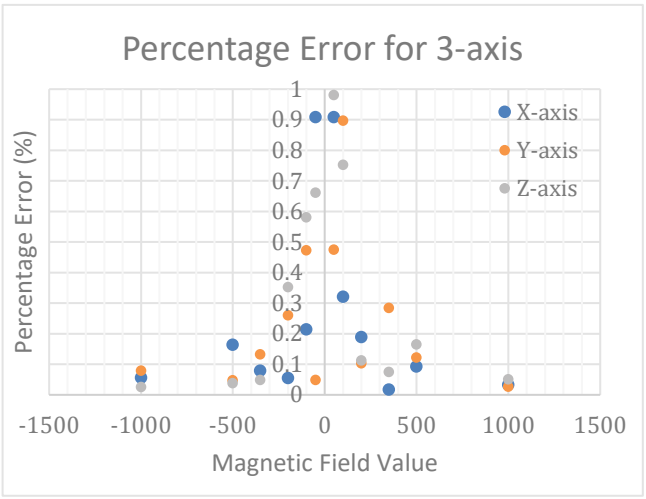

Figure 2: Percentage error for 3-axis field values

Design of a High-Performance Embedded Image Processing Library for FPGA-Based Reconfigurable Platforms

Student: Daniel Cassar / Supervisor: Dr Paul Zammit / Co-Supervisor: Mr Andre Micallef

Introduction

The ever-growing market for consumer electronics such as smartphones and cameras has created significant demand for image processing on embedded hardware. However, processing an image is computationally intensive and often requires significant system resources. Unfortunately, this is in direct contrast with the cardinal requirements of embedded systems. High-performance, state-of-the-art hardware, such as GPUs and high-end CPUs, do provide the necessary resources; at the cost of high power requirements. As a result, they are unsuitable for the mentioned application. On the other hand, FPGAs, which are inherently parallel, are relatively low power and are particularly suited for image processing because most image processing routines are apt for parallelisation. This thesis, therefore, treats the design and implementation of a high performance image processing library intended for embedded image processing application in VHDL.

Project Objectives

The project objectives were to design, implement and testing of an image processing library for use on an FPGA device. Testing was carried out to establish the performance of the design. The parameters of interest are: the execution speed, power consumption, cost and FPGA resource-requirements. These gives a good idea of the viability of the design for the intended application. This work focuses primarily on convolution-based image filtering because these operations are used frequently and are some of the most demanding in image processing. As a result, they were deemed representative.

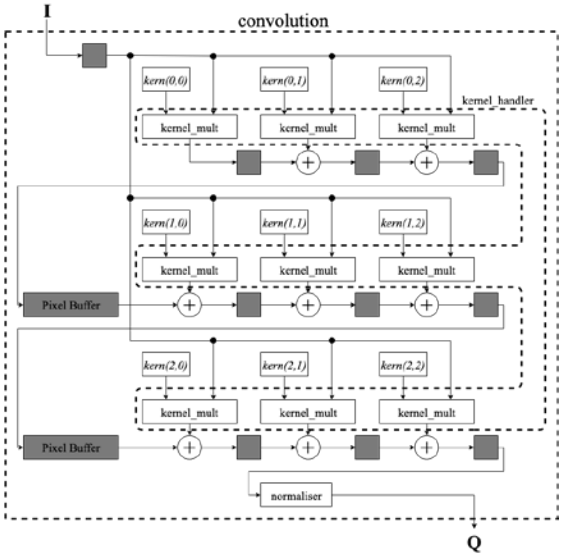

Figure 1: System Block Diagram

Project Methodologies

Many different algorithms were considered for the realisation of the convolution function, each with its individual merits and faults. In the end, the one which was finally implemented was chosen due to its simplicity and ease of enhancement. The enhancements were applied by using a technique called pipelining whereby an operation is distributed over multiple clock cycles to reduce the delay due to the logic and hence allow for a higher clock frequency. Additionally, certain multiplications and divisions were implemented using a combination of shift operations and additions which are less time consuming as well as require less resources.

Results and Achievements

The design was implemented on an FPGA (Xilinx's XC7A100TCSG324) using a maximum clock frequency of 232MHz. This highly outperformed a similar implementation using MATLAB, a matrix-based programming language, optimal for image processing, despite the MATLAB script being run on a dual-core CPU operating at a clock speed of 2.2GHz. Using the FPGA implementation resulted in a time improvement of up to 95% for small images and 56% for larger images, over the MATLAB implementation, in spite of the fact that the FPGA is running at a clock speed equal to 10.5% of that of the CPU. Whereas the CPU used had a power rating of 15W, the FPGA design consumed 0.243W for small images with a size of 64 by 64 and only increased to 0.269W for larger images of 1920 by 1080. This is a very ideal power consumption for embedded systems which operate off of a portable power source such as a battery.

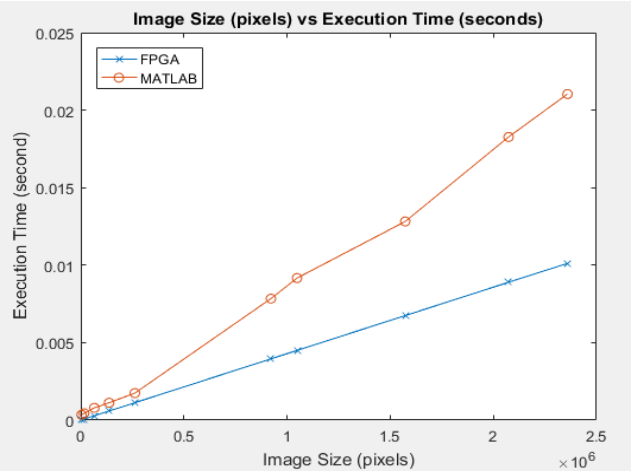

Figure 2: FPGA Development Board

Development of a Microwave Ablation System for Medical Applications

Student: Federico Cilia / Supervisor: Ing. Evan Joe Dimech / Co-Supervisor: Dr Lourdes Farrugia

Introduction

Cancer is one of the leading causes of death, contributing to a global estimate of 9.6 million deaths in 2018[1]. Microwave ablation is a promising alternative to surgical resection for the treatment of cancer. The surgical procedure involves, inserting needle type applicator through the skin into the tumour to perform ablation. The eradication of the tumour is achieved by propagating microwave, causing a temperature rise in the surrounding tissue.

Project Objectives

The aim of this thesis was to design a microwave coaxial based monopole antenna for cancer ablation at 2.45GHz. The relation between a coaxial cable and biological tissue was investigated both experimentally and computationally using Computer Simulator Technology (CST) software.

Project Methodologies

A detailed literature review was carried out to, understand cancer and its causes, review state of the art ablation applicators and understand concepts behind antenna design.

A design of experiment was conducted to validate the model of a coaxial cable created on CST studio software, with an experimental setup using a Vector Network Analyser (VNA). This included, measuring and comparing results using Smith charts for both the simulation and the experimental setup, backed by transmission line theory.

After the validation was concluded, the model of the coaxial cable was used to design the microwave coaxial based monopole antenna. Phantoms of blood, liver and muscle were first modelled in CST studio and then validated using the experimental setup. The liver results were also verified with biological sample from pig's liver. Then the software model was used to design the monopole antenna which then was constructed and tested in a blood mimicking solution as shown in Figure 2

Results and Achievements

During the validation of the model, the results obtained from the matched terminated transmission line Simulation model and experimental setup, were a measure a Voltage Standing Wave Ratio (VSWR) of 1.08 and 1.17 respectively. Comparing the result with a theoretical VSWR of 1, this concluded that the model of the simulation and the experimentation setup were validated. Then the modelled phantoms in CST studio and the mimicking solutions were compared and verified by the characteristic impedance, using impedance transformation techniques. Finally, a coaxial based monopole antenna was designed and modelled in CST studio using the previously verified model on a blood phantom. This was confirmed using blood mimicking solution and shown that the optimal antenna tip length required to obtain the best matching condition that of an effective quarter wave length of a coaxial cable immersed in biological tissue.

References

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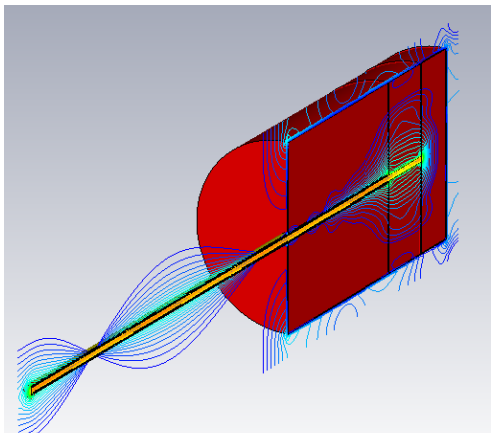

Figure 1: Simulation of a monopole antenna in blood

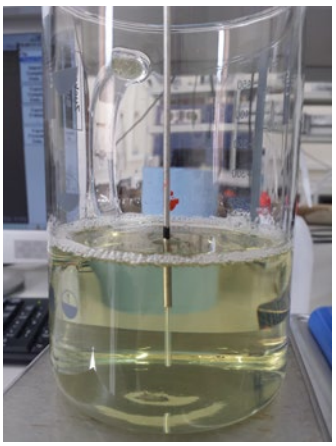

Figure 2: Setup of a monopole antenna in a blood phantom

A Low Cost Setup for Underwater Positioning

Student: Francesca Farrugia / Supervisor: Dr Ing. Brian Zammit

Introduction

Underwater remote offshore vehicles (ROV) such as the one presented in Figure 1 are found in various applications such as deep-sea exploration, salvage operations and locating of underwater structures [1]. To enable autonomous operation, a positioning system is required to accurately locate and track the vehicle. GPS technology cannot be adopted for the underwater environment.

Project Objectives

The main objective was to identify and test low cost technology that could be used for the underwater positioning system. The underwater tests would then provide a clear understanding of the performance of the setup in the underwater environment and will characterize its suitability for our requirements.

Project Methodologies

After a literature review of existing underwater positioning systems, a suitable setup was chosen based on the requirements of our particular application. The selected long baseline positioning system comprises of several range measuring sensors, typically three for locating the position of the ROV. The ultrasonic frequency was selected to provide the range measurements. The ultrasonic sensors can be either used as a radar, in which sound waves are reflected off an object as shown in Figure 2a or as a receiver transmitter pair (Figure 2b). The time-of-flight is then converted to distance and fed to a trilateration model for relative localisation.

Figure 1: Remote Offshore Vehicle (ROV) [2]

Results and Achievements

In this project the focus was on characterising the suitability of low cost ultrasonic sensors for underwater operation. Various underwater tests were performed both at the University and in a residential pool to extract the behaviour of the designed setup. Two setups were tested; one using one sensor in a radar configuration and the other using two sensors.
Before testing underwater, all the hardware was tested for proper operation in air, taking into account the variations in the speed of sound.
The results will provide a clear understanding of the accuracy and repeatability of the setups. The details of the analysis will be presented in the final writeup.

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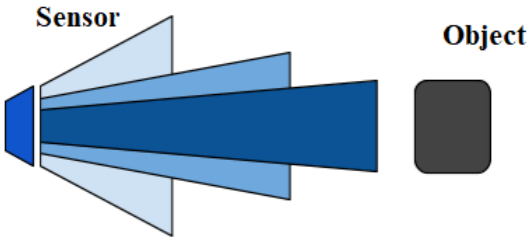

Figure 2a : Radar configuration

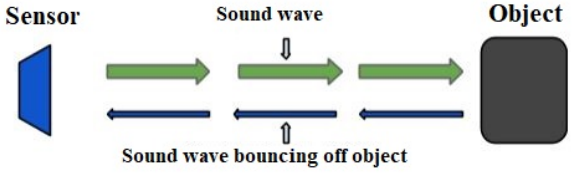

Figure 2b: Receiver transmitter pair

An Investigation of Robotic Swarm Behaviour using Decentralized Control Algorithms

Student: Luke Galea / Supervisor: Dr Ing. Brian Zammit

Introduction

Although the roles of single and small multi-robot systems have been widely accepted and adopted for the needs of our society, the roles of swarm robotic systems are still under investigation. Swarm robotic systems typically mimic the behaviour of groups of social insects and animals. They can bring about a number of improvements over traditional multi-robot systems due to their adaptive nature [1].

Project Objectives

The main aim of this project was to conduct a review of typical swarm behaviours and investigate the algorithms that are used to replicate such behaviour in robotic systems. The project would then adapt these algorithms to be implemented on an available robotic system. A simulation model of the swarm behaviour was also required for preliminary testing.

Project Methodologies

The simple individual behaviour within a swarm, as also observed in ants or flocks of birds, can in turn result in complex collective swarm behaviour. Having a large number of robots equipped with basic sensing and processing capabilities and following basic rules makes it attractive for applications such as search and rescue or clean-up of toxic materials [2]. After conducting the literature review, two algorithms were chosen and simulated to understand the emerging behaviour. The selected robot hardware was upgraded such that the algorithms could be implemented and demonstrated.

Figure 1: The eeMod robot hardware [3], with redesigned communication module at the top

Results and Achievements

The algorithms chosen exhibited flocking and foraging behaviours. For the flocking algorithm, it was interesting to observe the robots slowly aggregating from random initial positions and then exhibiting a flocking behaviour. Since this algorithm is based on just three simple rules, this enabled it to be easily modified which resulted in other swarm behaviours such as following a number of predefined leader robots.

The foraging algorithm was inspired by the aggregation of `slime mold amoeba' and obtained positive results in simulation. The actual robot implementation needs further adjustments. The encountered issued were mainly attributed to the capabilities of the robotic hardware which can easily be improved.

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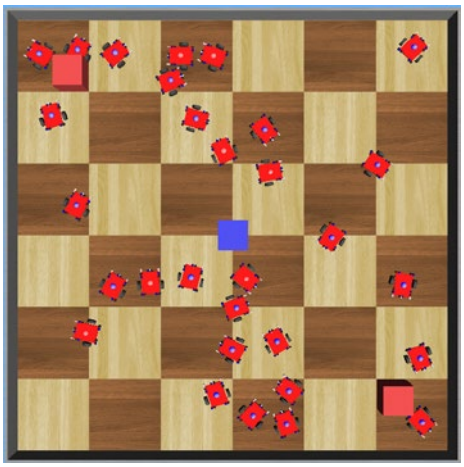

Figure 2: Swarm of robots carrying out a foraging task in the simulation environment

Development of a Waterproof, Alert Device for Hearing Impaired Water Polo Player

Student: Matthew Sultana / Supervisor: Ing. Evan Dimech

Introduction

Gabriel suffers from a bilateral sensorineural hearing loss and wears hearing aids. He is a keen water polo player and plays with the junior team of a first division club. There are currently no waterproof hearing aids able to withstand the rigours of water polo, and therefore Gabriel must remove his hearing aids while he plays. Gabriel's greatest handicap while playing is that he cannot hear the referee's whistle. This severely hampers his ability to respond quickly and at times compromises the performance of his team. His future as a water polo player is at risk unless a solution can be found. This project aims to develop an electronic device able to pick-up the referee's whistle hence providing an alerting signal.

Project Objectives

The main objective of this project is to develop an electronic device able to detect the water polo referee's whistle hence translating the audio alerting signal to a haptic vibrating signal. The device must be waterproof and must be robust enough to withstand the game; keeping in mind that water polo is a high contact sport. Ideally, the device should be worn in the player's water polo cap as wearing the device on any other part of the body would provide the opponent with a means of holding on to Gabriel, which is far from ideal in the game.

Project Methodologies

The problem that Gabriel has was thoroughly analysed, and a system to solve this problem was designed. The system designed consists of two main subsystems: whistle detection subsystem and alerting subsystem. The whistle detection subsystem interprets the referee's whistle and transmits a cue to the alerting subsystem. The alerting system alerts Gabriel when the referee whistles by transmitting haptic cues. This system consists of an electronic device incorporated within the cap's ear guard. The player's head cap is the safest place to incorporate the electronics since it will be out of water most of the time.

An Android mobile phone app was developed which is able to pick up and interpret the referee's whistle in real-time. An electronic device was developed which can communicate with the mobile phone and alert Gabriel when necessary. The developed embedded hardware and software were tested, verified and validated within a controlled environment to ensure that the design criteria were met.

Results and Achievements

The electronics components were successfully integrated on a 3.6cm by 2.4cm PCB which can be incorporated inside the ear guard. The whistle detection algorithm was successfully implemented and tested on an Android mobile phone.

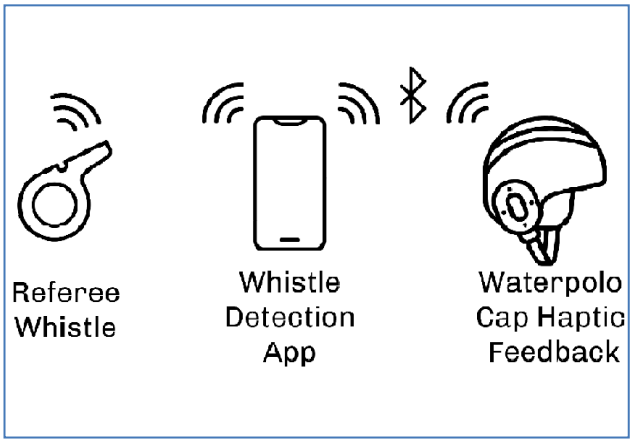

Figure 1: System Overview

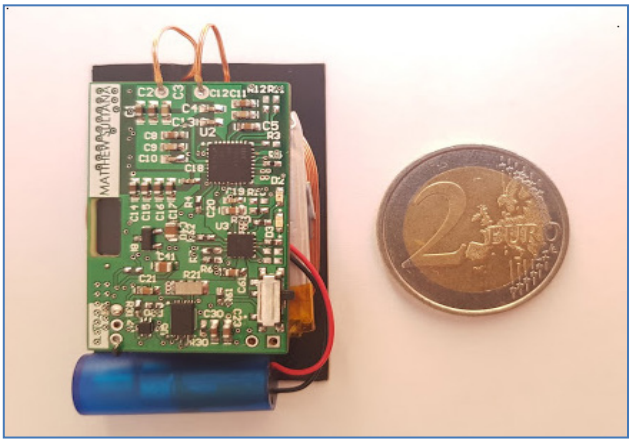

Figure 2: Final PCB Developed

Video Transmission over 10G Ethernet

Student: Luke Vassallo / Supervisor: Mr Andre Micallef / Co-Supervisor: Mr Karl Galea

Introduction

Ethernet is the primary standard used in general purpose wired communications. Tremendous advancements in Field Programmable Gate Array (FPGA) technology has paved the way for providing multi gigabit Ethernet solutions on a single IC. This power is leveraged for the transmission of video data in excess of 70Gbps generated by a high resolution, high frame rate imaging sensor.

Project Objectives

The primary objective is the implementation and testing of a point-to-point 10G Ethernet Link over fiber optic (10GBASE-R), optimized for the transmission of video data. This is the first step in achieving the goal of an 80G aggregated Ethernet link on a mid-range Xilinx FPGA.

Project Methodologies

The Ethernet Link encapsulates the Medium Access Controller (MAC) and Physical (PHY) interface to the transmission medium. The MAC is responsible for ensuring the integrity of point-to-point data transfer. The PHY transmits and receives the serialized data at 10.3125Gbps. These two components were implemented using certified XILINX IP.

The Ethernet link is served with framed video data generated in compliance with the Ethernet standard. For this purpose, framing hardware was developed and interfaced with Xilinx IP through the AXI interface.

Following the verification of a single link further hardware was developed for distributing video data over a maximum of eight 10G Ethernet Links aggregating a bandwidth of 80Gbps.

The designed hardware incorporates a set of registers that are accessible through MicroBlaze – Xilinx's proprietary microprocessor. These provide control and monitoring of the hardware through software making the subsystem flexible and ready to be integrated as a peripheral in a larger system.

Results and Achievements

Given the complexity of such a system, an integrated design / testing methodology was adopted, whereby multiple development iterations were performed. This allowed for quick debugging whilst alleviating performance bottlenecks.

Final benchmarking tests in hardware verified sustained bi-directional video transmission at 10G speed on a single Ethernet Link. The developed 80G link aggregation subsystem proved 80G capability whilst achieving a maximum payload bandwidth of 32.5Gbps when aggregating 4 Ethernet Links.

The hardware architecture of the developed subsystems is parametrized. As a result, it can be very easily extended to accommodate data transfers anywhere in the range of 10 to 160G.

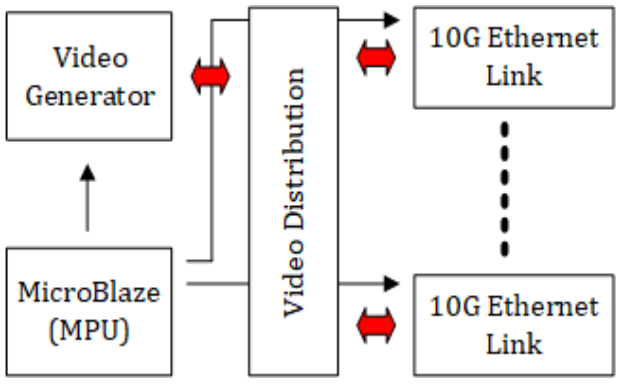

Figure 1: Ethernet Subsystem Block Diagram

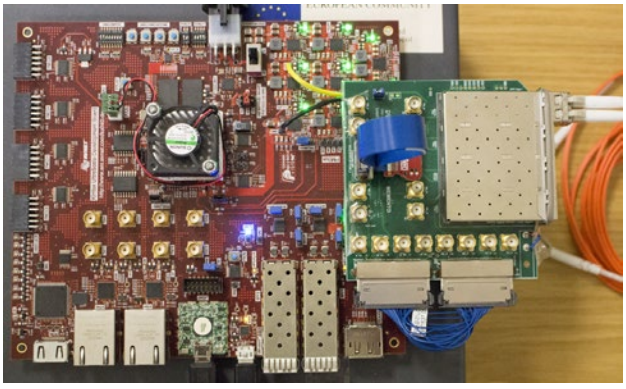

Figure 2: FPGA Board interfacing with Optical Transceiver

Hot Pluggable High Speed Video Transceiver Module

Student: Andrea Vella / Supervisor: Mr Andre Micallef / Co-Supervisor: Dr Ing. Marc A. Azzopardi

Introduction

Most off the shelf video communication systems are designed around pre-established resolutions and frame rates, as this allows for harmonisation between capture and display products. Such limitations, however, tend to constrain the operation of custom high speed cameras that function at the different resolutions and frame rates. Thus an alternative data link needs to be explored which provides both high bandwidth functionality as well as allowing plug-and-play operation.

Project Objectives

The aim is to develop a module to enable high bandwidth video data transfer between a camera and a receiver. This is done by implementing a carefully selected high speed (HS) serial communication protocol over an industry standard hot pluggable transceiver module.

Project Methodologies

The HS video standard adopted was the CoaXPress (CXP) protocol [1]. This provides up to 6.25Gbps data throughput per link, whereas the transceiver was selected from a common standard adopted in telecommunication applications as illustrated in Figure 1.

A testing module was designed to provide a performance characterization platform for the module controller and CXP transmitter and receiver chipset. The work carried out consisted of High Speed PCB design, implementation of FPGAs code to generate and control the CXP standard, in addition to the use of a microcontroller to serve as the module controller.

Once the design was verified it was scaled down to the mechanical constraints defined by the transceiver standard, whilst still complying with the CXP protocol.

Results and Achievements

Bit error rate (BER) tests were conducted on every lane at 1.25/2.5/3.125/5.0/6.25Gps. These resulted to be error-free i.e. lower than $1x10^{-12}$ BER, provided that the transmitter increases the output power by 0.45dB at bit transition. Figure 2 illustrates, the eye diagram of the final implementation at the maximum bitrate of 6.25Gbps.

The CXP link was successfully implemented and tested, with a standard GenICam application detecting the generator as a compliant “device”. An acquisition process was then undertaken, by which a specified image format on the device was captured, processed and displayed over the frame grabber interface.

A major improvement on the basic setup was to extend the number of links used. Due to physical constraints a total of two links were implemented. This was sufficient to prove the principle and verify the modularity of the design during runtime due to the bootstrap registers defined for the CXP.

References

[Book:]
[1] [JIIA], ‘[CoaXPress Standard v1.1.1]’ [Japan Industrial Imaging Association Standard], 2015.

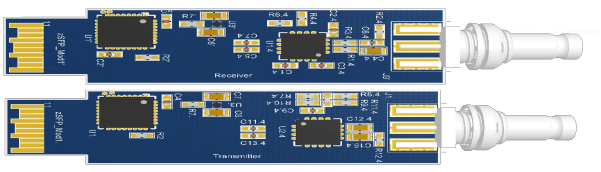

Figure 1: CXP Transceiver Complaint Board

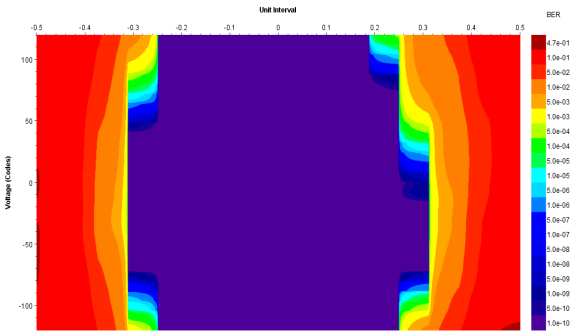

Figure 2: Eye Diagram of HS channel at 6.25Gbps

Radiation Tolerance of Components for PicoSatellite on Board Computers

Student: Glenn Zammit / Supervisor: Dr Ing. Marc Anthony Azzopardi / Co-Supervisor: Ing. Evan Dimech

Introduction

Space around planet Earth has all kinds of radiation coming from the Van-Allen belts, the sun or even background cosmic rays. At ground level, these do not pose a problem but as the altitude increases, the Earth's magnetic field gets weaker and the atmosphere gets thinner (which both shield Earth from radiation). This means that the electronic devices in space receive a large radiation exposure.

Project Objectives

The On Board Computer (OBC) of a satellite has the task of supervising all systems and take decisions, which means high reliability is required. Pre-radiation testing of the devices utilized on the OBC is the key to reliability by providing insight into what the problems might be together with their symptoms.

Project Methodologies

This dissertation discusses some research into the radiation effects on electronic components, as well as designing hardware for evaluating the performance of devices undergoing radiation testing. The devices tested are MOSFETs, memories, and microcontrollers. Latch-up protection circuitry was designed to cut off the power and isolate the device under test (DUT) after exhibiting a latch-up condition for a fixed amount of time.

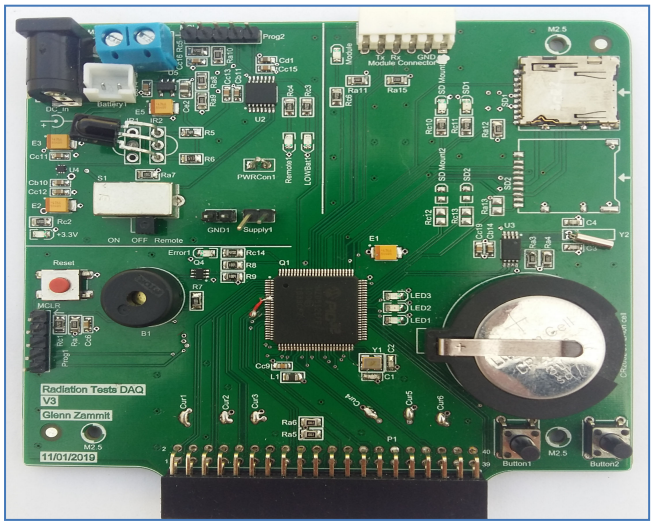

Figure 1: Data acqusiting board designed to gather data on the devices under radiation

The testing is performed to analyze the effects and symptoms of radiation, in this case X-Rays. Repeatability is ensured from one test to the next by varying only one parameter at a time – typically the only difference between tests being the DUT itself.

The DUTs are subjected to X-Rays while continually monitoring their power and storing the measurements every 10 ms with the board in Figure 1. Any functional errors captured during testing are stored on a text file alongside any available data like date, time and elapsed time since the beginning of the test. Details about the occurrence of any latch-up event are saved on a separate text file.

Results and Achievements

It is found that unpowered MOSFETs will have a threshold voltage shift less than a powered one during radiation exposure. This means that unpowered devices survive longer in radiation.

The MRAM memory tested can handle much greater radiation dosage than the other memory technologies tested. In fact, no failures were observed.

The FRAM memory tested underwent a full recovery with thermal annealing, while NOR FLASH experienced a partial recovery due to the damage done to the charge pump circuitry used to erase.

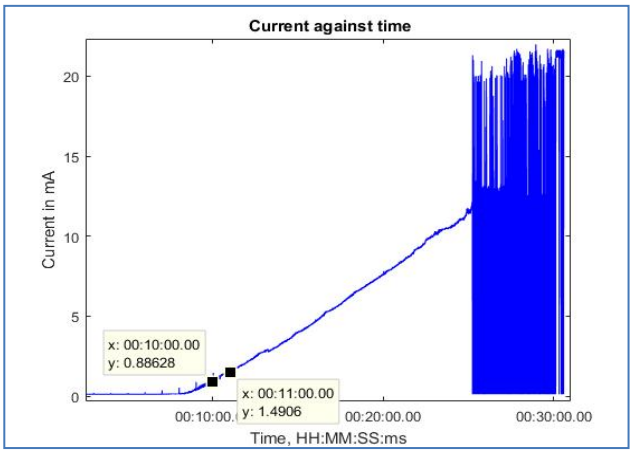

Figure 2: FRAM memory under radiation. Cursors showing the time of first error , followed by complete failure

Mitigation of Power Quality Issues in All-Electric Ship Power System

Student: Lara Agius / Supervisor: Dr Ing. Cedric Caruana / Co-Supervisor: Dr Ing. Alexander Micallef

Introduction

The term 'all-electric' ship implies an integrated power system where both propulsion and major loads are electric [1]. Electric propulsion is becoming increasingly popular as it facilitates meeting the societal demands relating to reduction of carbon dioxide emissions and fossil fuel consumption. The proliferation of nonlinear loads on ship power systems however is leading to power quality issues thus necessitating some form of mitigation [2].

Project Objectives

The main objectives of this project are to enhance the simulation model to represent a more realistic ship power system; examination of dominant power quality issues under typical operating conditions and implementing solutions to mitigate their negative effects.

Project Methodologies

Firstly, some refinements were introduced on the software model. These include modification of the bow thruster model to better match the motor datasheet parameters; increasing the inertia of the propeller motor in order to include the propeller inertia and introduction of cable impedance between the generation and load sides.

The project then focused on harmonics arising from the operation of the main traction motors. The harmonic content was noted under various operating conditions, both at the load and generation ends. Following on common practice, the rectification stage of the main traction drive was changed from a six-pulse rectifier to a twelve-pulse rectifier through the introduction of a three winding transformer and an additional six-pulse rectifier connected in series to the original one.

Following this improvement, the remaining dominant harmonics were the 11^{th} and the 13^{th}. In order to mitigate these, single-tuned passive filters were designed to improve the power quality of the ship power system. Two filter designs were considered; one based on a combination of capacitor banks and the other considering a parallel combination of smaller individual three-phase capacitors. The filter designs were evaluated in terms of space and weight and the better option was implemented in simulation.

Results and Achievements

The operation of the ship power system was tested under various loading conditions of the main thruster for each configuration considered for the mitigation of harmonic distortion.

An analysis of both current and voltage harmonics at each stage was carried out. For the original system, the most dominant harmonics were the 5^{th} and 7^{th}. As the cable impedance was introduced, the 11^{th} and 13^{th} harmonics also became dominant in addition to those present for the original system. However, with the improvement in the rectification stage to a twelve-pulse rectifier, the 5^{th} and 7^{th} harmonics were practically mitigated. After the addition of the passive filters, the 11^{th} and 13^{th} harmonics' magnitudes were effectively reduced hence the total harmonic distortion (THD) for both voltage and current was improved.

From the results obtained, it could be observed that the droop settings of the generators resulted in a drop in frequency hence the harmonics did not occur at the system frequency, 50Hz and its multiples but slightly lower frequencies. As the load increases, so does this drop in the system frequency.

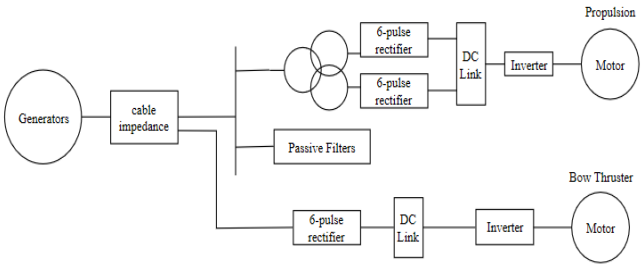

Figure 1: Block diagram of ship power system with the modifications

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Distributed Voltage Control with Electric Spring Smart Loads

Student: Dylan Falzon / Supervisor: Dr Alexander Micallef / Co-Supervisor: Dr John Licari

Introduction

The installation of renewable energy sources (RES) has increased drastically throughout the last years, with RES including solar, wind, hydroelectricity. This increase leads to tougher challenges when handling the distribution of electricity, due to the introduction of power quality issues such as over-voltage, under-voltage, frequency fluctuations and the injection of harmonics into the grid.

Project Objectives

This project was mainly concerned with the voltage and frequency fluctuations due to high RES penetrations in order to keep the grid voltage as stable as possible

Critical loads are loads that cannot withstand variations on their supply voltage. Thus a constant 230V rms (single phase) is required in order to ensure that no damage is occurred. On the other hand, non-critical loads can withstand tolerances in their supply voltages without affecting the operation or performance of the equipment.

Project Methodologies

There are various compensators which can be used in order to control these aforementioned power quality issues. The main types consist of statcoms, static var compensators and energy storage systems. Statcoms and static var compensators can only control reactive power while on the other hand control of both real and reactive powers can be achieved by means of an energy storage system although the latter tend to be quite bulky and expensive. A new concept is introduced in order to compensate for these issues, this is the smart load.

These electric spring systems (ES) are divided into three types. The first type consists of a DC link capacitor as a storage system while the second type of ES uses a battery instead of the capacitor on the other hand the last type which is used throughout this project replaces the battery with a back to back converter. In this project the ES with a back to back converter topology was used.

Results and Achievements

This project serves as proof of concept of an ES system operating with a back to back converter in various voltage scenarios due to local RES generation. The ES was modelled, designed and simulated by means of Simulink and Plecs.

In order to verify the designed system, various tests were carried out. The system was tested for each state of operation including, Over-voltage, Under-voltage, stable state. The system performed as expected, the voltage on the critical load was kept stable at 325V peak. The DC link voltage was stable at 400V and the ES voltage varied accordingly with the non-critical voltage in order to maintain control of the critical voltage.

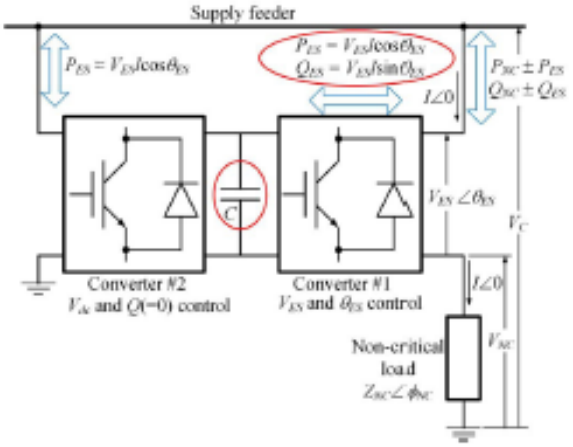

Figure 1: Simulink Model designed

Monitoring and Simulation of Power Quality of PV Inverters

Student: Claire Grima / Supervisor: Dr Ing. John Licari / Co-Supervisor: Prof. Ing. Cyril Spiteri Staines

Introduction

People are becoming more concerned about the environment and the concept of renewable energy sources is deeply researched. Malta's PV Systems uptake has remarkably increased throughout the past four years. Even though it is a greener solution than burning of fossil fuels and usage of steam turbines to produce electrical energy, it might be negatively affecting the electrical grid.

Project Objectives

The objectives of this project were to conduct Power Quality data logging of several single- and three- phase PV systems and perform analysis of the data, develop both types of inverters on MATLAB Simulink ® and assess the effect of different PV penetration levels on the grid.

Project Methodologies

Power Quality data was gathered for 7 different systems, four were three-phase systems and three were single-phase systems. The data logging was repeated for two of the systems in a different season. The harmonic profile of each brand was analysed. The developed models on MATLAB Simulink were tuned to match the performance of commercially available inverters. With these profiles, the effect of different PV Penetration levels of single-phase systems on the low voltage network were simulated and analysed.

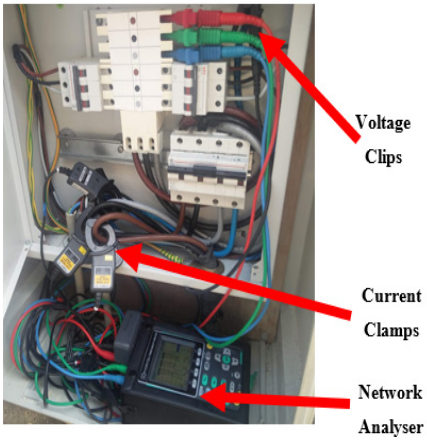

Figure 1: Three-Phase Connection of Network Analyzer

Results and Achievements

From the harmonic results obtained it was concluded that different brands have different architectures and harmonic profiles. During sunrise, sunset and cloud cover, harmonic currents with respect to the fundamental increase in relative harmonic content. The practical results obtained were used to tune the modelled inverters and assess their effect on the network. The harmonics generated during different times were simulated in 4 different scenarios with a typical loading of the network. As expected from literature, voltage rise was observed. Voltage rise got worse when PV penetration was concentrated on a cluster furthest away from the substation. Harmonic content is prevalent during sunrise and sunset in the network infrastructure but may be affecting more the network operators rather than the end-consumers.

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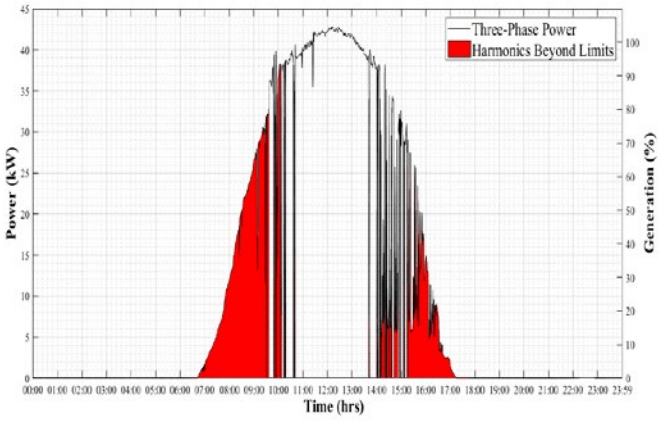

Figure 2: Typical PV generation curve with harmonic shading

Study and Implementation of Home Automation System with Energy Monitoring

Student: Miguel Mizzi / Supervisor: Prof. Cyril Spiteri Staines / Co-Supervisor: Dr Alexander Micallef

Introduction

Home automation is about "bringing life" into various devices installed in a building or apartment, giving home owners the access to control these devices using central hubs or smartphones. Home automations systems are quite common in both residential, commercial and industrial applications. The management and control of residential or commercial devices is relatively established but still lacks in the proper management of energy flows. Research carried throughout the years has shown that residential energy consumers waste almost 41% of energy supplied to their homes [1]. Recently, home owners have become more aware of energy consumption and had started investing in energy monitoring systems to observe energy consumption and reduce energy waste. A real time power meter is an electronic device that is used to record the electric power being consumed by devices. A key benefit of energy monitoring system is that it provides home owners the necessary knowledge and understandings of how energy is being consumed.

Project Objectives

The main objectives covered in this project is the design and construction of a single-phase electrical energy monitoring system compatible with the KNX system. Furthermore, the project also developed a graphical user interface (GUI) for energy monitoring and to provide a platform-based control of electrical equipment.

Project Methodologies

In this project, an accurate power meter is built using the instantaneous power calculation method;

$$p(t) = V_m I_m \cos(\omega t + \theta_v) \cos(\omega t + \theta_i)$$

A voltage and current sensing circuit was designed and constructed to sample the voltage and current of a connected load. These are then sampled using the KAIstack development board which carries out the power calculation and communication with the KNX system. The rms voltage, rms current, power, power factor and phase angle are transmitted in real-time to the KNX system and are displayed on a graphical user interface (GUI) over an HTTP connection. Thanks to the HTTP connection, users can easily control and monitor data from a tablet, computer, smartphone or any device which have access to Wi-Fi.

Results and Achievements

This project supports development of a low budget smart KNX power meter capable of measuring rms voltage; rms current; power; power factor and phase angle. The developed meter was targeted to be used on single phase electrical appliances. The designed power meter can accurately measure true power regardless of the type of connected load being resistive, inductive, capacitive or a mixture of all. The designed KNX power meter, is aimed to set the basis for a system whereby energy management algorithms can be applied to increase energy efficiency inside a domestic application.

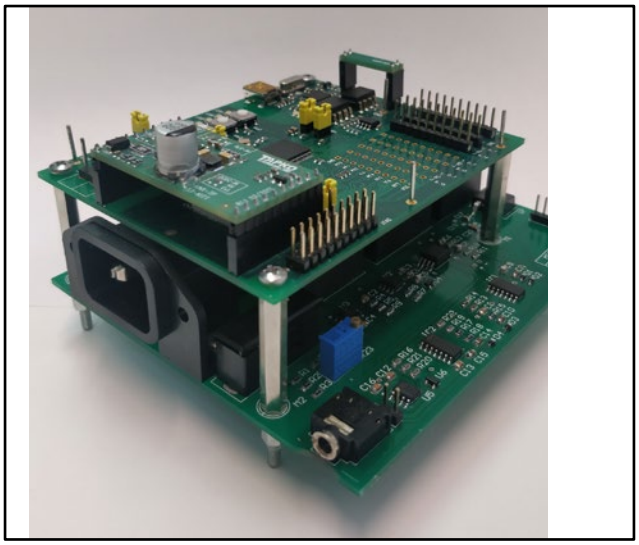

Figure 1: KNX Real Time Power Meter

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Implementation and Testing of Paralleled Droop Controlled Three Phase Inverters

Student: Neil Mizzi / Supervisor: Dr Alexander Micallef / Co-Supervisor: Prof. Ing. Maurice Apap

Introduction

The main grid is no exception to improvement and evolution. The grid's main function is to transmit and distribute electricity from both the suppliers to the consumers and vice versa. The latter has become more prominent, such as with excess solar power generation in Malta. These last ten years, power engineers have researched and developed different types of microgrids to facilitate the integration of distributed energy resources (DERs). These microgrids are able to interconnect together and to the main grid, increasing the reliability and efficiency of the latter. Microgrids can perform in conjunction with the main grid (grid-tied mode) or autonomously (islanded-mode). Furthermore, they employ several power electronic converters (PECs) in order to connect the DERs and certain local loads to its main bus. These PECs can be controlled via various load sharing techniques, one of which is droop control.

Project Objectives

The main focus of this dissertation is the study of droop controlled three-phase inverters and their paralleling to form an islanded AC microgrid. As part of the study, a lab-based prototype with two parallel inverters capable of sharing the load connected to the microgrid was designed, implemented and tested.

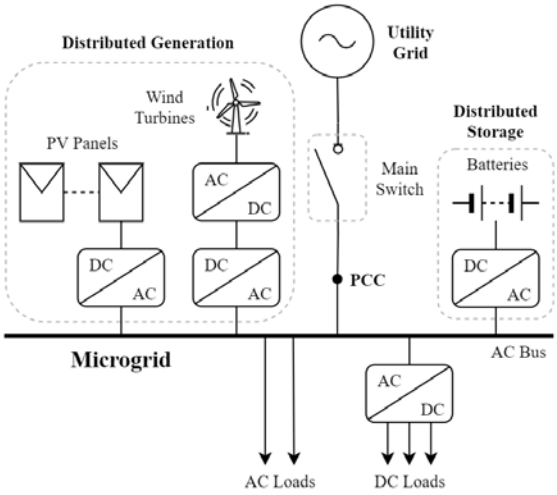

Figure 1: Typical example of an AC microgrid structure

Project Methodologies

The project may be sub-divided into four main stages. Firstly, *Stage 1* is concerned with the system modelling and design of the droop controlled inverters. This also includes the ability of one inverter to synchronise with the microgrid voltage and to connect once the synchronization criteria have been met. Consecutively *Stage 2* consists of the implementation of the complete system model with the use Simulink and PLECS in order to verify the correct operation of the designed control loops. In *Stage 3*, the hardware prototypes' power circuitry and PCBs required for sensing and interfacing with the three-phase inverters were implemented. Furthermore, the control algorithms developed in stage 1 were programmed in the respective microcontrollers of both inverters. Finally, *Stage 4* encompassed the testing and analysis of the individual inverter prototypes' ability to provide power to the local load, as well as their load sharing capabilities when connected in parallel.

Results and Achievements

Paralleling between two three-phase inverters utilising hierarchical control was successfully achieved in the laboratory. Testing and analysis of the inverters' ability to separately supply power to the local load and share when in parallel was also conducted.

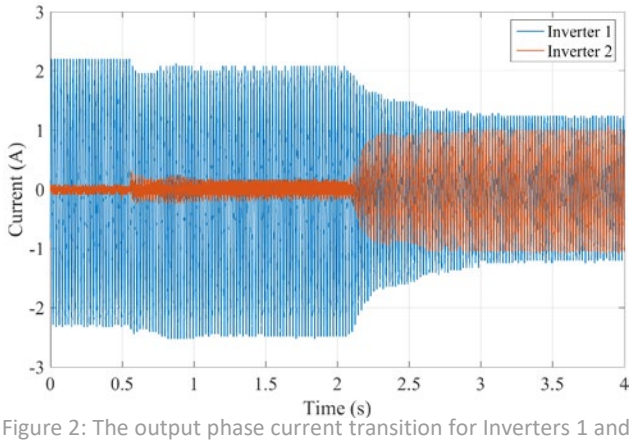

Figure 2: The output phase current transition for Inverters 1 and 2 upon paralleling, when connected to a balanced R-load of *19.84Ω*. Prior to *0.57s,* only one inverter is connected to the load. At *0.57s,* a 2nd inverter is paralleled. At *2.07s,* the frequency of the 2nd inverter is allowed to vary and active load sharing is initiated

Commissioning of a Wireless Power Transfer System

Student: Matthew Pisani / Supervisor: Dr Ing. Reiko Raute

Introduction

Throughout the last century, wireless power transmission has gained interest from many individuals and institutions, giving them the opportunity to apply their field of expertise in this unique power transmission. In fact, multiple standard bodies like for example QI & Rezence are available today and they help define the electrical parameters and communication interface for both the transmitter and the receiver. Currently, data transfer is already being done in a wireless manner, but a more efficient method is needed to purely charge the device wirelessly without the use of any physical charging port. Even though the most common application is the charging of portable devices, this method of transmission can be also used for a wide range of small appliances and for electric vehicles which provide an increase of convenience and great level of protection from electrical power.

Project Objectives

This dissertation presents a thorough analysis in the operation of a wireless power transfer system. Hence, this includes both the power transfer between the transmitter and the receiver as well as how they communicate between each other and deliver the needed power to the load with utmost efficiency.

Project Methodologies

This paper initiates with the analysis of the STEVAL-ISB042V1 (receiver) and STEVAL-ISB044V1 (transmitter) evaluation boards. The power electronics in the evaluation boards have been inspected and a complete testing procedure was performed. The testing procedure was designed to ensure that each block could be sufficiently tested to ensure its role in the entire system design. The specialized software for both the transmitter (STWBCGUI) and receiver (ISB042GUI) was used to help monitoring important information such as power delivered and ADC measured values. The Software was used to conduct specific tests as to get a full evaluation of the results which was required to achieve.

Results and Achievements

The results achieved during the testing of the system confirm that the goals of the dissertation have been met. From the obtained results, it was shown that each tested subsystem of the transmitter and the receiver such as the DC supply voltage was validated to work in accordance to the operational requirements of the Qi standard. Furthermore, the investigation in relation with both evaluation boards has been conducted. This involved the communication interface which uses both Amplitude Modulation and Frequency Modulation to transmit the data bi-directionally between the two boards. Moreover, the detection of foreign metal objects between the two coils have been investigated since such objects can alter the operation of the system and could potentially lead to temperature rise if not dealt with. Other important tests were also conducted to obtain key factors such as the efficiency of the power transferred as it helped further test the boards' performance.

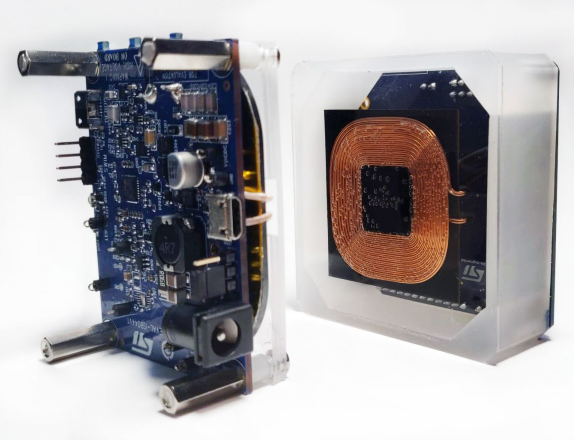

Figure 1: Transmitter (Left) and Receiver (Right) evaluation boards

References

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Transformerless Inverters for Grid-Connected Photovoltaic Systems

Student: Mario Said / Supervisor: Dr Alexander Micallef / Co-Supervisor: Prof. Maurice Apap

Introduction

Nowadays, solar energy generation has gained significant popularity in light of the increasing energy demands. Transformerless inverters have become an important alternative to interface photovoltaics with the grid since they are more reliable and have higher efficiencies of up to 98%. However, they are prone to leakage currents and their use is regulated by the local grid codes of individual countries.

Project Objectives

This project is concerned with the analysis and comparison of the operation of the H4, H5 and HERIC transformerless inverter topologies. The main objective of the project is the design, modelling and simulation of a 2.5kVA single phase inverter implemented with these three topologies. Simulations results will include a comparison of efficiencies at different power injection levels; common mode voltages and leakage currents.

Project Methodologies

The initial phase was to design and simulate the Photovoltaic Array which was going to serve as the DC source for the inverters. The second phase was to design and simulate the inverter topologies under different DC input power levels. In order to perform these tests, control loops for the grid connected operation of the inverter were also designed and modelled. Third stage was to investigate their Common Mode Voltage and leakage currents. In order to achieve these tests, stray capacitances were used at the input side of the inverter.
Finally, the simulation of the inverters including switching and conduction losses of the IGBTs and diodes was considered in order to determine the efficiency curves of the three topologies. In addition, the European Efficiency was also considered which takes into consideration the operation of the PV array.

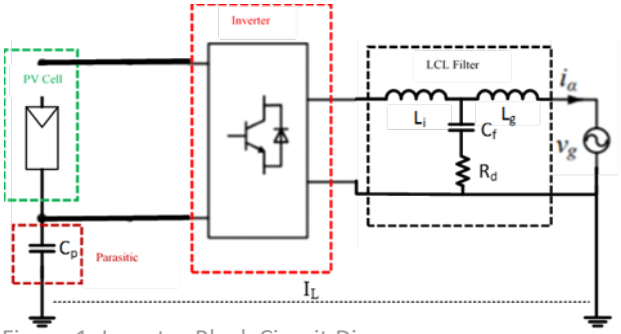

Figure 1: Inverter Block Circuit Diagram

Results and Achievements

The output power results for each topology were carried under different DC input power levels, which were then analyzed and compared with each other. The HERIC inverter had the highest output power when compared with the H4 and the H5 inverters. The losses of each converter is affected by the modulation scheme and the number of power semiconductor devices in the inverter. Furthermore, the efficiency results such as the maximum efficiency and the inverters efficiency of the H4, H5 and HERIC inverter were determined as can be seen from Figure 2. The maximum inverter efficiency of the H4 inverter is 96.68%, the H5 inverter is 96.88% and the HERIC inverter is 97.24%. While the European Efficiency of the H4, H5 and HERIC inverters are 96.09%, 96.42% and 96.79% respectively.

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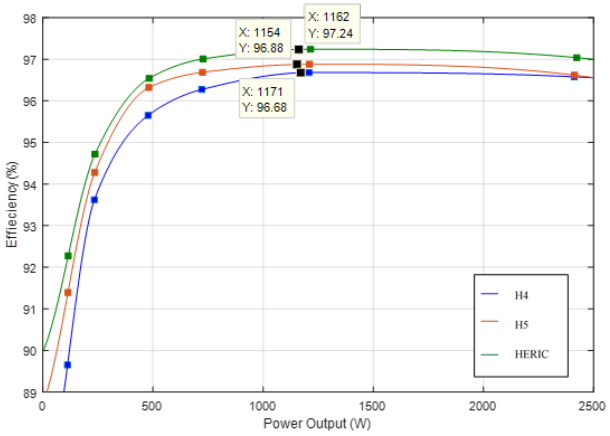

Figure 2: Inverter Efficiency Curve

Design of a Thyristor Controlled Rectifier for a DC Motor

Student: Matthew Schembri / Supervisor: Dr Ing. Reiko Raute

Introduction

Thyristor multi-pulse rectifiers are widely used in industrial applications, particularly for DC motor drives with variable speed control. For such converters, attaining variable output voltage with a DC current involves the incorporation of phase angle control which utilizes six silicon controlled rectifiers (SCRs) connected in a bridge configuration. Phase angle control is achieved by varying the triggering angle of the thyristor firing and therefore collectively controlling the conduction time of each device.

Project Objectives

The main objective for this project was to design and build a thyristor controlled rectifier for a variable speed motor. The triggering of the SCRs at precise instances requires synchronization to the AC grid. Thus an AC voltage zero crossing detection algorithm was implemented on a microcontroller. The developed product was to be tested by operating the converter at different firing angles, as well as connecting different loads to the motor.

Project Methodologies

The complete system revolves around a microcontroller based approach, where the embedded program is responsible for; running a zero crossing detection algorithm upon the data acquired, perform all necessary calculation for thyristor gate triggering, sending triggering pulses and also send measurement readings to MATLAB.

As to acquire and store readings on the microcontroller, appropriate signal conditioning for the required input and output readings was designed. In succession, this data was processed as to be used by the input AC voltage zero crossing detection algorithm and thus establishing the location of such points. After determining the position of a zero crossing, the microcontroller firmware processes the firing angle set by the user and initiates a trail of pulses. Furthermore, a pulse transformer gate triggering circuit with the capability of supplying enough current to activate the SCR was also included in the circuit.

To perform appropriate testing of the six-pulse converter at different firing angles, a synchronous generator connected to a load bank was coupled to the motor.

Results and Achievements

Testing of the final product revealed satisfactory results and all elements within the system proved to be working correctly. The converter output DC voltage showed that the thyristors are being activated at accurate firing times. Adjusting the firing angle by means of the designed controller brought about a change in the output average voltage and also a variation in the speed of the motor.

Decreasing the load connected to the synchronous generator at lower firing angles, resulted in a discontinuous current which occurs when the SCRs stop conducting due to the armature current falling below their rated holding current. Furthermore, loading the synchronous generator caused more current to be drawn within the armature windings, which caused a drop in motor speed and an increase in torque.

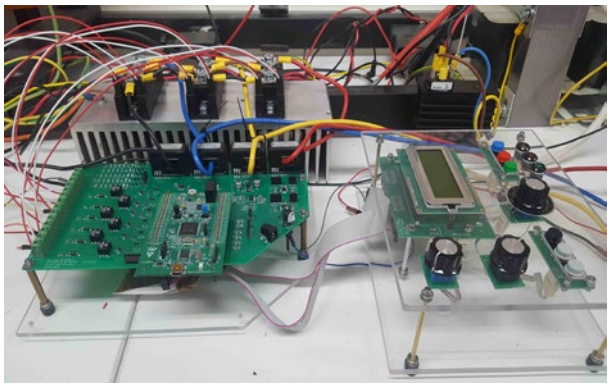

Figure 1: Thyristor controlled rectifier and controller

Vision-based Iris and Pupil Detection

Student: Diana Antic / Supervisor: Prof Ing. Kenneth Camilleri / Co-Supervisor: Dr Ing. Stefania Cristina

Introduction

Vision-based iris/pupil localisation is a necessary component in robust eye-gaze tracking as well as biometrics. However, this localisation becomes challenging when hindering situations are involved. Such cases include uneven lighting conditions containing specular reflections and shadows as well as low resolution images, non-frontal head poses and iris occlusion by the eyelids.

Project Objectives

The objective of this project entails an extensive review of the available literatures pertaining to iris/pupil centre localisation to identify the state-of- the- art. The preferred methods are implemented using MATLAB and their performance is tested and compared to determine the best method. Figure 1 illustrates the pipeline of the implementation.

Project Methodologies

The methods chosen from the literature review are categorised into shape-, feature-, and appearance-based approaches and described as follows:

- Method A: The appearance-based Bayes' classifier [1] classifies pixels as either iris/pupil or skin/sclera, based on the red-channel intensity values of the pixels around the eye. This process is based on calculating a ratio which considers the probability of a pixel belonging to the iris, to that of a pixel which does not belong to the iris. If this ratio exceeds a threshold, the pixel is classified as an iris pixel. The resulting binary image typically contains a circular blob which represents the iris. The centre of mass of this blob indicates the iris centre.
- Method B: The shape-based Circular Hough Transform is performed after Canny edge detection of the result of the Bayes' classification of Method A. The centre of the detected circle represents the iris centre.
- Method C: The feature-based approach of Fast Radial Symmetry [2] is applied to the grayscale eye images. The transform detects points having the highest radial symmetry, resulting in a binary image with a blob located at the iris centre whose centre of mass is the iris centre.
- Method D: Specular reflections within the iris may hinder the iris centre localisation process.

  A modified bilinear interpolation method [3] was implemented to fill in the reflections with the appropriate intensity values.
- Methods A to C were then tested again with this alteration.

Results and Achievements

All the methods produced relatively accurate results, with the Fast Radial Symmetry Transform together with the reflection removal yielding the best results, represented by an average mean square error of 5.16.

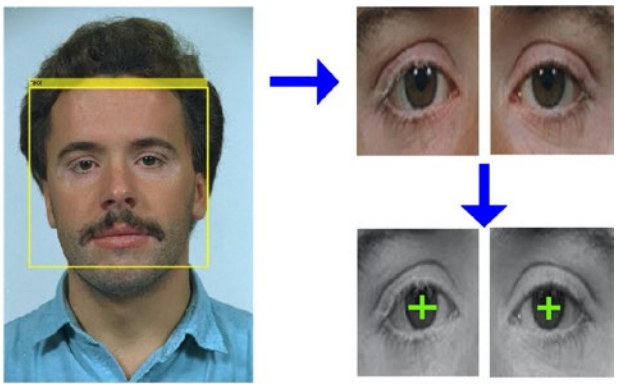

Figure 1: The figure depicts the typical flow of the algorithms: face detection is carried out first, followed by eye detection and, finally, iris centre localisation based on the approaches described

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Natural Language Processing for Sentiment Analysis

Student: Luke Camilleri / Supervisor: Dr Kenneth Scerri

Introduction

In today's business and technology world, data analytics has become indispensable, with technologies such as sentiment analysis allowing companies and corporations to gain key insights about consumer perceptions and options that can help shape effective strategic and marketing decisions.

Sentiment analysis can be defined as the process of automatically extracting an opinion about a specific topic from the written language.

Project Objectives

The aim of this project was to design and implement a sentiment analysis algorithm capable of extracting sentiment orientation from user generated tweets through the use of suitable natural language processing techniques.

Project Methodologies

In order to implement a sentiment analysis algorithm, the raw tweets extracted from twitter were pre-processed removing any irrelevant information such as hashtags and stop words. Then important information relevant to the sentiment analysis task was extracted from the processed tweets using word vectors that represent the semantic relationships between words. These word vectors were then used as the inputs to the sentiment classifier which was capable of classifying the input tweets in terms of positive, negative or neutral sentiment polarity with respect to a specific topic as shown in Figure 1.

Given the successes being reported in literature of using deep neural networks for sentiment analysis, these were used to implement the sentiment classifier within this dissertation. Multiple deep learning classifiers mainly, feedforward, convolutional and recurrent neural networks were trained and evaluated on two annotated datasets related to the topics of climate change and technology products respectively. The performances of these deep learning models were compared and contrasted with commercially available sentiment analysis tools and contemporary literature in order to evaluate their potential as sentiment analysis algorithms.

Results and Achievements

The performance of the implemented deep learning models compares favorably with contemporary approaches for sentiment analysis of tweets and commercial and freely available tools highlighting the potential of deep learning models when applied to sentiment analysis tasks [1] [2]. The results also underlined the variance in performance of a model when applied to different topic domains, with models performing better when applied to the technology dataset. This implies that it is not easy to extract sentiment from domains that lack clear sentiment indicators and contain subtle nuances such as the climate change dataset, while performing better on datasets that are more cut and dry.

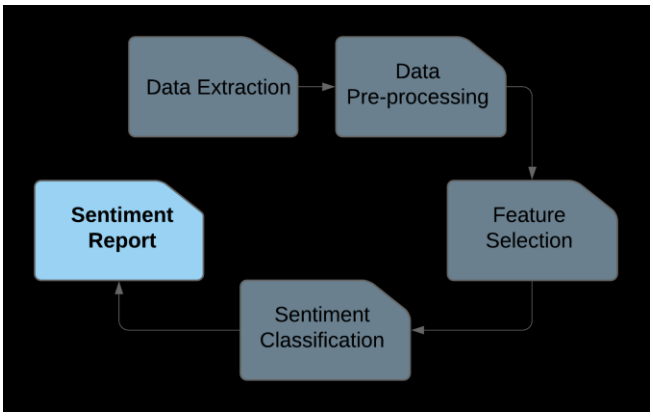

Figure 1: The process of Sentiment Analysis

References

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[2] A. Abbasi, A. Hassan and M. Dhar , "Benchmarking Twitter Sentiment Analysis Tools," in *9th Language Resources and Evaluation Conference*, 2014.

Automation Enforcement on Priority Lanes

Student: Caroline Debattista / Supervisor: Dr Kenneth Scerri / Co-Supervisor: Dr Alexandra Bonnici

Introduction

This project aims to tackle the enforcement on priority lanes. Unfortunately, this lane is continuously being illegally used by private vehicles. Current Maltese Regulations, reserve this lane to motorcycles, LPG cars, electrical vehicles, route buses, passenger transport vehicle, taxis, pedal cycles, vehicles on priority duties and vehicles carrying more than three people, including the driver[1]. Automated Enforcement Systems (AESs) are one possible solution to encourage drivers to follow the road regulations. Increasing enforcement in this field, will motivate more people to observe the laws and hence decrease traffic on these lanes.

Project Objectives

The final objective of this project is to detect and export a short clip of the scene, showing any private vehicle on the priority lane that does not fall in the aforementioned categories. Automatic number plate recognition is then applied to identify the infringing vehicles.

Project Methodologies

The implementation of this project was divided into four main categories: Vehicle detection, vehicle tracking, automatic number plate recognition and exporting a video of the scene. All this was completed using image processing and video vision techniques.

Vehicle detection was implemented using the algorithm of background subtraction to detect a foreground. An area threshold with respect to the position of the car was then used to classify the object as a vehicle

Vehicle tracking was then performed using the KLT algorithm[2], where corner points on the object were first extracted. The new location on the next video frame was estimated by evaluating the velocity of the vehicle.

Automatic number plate recognition (ANPR) was then applied. The first step was to locate the number plate in an image and with the aid of a manually trained optical character recognition (OCR) function, the characters on the number plate were recognized.

Finally, a video clip showing the vehicle infringing the law was exported in order to send it to the enforcement unit for further verification.

Results and Achievements

The result obtained when the algorithm was tested for vehicle detection in different scenarios gave a 95% successful rate. Number plate location and recognition was also tested under the same conditions and a successful rate of 90% and 84% respectively was achieved.

This shows that the aim of the project to detect a vehicle worked at most times of the day and hence it is prone to light changes. In addition, the ANPR function also gave a high successful rate in both locating and recognizing the characters.

Figure 1: Set-up used to collect data

References

[1] Traffic signs and carriageway markings regulations. 29thAugust 1969

[2] Bruce D. Lucas, T. K. An iterative image registration technique with an application to stereo vision, 1981.

Vibration Control in Flexible Systems with Multiple Modes

Student: Rebecca Spiteri / Supervisor: Dr Ing. Marvin Bugeja

Introduction

In the Robotic industry one typically attempts to reduce the robotic manipulator's weight and at the same time increase its speed for a faster response. Flexible structures are thus becoming popular by reason of utilizing lightweight materials that enable higher accelerations and velocities. However while lightweight structures are desirable, high performance is mandatory, and in such a way significant vibration problems can be created.

Project Objectives

The aim of this project is to address vibration problems in multiple mode systems that is, systems that employ more than one flexible structure with a different mode of vibration. Naturally, it is also required that high precision and accuracy are attained in the shortest duration possible.[3]

Project Methodologies

Feed-forward or feedback control techniques can be utilized in order to suppress the undesirable vibrations in a flexible structure. One of the most effective and popular feed-forward computer controlled technique is *Input shaping* which makes use of the constructive cancellation principle.[1] Input shaping entails convolving a sequence of impulses with a desired base command, which in turn creates a self-cancelling command signal. Considering a number of Input Shapers, a realistic simulation environment was used to model the flexible system considered in this project along with simulations of the input shaped commands. The shapers were then implemented and tested on the real physical set-up shown in Figure 1 and their effectiveness was validated and analysed experimentally.

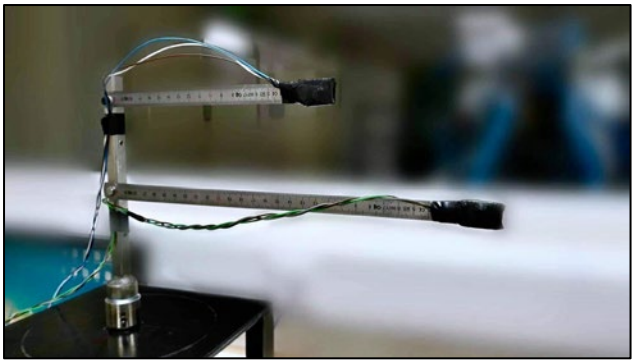

Figure 1: Multiple flexible link experimental set-up

Results and Achievements

A number of different feed-forward input shaping strategies were implemented and tested using both simulations and real experiments. Those input shapers that consider both flexible links in the design, are the most effective in reducing undesirable vibration in both links as illustrated in Figure 2. Another solution is that of using an S-curve command convolved with an input shaper designed for one flexible link only, which proved to be very effective in cancelling unwanted vibrations in both links as well. This project addresses vibration related issues related to multiple flexible structures within systems. Multiple flexible structure systems are widely used in industry, such as gantry cranes, manufacturing equipment and space borne robotic systems.[2]

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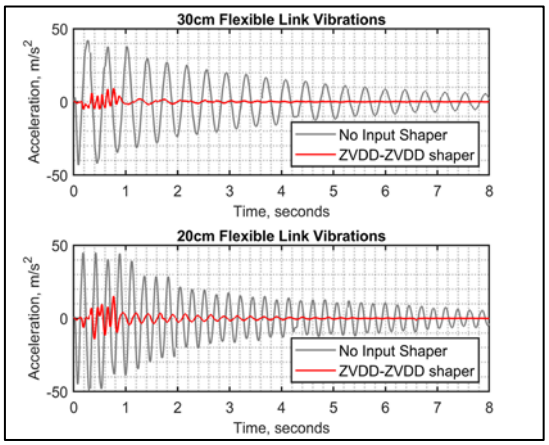

Figure 2: Residual vibration of the two flexible links when a shaped command based on the two links was applied at the system's input

Automated Page Turner for Musicians

Student: Andre' Tabone / Supervisor: Dr Ing. Alexandra Bonnici / Co-Supervisor: Dr Ing. Stefania Cristina

Introduction

Page turning has at some point frustrated every musician by interrupting his/her performance to manually turn the physical page. During a performance, the pianist would be using both hands to play the instrument and so, turning the page means that the pianist must quickly lift at least one hand from the keyboard to perform such a task. This may lead to various types of performance errors and every musician has to learn and develop his/her own method to overcome this difficulty, in fact, good music book editors edit the music such that there is a long note, or a pause towards the end of the page, making it easier for the performer to turn the page.

Project Objectives

To develop an automated page turner that tracks the user's progression on the music score using an eye gaze tracking system.

Project Methodologies

In order to successfully design and implement the fully automated page turner, it was first sought to understand how the musician interacts with the score. This led to a data collection and processing stage on which the design criteria of the page turning application were set.

Future improvements on this application are planned will use the camera of a tablet to record eye gaze and the tablet screen to display music. Keeping this in mind, the score was divided into pages with only two lines of music. Under such conditions, half-page turns are implemented replacing individual lines of music. This format of music was presented to the test subjects, whose eye gaze and performance were recorded using the eye gaze sensor system and a digital piano respectively.

From this preliminary study it was concluded that sensor deviations and instances where the musician looks down at the keyboard cause the tracker to lose track of the eyes and return redundant or zero values. Hence, the system was to include a Kalman filter to smooth out such readings. The sensitive areas on the script were found by using image processing to detect the bar lines such that an understanding of the temporal structure of the script

The values obtained from the eye gaze tracker were of a different resolution than the information obtained from the score processing. The tracker system returned coordinates ranging throughout the screen, whilst the image values were based inside a figure, so a scaling and compensating function was required to ensure the values were relevant to each other. Based on this information, areas of interest were placed on each page which build a population proportional to the number of eye gaze coordinates landing in that area.

These functions were tested separately and implemented into a single application using Matlab's GUIDE environment.

Results and Achievements

Initially the page turning application was tested out resulting in a minor number of redundant page turns but upon inspection, they were all linked to the same series of events of the musician's performance. Tuning the sizes of the sensitive areas and the resistance towards triggering page turns, a better system was achieved. Glances at the keyboard were also tackled by switching to a model input when the tracker loses track of the eyes. The result was a page turner that suffered only from delayed page turns and with no early page turns that would cause loss of information by replacing the current line being performed.

Figure 1: Set up of the eye gaze tracking system for the automated page turning application

IoT-Based Traffic Light Control

Student: Matthew Zammit / Supervisor: Dr Kenneth Scerri

Introduction

Traffic in Malta is a problem felt nationwide. Research has shown, daily commuters on the Birkirkara bypass spend an average of 66 hours a year in a non-moving state on this road alone [1]. Furthermore, congestion increases pollution, which introduces several health risks, not to mention the negative impact it has on the environment [2].

Project Objectives

This thesis examines the use of cloud-integrated Traffic Lights System (TLS) and machine learning as part of the solution for the ever-increasing traffic problem in Malta, specifically congestion caused by statically timed TLSs. The university's own TLS is used as test junction throughout this project.

Project Methodologies

This thesis outlines the development of a traffic controller which works in conjunction with induction loop sensors to upload traffic information, including vehicle classification, to a centralized cloud server. This server in turn processes this information and displays the real time traffic data on a newly developed web application.

On another note, recent advancements in machine learning have spurred above human level performance in many games known to be difficult to master. This thesis extends the application of deep reinforcement learning to traffic signal control. A simulation of the test junction was developed, using Simulation of Urban Mobility (SUMO), as a means to compare the current implementation with the novel control method.

Results and Achievements

A high vehicle detection rate is of significant importance in such an application especially in low traffic densities as it causes catastrophically large waiting times for undetected vehicles. The induction loop sensors were deployed on an actual road for a test period of 1 hour. The result achieved is a 100% detection rate and classification accuracy over a sample of 29 vehicles in total.

Testing the machine learning model resulted in an average waiting time reduction of 29.3 per cent when tested over congestion rates of 50, 100 and 150 vehicles/hour. The model is also capable of achieving waiting time reductions over 50 per cent when tested for peak traffic times, i.e. vehicle occurrence on any of the two lanes occurs at a probability of 80 per cent or higher than on the other lane.

References

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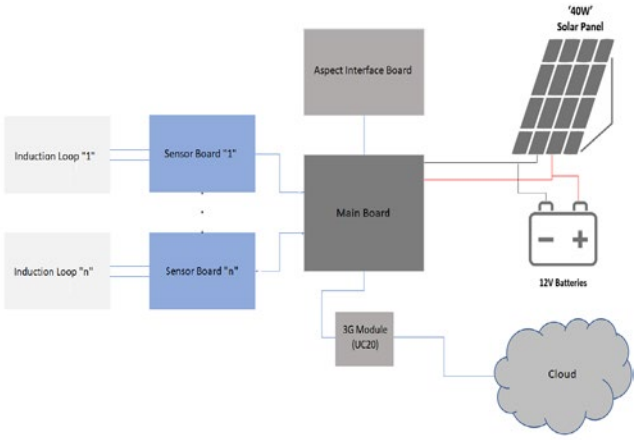

Figure 1: Overview of whole system implementation

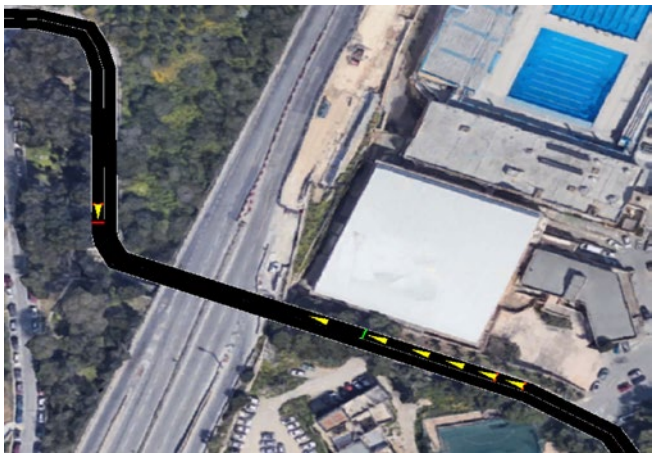

Figure 2: University junction simulated in SUMO

FINAL YEAR ENGINEERING PROJECTS

MECHANICAL STREAM

Development of a Knowledge Management Framework for Product Development Knowledge Reuse

Student: Nezar Abouaisha / Supervisor: Dr Ing. Joseph Zammit

Introduction

One of the issues companies face in product development (PD) is the lack of knowledge reuse from previous projects or lesson learned from problems faced in the past [1]. A way to address the issue is to follow an Advanced Product Quality Planning (**APQP**) process. APQP is a structured methodology that can document, plan and manage knowledge in PD. It is aimed to fulfil customer requirements and ensures communication and collaboration between engineering activities in a structured manner.

Project Objectives

This research project will focus on investigating the issues related to PD and manufacturing industry, APQP and knowledge management (KM) within industries, in order to develop a cost-effective framework to capture and reuse PD knowledge created from an APQP process. This aims to simplify the capturing, storing, and sharing of knowledge within an organisation.

Project Methodologies

The methodology of this study was divided into four phases. In phase 1, an extensive literature review on the state of art of the subject area was conducted in order to identify the key elements and gaps of KM within new product development (NPD) and APQP.
Phase 2, an industrial investigation study was carried out. This involved developing a questionnaire to explore the current AS-IS state of the use of KM and APQP practices within PD and manufacturing companies in Malta, addressing the gaps found from the literature review while also highlighting the needs from local industry.
In phase 3, a proposed KM framework was created, composed of four quadrants as shown in figure 1. This provides a guideline on the method that was used to create a form from an APQP documentation process, thus, it can be used for PD knowledge reuse.
Phase 4 involved a validation exercise that was utilized to evaluate the functionality of the developed KM framework. This was performed in order to confirm that the developed framework was relevant to companies and full-fills their requirements in PD knowledge reuse.

Results and Achievements

From the industrial investigation, it was concluded that a structured framework that can guide engineers to manage knowledge created from an APQP documentation process should be developed, in order to provide value to an organisation.

The created framework is made up of four quadrants: **Creation, Classification, Capture and Sharing**. It begins with the creation stage, where an APQP document was selected and created. In the second quadrant, an APQP classification was implemented. Where information was extracted, analyzed from an APQP documents, and tagged in a final APQP form. Suggestions to search, capture, store and share information contained in the created form were implemented and discussed.

From the validation exercise, it was concluded that the framework meets companies' expectations; however, this can be expanded or fine-tuned more specifically to meet different industry requirements and regulations. Also, an ICT tool should be developed in order to make this as future work as the next step make the developed theory into practice.

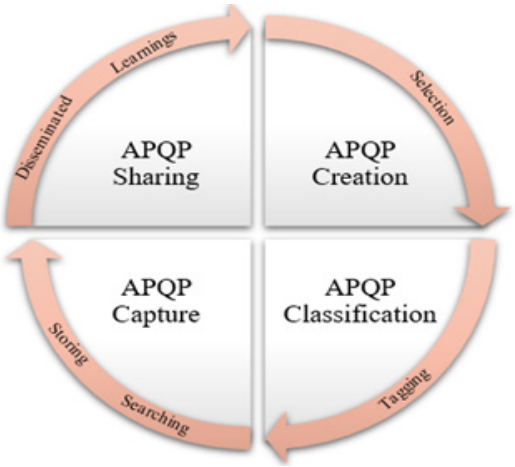

Figure 1: Development of KM framework

References

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Sustainability Analysis of a Plastic Injection Moulding Heat Recovery Device

Student: Mohammed Alkharusi / Supervisor: Dr Ing. Paul Refalo / Co-Supervisor: Dr Ing. Arif Rochman

Introduction

Sustainability has become a priority in the industrial sector. The energy consumption and the resulting carbon footprint by countries and industries need to be reduced. Therefore, ways of achieving the best methods to achieve sustainability for different operations has become a priority [1].

Project Objectives

The objective behind this project is to investigate the performance of a heat recovery device which extracts heat from an injection mounding machine and uses it to preheat material. The drying effectiveness of the drier unit for different materials was also investigated.

Project Methodology

The process of achieving this was by conducting various tests to measure temperature, humidity, moisture removal and energy consumption. Preliminary tests were carried out to see what improvements could be done to improve the performance of the prototype.

Following the modifications, the prototype device was paired to a BOY 22E hydraulic injection moulding machine and measurements were used to assess the feasibility of the prototype device to replace the chiller and the drier, and hence act as a heat recovery device.

The prototype device was operated as a chiller unit only, and as both as a chiller and a drier. When the prototype device worked as both, drying results were taken for ABS, PLA, and PA6 for 1, 3, and 6 hours of drying successively.

The prototype device was equipped with 7 temperature sensors, 3 humidity sensors, and a power monitor, while the injection moulding machine has a power monitoring device to measure its energy consumption and compare it with the prototype device.

After analyzing all the results, a room for improvement and future work was identified.

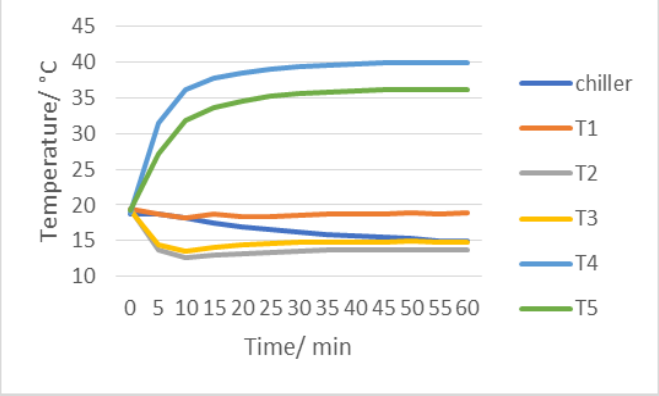

Figure 1: Temperature Vs. Time graph

Results and Achievements

Temperature results of the prototype device when used as both a chiller and a drier unit is shown in Figure 1. The inlet temperature does not change which is T1, while T2, and T3 reduce in temperature since the air is being cooled and dehumidified using the evaporator. T4 and T5 are the temperature that are used to dry the granules, thus, they increased since they are placed after the condenser. The prototype device has shown better results when it worked as a chiller unit only. The drying temperature increased to about 46 °C.

ABS granules were drying most when dried for 1 hour at 40 °C, while PA6 have shown that it dries more at the same temperature in 3, and 6 hours of drying. The 6 hours drying test is shown in Figure 2, which shows that PA6 dries more than ABS and PLA. Also, temperature at the tank increased when injection moulding production is occurring, therefore, the test had to be stopped.

Overall, further modifications should be done to the prototype device in order to replace the old chiller and drier.

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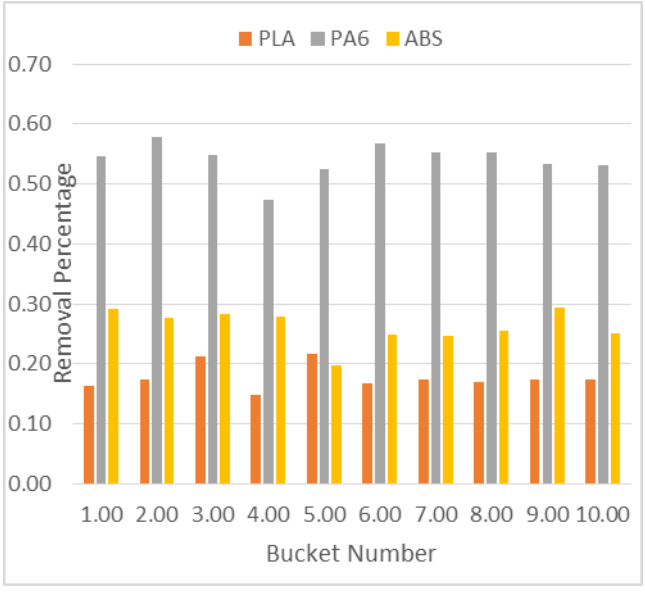

Figure 2: Moisture removal percentage for 6 hours for drying

Design Optimisation of a Mass Produced Smart Toy Device

Student: Yaqoob Al-Namani / Supervisor: Dr Ing. Philip Farrugia / Co-Supervisor: Mr Emanuel Balzan

Introduction

Smart toys are becoming popular as they provide a more engaging learning and playing experience for children. For this reason, smart toys are also being used for therapeutic purposes, such as for speech and language therapy. 'Olly Speaks' (see Figure 1) is a smart toy aimed for such a therapy. It is being developed at the University of Malta in collaboration with Flying Squirrel Games, as part of the SPEECHIE project.

Project Objectives

The overall aim of this project is optimise the design of the back housing, such that its manufacturing by plastic injection moulding, is facilitated. Focus has been placed on how an alternative means of attaching the textile-based hair (see Figure 1) with the housing can be designed, in order to eliminate form features, which would otherwise increase the moulding costs.

Project Methodologies

The methodology used in this project is based on the basic design cycle. A literature of the injection moulding terminologies and equipment was first carried out to provide a clear understanding of the problem.

Furthermore, the current design was analysed via mould flow simulations (see Figure 2). This led to the generation of concepts on news means of attachment of the textile-based hair with the housing. A decision matrix was then employed to select the optimum concept. The Computer-Aided Design (CAD) model of the housing was modified and analysed using mould flow analysis. The solution was also evaluated form the cost-saving point of view.

Results and Achievements

The new proposed design has proven to have various advantages over the original design. In particular, the number of undercuts in the mould were reduced, thereby reducing sliding cores and hence mould costs. Also, calculations have shown that up to 9kg of material can be saved for each 10,000 units produced.

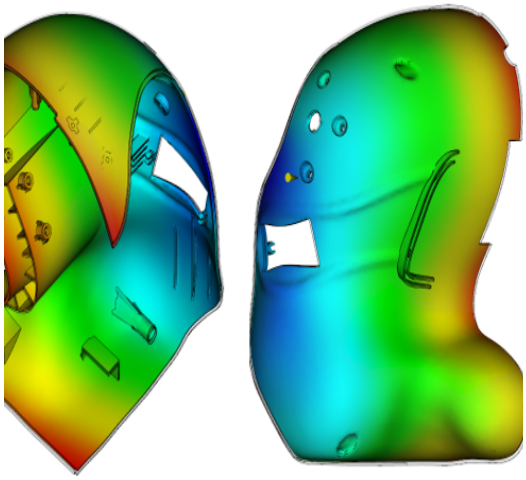

Figure 2: The Mould Filling Simulation of the Housing

Figure 1: Olly Speaks

Development of Screw Extrusion Based 3D Printer

Student: Anthony Bonnici / Supervisor: Dr Arif Rochman

Introduction

3D printing has left a significant impact on various industries mainly due to its appealing characteristics which include mass customization, rapid prototyping and freedom of design and manufacturing. In this project, a new 3D printing process has been developed, enabling the replacement of conventional plastic filament processing with less costly plastic granules processing.

Project Objectives

The main objectives of this dissertation include the concept, design and manufacturing of a new printing head to replace the conventional one. It is then to be connected to the 3D printer in order to attempt to perform a printing procedure and analyse its

Project Methodologies

The methodology of this project was based on a Research Methodology Framework developed by Alex Duffy and F.J. O'Donnell [1]. Primarily, a study has been conducted regarding the conventional 3D printing processes with an in depth analysis being carried out on the Filament 3D printing process (FDM) due to it being the most commonly used printing procedure. The various extrusion processes were also studied with higher emphasis on the screw extrusion process. Research was then carried out on the different components required to manufacture a new printing head. Two practical concepts were created and the preferred design was then selected. The separate components making up the system were designed and manufactured by performing the necessary calculations and material selection procedures.

In order to test the functionality of the new printing head, it had to be incorporated to a standard FDM 3D printer. A study regarding the different 3D printer kinematics has been conducted in order to determine the most suitable structure for this design. After selecting the specific 3D printer, both the electrical and mechanical modifications to allow for the connection of the new printing head to the 3D printer, have been carried out.

Once connected, separate tests were made to assess the system's performance and functionality. Some of these tests included heating tests and stability tests. After these tests were successfully performed, the final printing operation was attempted.

Results and Achievements

Modifications were required in order to effectively and efficiently print the, pellet form, PLA raw material. These included the redesigning of the screw and reaming of the cylinder and the nozzle to accommodate for the new screw design. Different test samples, which included both solid and also hollow parts, were then printed to attest the system's functionality. During testing, different processing parameters were changed, with the aim of improving the quality of the print. Such parameters included the extrusion multiplier (flow rate) of the printing head and the distance between the nozzle and the printing bed.

Finally, the optimum printing conditions, being a printing temperature of 200˚C and extrusion multiplier of 20 were established. These parameters led to the optimal results in terms of part quality and dimensionality. This shows that the objectives for this project were successfully reached as the newly designed printing head could successfully print with rather good quality using less costly raw material.

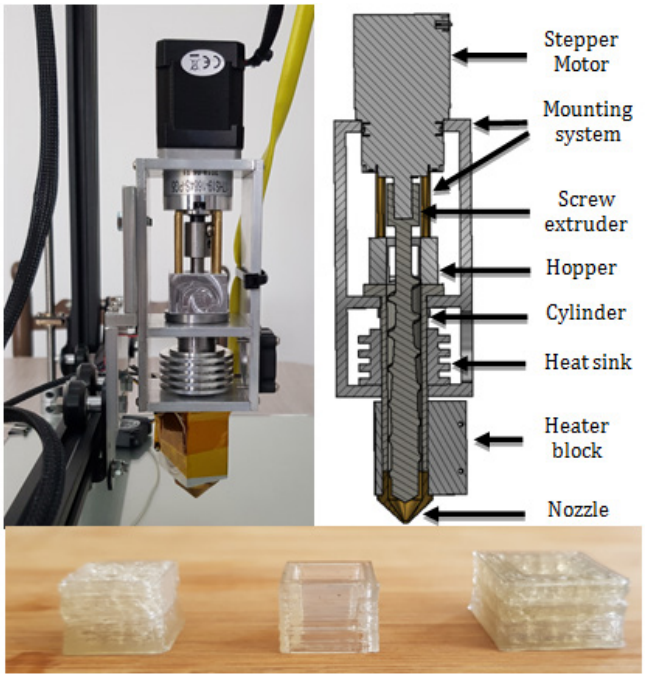

Figure 1: (top) Physical and labelled CAD model of the newly designed printing head and (bottom) best print results

References

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Sustainability Analysis of Compressed Air uses

Student: Angelo Cassar / Supervisor: Dr Ing. Paul Refalo / Co-Supervisor: Dr Ing. Emmanuel Francalanza

Introduction

Compressed air (CA) is widely utilised in industry as it is generally viewed as easy and safe to use. However, CA in industry contributes to a total of 10% of the energy consumption in the European Union [1] and the United States of America [2] which is a great concern for industrial facilities. This is so, as energy efficiency is one of the main concerns for industry due to the ever-increasing energy costs and the negative impact on the environment.

Project Objectives

The scope of the project was to analyse a pneumatic pick and place system, shown in Figure 1, by varying the system parameters. The aim was to find a beneficial tradeoff between the system's productivity, and energy and air consumption.

Project Methodologies

Initially, the most critical system parameters of the pick and place system were selected through calculations and system constraints. These parameters included, the set pressure, the mass of the parts being picked, the diameter of the suction pad, and the horizontal and vertical distances travelled by the part picked. The pick and place system was connected to a compressed air test bed and programmed in order to obtain the desired functions. Parts which were to be picked and placed were then designed together with parts that would make it possible for some of the process parameters to be altered during experiments. Preliminary testing was subsequently conducted in order to finetune the system parameters selected further and to stabilise the behaviour of the system.

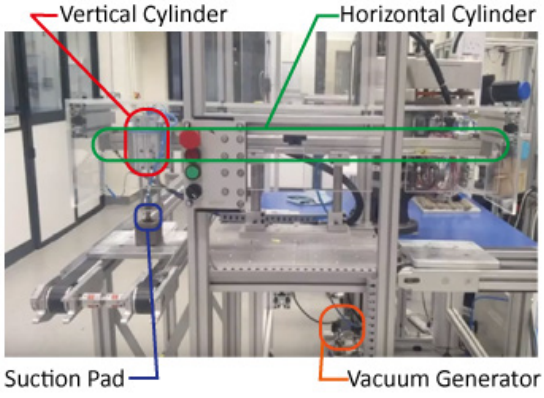

Figure 1: Pneumatic Pick and Place System

Design of Experiments was employed to create an experimental procedure and several experiments were performed. Data was recorded automatically using sensors connected to a PLC. The electrical power consumed by the compressor, the air flow rate, the pressure and the status of the solenoids were measured and collected to determine the productivity of the system. Consequently, the data was analysed, identifying the most critical parameters, and recommendations were formulated.

Results and Achievements

From the data analysis carried out it, was concluded that the mass of the part and the diameter of the suction cup do not have any significant effect on the responses of the system, as shown in Figure 2. Thus, designers of such systems would benefit from designing for a heavier load given that the components constituting the system permit it. Moreover, it was also determined that the process parameters that had the largest effect on the productivity, energy, and air consumption, were the horizontal, vertical distances, and the operating pressures respectively. For example, reducing the horizontal traversed distance from 800 mm to 100 mm reduced the air and energy consumption by 30%. Moreover, increasing the set pressure from 6 to 7 bar, increases the energy consumption by 8.5%. Automation designers would gain from operating at lower pressures and eliminating any unnecessary movement as this would increase productivity while consuming less energy and

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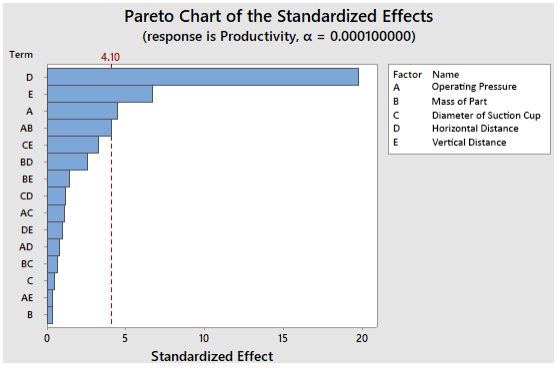

Figure 2: Pareto Chart Showing Critical Parameters

Design of Digital Industrial Automation Systems

Student: Ian Ciantar / Supervisor: Dr Ing. Emmanuel Francalanza

Introduction

Developments in product design, connectivity and cloud computing lead to a paradigm shift from mass production to intelligent, over-the-web personalized products. In order to efficiently manufacture such products, industry has to adapt its manufacturing systems to this new production paradigm. Personalised Production paradigm makes the most out of the digitisation of manufacturing, Industry 4.0 and the Industrial Internet of Things (IIoT).

Project Objectives

The project's objectives include; the evaluation of literatures concerning digital automated systems and personalised production. Development of a high-level personalised production system architecture. The modular design and implementation of a cyber-physical production system which includes an aspect of personalised production.

Project Methodologies

For this project, the methodology adopted is developed by M. Mercieca [1] i.e. the Modular Function Deployment 4.0 (MFD 4.0) which is a reference to Industry 4.0. This methodology is a combination of two other methodologies, one developed by Erixon et al. [2] called Modular Function Deployment (MFD) and the other developed by Scalice et al. [3] termed as the Interface Design Methodology (IDM).

The MFD 4.0 approach is made up of 5 main steps in which a number of tools such as QFD, FMA, etc. can be used in order to achieve the goal of designing a modular system capable for production of personalised parts. These steps can be viewed in *Figure 1* below.

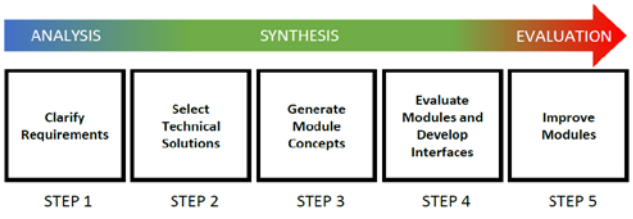

Figure 1: MFD 4.0 Methodology

Results and Achievements

By using a modularity approach, a high-level reference architecture was developed for personalised production. Part of this architecture held a Cyber-Physical Production System (CCPS) module which was designed based on the MFD 4.0 methodology explained in the previous section. Two other modular architectures where developed for this CPPS, which were split into the physical aspect and the cyber-physical aspect of the system. These two architectures led to a reconfigurable and smart machine (STRIX 3.0) design as the one seen in *Figure 2.* Incorporated within the system is a CNC Router which acts as the medium providing the personalisation aspect required from the system. STRIX 3.0 is integrated with an already developed material handling system called ORCA. ORCA feeds STRIX 3.0 the required parts.

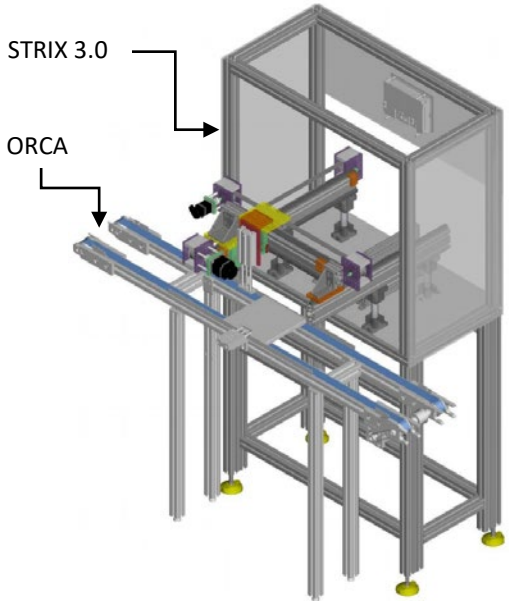

Figure 2: STRIX 3.0 Assembly next to ORCA

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Design and 3D Printing of Polymer Templates for Metal Bone Scaffold Production

Student: Yann Demicoli / Supervisor: Dr Arif Rochman / Co-Supervisor: Prof. Ing. Joseph Buhagiar

Introduction

The treatment for when a large piece of bone is missing is to harvest bone from one area of the patient and implant it within the bone defect and this procedure is risky. Thus, artificial substitutes for bone to be implanted within bone defects are being researched which are called bone scaffolds. A bone scaffold is a three-dimensional support structure designed for bone to grow through it [1].

Project Objectives

To study the properties of existing metal bone scaffolds and determine 3D printing techniques suitable for the printing of polymer templates. To design, print and evaluate the polymer templates. To carry out experiments to manufacture bone scaffolds from the printed templates and analyse the results.

Project Methodologies

The template must be porous so it was necessary to design a lattice, which is similar to the one shown in Figure 1a. Such a structure requires feature sizes within the hundreds of microns. This meant that a 3D printing machine with high accuracy was required. After carrying out an equipment selection, the Form 2 by Formlabs was chosen since it was advertised that it could print features of size of 150 µm [2] while offering a wide variety of materials which can be printed. Two materials were chosen, a clear resin and a castable wax resin which was designed to be burnt within a furnace and thus had useful properties for the application. Specialized software was also required to create different lattices without manually specifying each feature. To achieve this, Element Pro by nTopology was used. The resulting file obtained from Element Pro was imported to PreForm, which is the software used by the Form 2 to prepare the digital file to be used for manufacture. PreForm was used to prepare the digital files to be 3D printed by providing support structures to the templates. Then, multiple different types of lattice with the two different materials were manufactured in a cubic shape and evaluated based on their porosity and ease of post-processing. The templates were passed through a cleaning procedure & a post-curing chamber was also constructed. Afterwards, simple templates made from each material were passed through the metal replication process and evaluated.

Results and Achievements

A porous template made out of a clear resin was achieved as shown in Figure 1a. It was observed that this material is easy to work with due to its strength. Multiple design iterations of porous templates made out of the castable wax resin were carried out. Only two template types could be possibly manufactured and thus their design was tweaked to improve their properties. One of the template types proved to be inadequate. The template shown in Figure 1b was designed from the other template type to successfully to reduce the supports required and thus reduce the manufacturing effort. The metal replication experiment proved that both materials were somewhat suitable to be used within the process.

a) b)

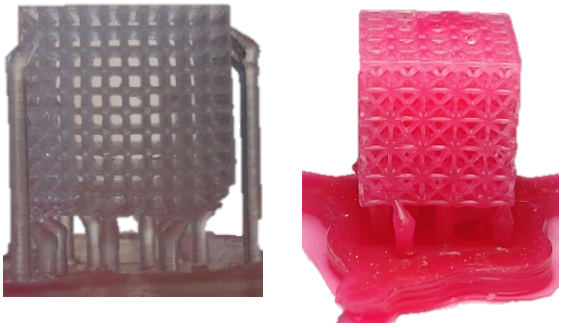

Figure 1 a) A template made from clear resin
b) A template made from castable wax

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Changeover Process Improvements of a Tablet Compression Machine

Student: Emma Marie Fenech / Supervisor: Dr Ing. Pierre Vella

Introduction

Manufacturing industries strive to achieve lean manufacturing within their systems. In order to reduce waste, continuous improvement must be carried out within the manufacturing system. In this project, a changeover process that is carried out on a tablet compression machine at a pharmaceutical company, was analysed in order to reduce and therefore improve the downtime of this process. Reducing the downtime will result in improved availability of the machine.

Project Objectives

The objective of this project is to analyse and propose solutions to reduce the time it takes to perform the changeover process for the tablet compression machine whilst maintaining the high-quality cleaning that must be achieved during such a changeover process. Thus, avoiding product contamination and cross-contamination.

Project Methodologies

For this project, a Lean Six Sigma approach was adopted to identify and mitigate the waste being produced in the changeover process of a tablet compression machine. This was carried out by means of implementing Lean Tools and the Design for Six Sigma, also known as the DMADV Cycle, which consists mainly of five phases [1].

The problem was defined by means of identifying all the resources required and analysing the process. This was achieved by means of various tools e.g. process flowcharts, an Integrated Definition Model and SMED Analysis that were implemented within the 'Define' phase. A market study together with the identification of the cleaning process and customer's requirements were carried out in the 'Measure' phase. Solution concepts were generated based on the above-mentioned requirements to reduce the downtime of the changeover process.

The solution concepts were tested in the 'Analyse' phase to identify the best design concept that will be implemented in the cleaning system. From the results obtained, a set of process parameters were established to clean the turrets contaminated by any type of Active Pharmaceutical Ingredient (API). A final detailed design for the proposed cleaning machine together with the new cleaning procedure was established in the 'Design' phase. Finally, all the data collected throughout the project was analysed and discussed in the 'Verify' phase. Once a prototype machine is built, several pilot and production runs will be necessary to ensure that high quality cleaning is maintained with such an improvement.

Results and Achievements

A reduction in the downtime for the changeover process of the tablet compression machine was achieved by reducing the time it takes to wash, rinse and dry the turret through the automation of such processes.

The process parameters established from testing were found to be sufficient to clean a turret contaminated with APIs that range from slightly soluble in water to practically insoluble in water.

The data gathered throughout the whole project proved that with the proposed process improvements, the time it takes to wash, rinse and dry the turret can be reduced by 59 - 71% when automating such a process.

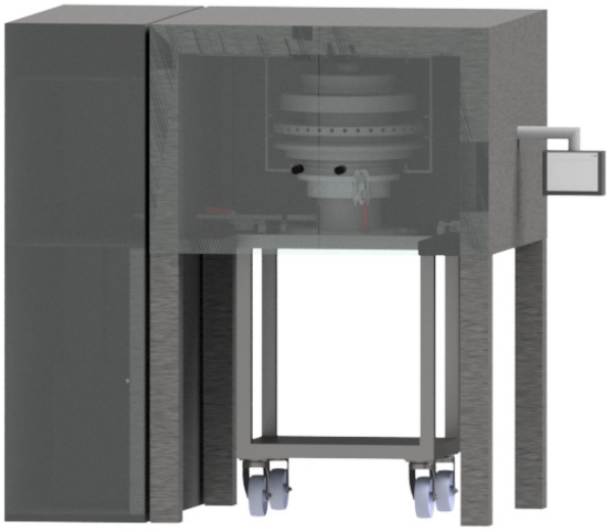

Figure 1: The Cleaning Machine Assembly Concept

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Design of an Innovative Soft Spherified Cosmetic Product Dispenser

Student: Andrew Galea / Supervisor: Prof. Ing. Jonathan C. Borg

Introduction

With the current trends within the Korean cosmetics market leading towards the use of spherified doses of liquid cosmetics, Toly Ltd. has assigned a project towards designing an innovative dispenser that stores cosmetic products as a liquid but dispenses the cosmetic product in the form of soft spherified solid cosmetic products in a novel and aesthetic manner.

Project Objectives

This product is to aim towards granting the ability to generate enough spherical doses for one day of use without needing to carry the whole liquid packaging. This design solution will solve two problems in the cosmetics industry: (i) An overall reduction of clutter in a woman's handbag and (ii) the reduction of waste when compared to their aerosol-based counterparts.

Project Methodologies

In order to achieve this goal effectively, this product must be able to convert numerous types of gel or liquid based cosmetic products (such as foundation and skincare products) into solidified spherical doses accompanied by a pleasant visual effect.

The project performed was based on the basic design cycle, where the problem was analysed via market research which lead to the creation of a Quality Function Deployment and a Product Design Specification. After the problem was analysed, conceptual designs were made using the Function Means Analysis tree as well as a morphological chart. The best three were then chosen and a SCAMPER exercise was performed on each of the three concepts. The aforementioned concepts went through the embodiment stage. Here, the concepts were evaluated and Design for Assemblies were completed for each concept. The use of these design methods allowed for concept selection, where the most fitting concept was chosen via a radar chart as well as a decision matrix.

Once the concept was selected, a Failure Mode and Error Analysis, a Design for Emotion as well as a Design for Manufacturing were done. During the Failure Mode and Error Analysis, the main design problems were addressed and Finite Element Analysis was utilised to verify the effects of the relevant design problems. During the Design for Emotion exercise, a study was carried out on the aesthetics and colour palette of the design. During the Design for Manufacturing exercise, a material selection study was carried out along with a selection of the manufacturing techniques used and how to cater the design towards the aforementioned techniques.

Results and Achievements

The overall dispenser concept generated (as seen in figure 1) was also evaluated with the innovation team at Toly who were very satisfied with the solutions conceived.

To conclude this project, the goals of the dissertation were checked whether or not they were completed and if so, the sections where they were completed were mentioned. Finally, the shortcomings of the current design were addressed along with the reason why these issues need to be addressed. An innovative dispenser for soft sphered cosmetic products was successfully designed and tested, with some advised actions for improvements and future work were given.

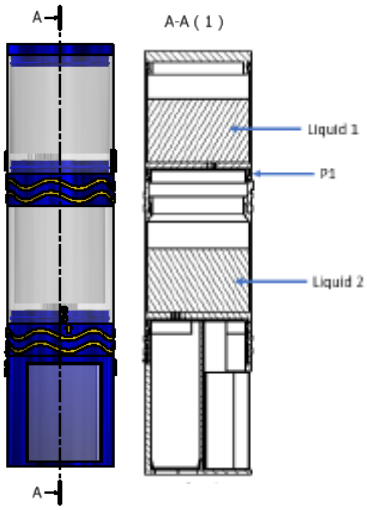

Figure 1: A sectioned view of the Final Design Solution for the Dispenser in the initial position

Implementing a Lean Six Sigma Approach for Manufacturing Process Improvement

Student: Victoria Grech / Supervisor: Dr Ing. Emmanuel Francalanza / Co-Supervisor: Dr Ing. Conrad Pace

Introduction

Lean Six Sigma (LSS) integrates two prevalent performance improvement methodologies: Lean methods and Six Sigma. In this project, this approach was adopted for the improvement of a manual manufacturing process at ProMinent Fluid Controls Ltd. This process involves the manufacture of various products used for flow control applications.

Project Objectives

There are two main objectives of this LSS project. Firstly, to reduce waste and maximise operator productivity whilst minimising the effort related to non-value adding activities. Secondly, reduce process variation.

Project Methodologies

The LSS DMAIC approach was adopted for this project. This improvement framework integrates lean tools such as Value Stream Mapping (VSM), 5S and Kaizen into the principles of the DMAIC problem solving cycle [1]. After many researchers identified VSM's shortcomings, the idea of using simulation was adopted within this methodology [2]. Therefore, a high-level methodology illustrated in Figure 1 was developed and followed.

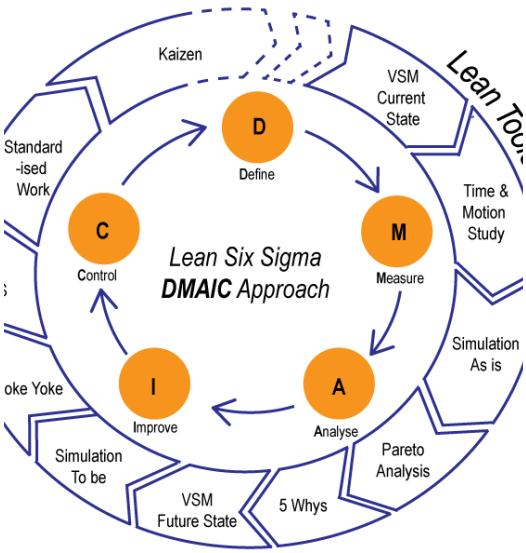

Figure 1: Adopted Lean Six Sigma DMAIC Approach

Results and Achievements

The solution was built gradually with every phase of the DMAIC methodology. In the Define stage, the wastes were observed and identified within the development of the VSM. Whilst in the Measure phase, a time and motion study was conducted to quantify the time wasted whilst observing attentively the process itself. This led to the development of an as-is simulation model and its validation. In, the analysis phase the flow of material and paths followed by employees were studied.

When lean tools were applied in the improve stage, the process improvements and layout improvements were developed. These were also experimented with in Simulation. This led to prioritization of solution using the pareto analysis. These were then built into the to-be simulation model, shown in Figure 2, visualizing the changes. Therefore, from the simulation and the lean tools, the production time would be able to reduce by 37.9% when all the improvements would be implemented.

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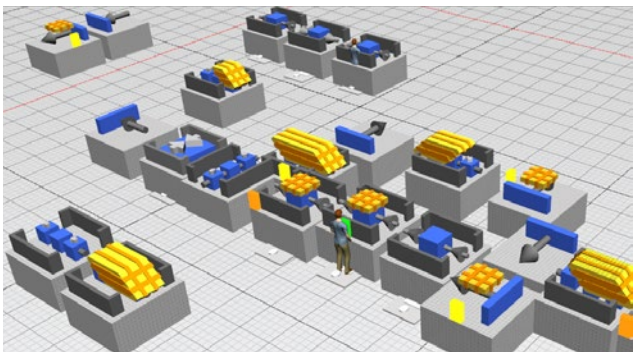

Figure 2: Simulation To- Be Model

Design of a Roll Cage for Hill Climb Racing

Student: Clayton Abela / Supervisor: Prof. Ing. Martin Muscat

Introduction

The roll cage is one of the most significant equipment for personal protection in every sports car especially in hill climb racing. It is generally made of thin gauge pipes, joined together to assemble a safety structure. The frame must be designed in a way to absorb the kinetic energy during impacts. The project addresses a new design of a roll cage simulated by Finite Element software.

Project Objectives

The project's main objective was to design a roll cage based on the rules and regulations of the *Fédération Internationale de l'Automobile*, FIA and Transport Malta, TM. The designed model was first simulated as a static structure and then dynamically. Dynamic testing simulation ensures a safe roll cage that protects the driver analytical study was carried out.

Project Methodologies

During roll cage simulation, emanated query that was made was whether it would make any difference if the roll cage was tested as a full welded structure rather than a bolt on cage structure. A simulation test was conducted to check how the bolt on structure would function. Three models were used for the testing phase. The first model consisted of 2 whole members. The second one had 2 members of which one was joined with a thicker sleeve. The third model was the same as the second one however with added bolts. For all the three models, the vertex was fully welded.

Two type of roll cages were static and dynamic tested. The roll cage was designed for racing however when removing some of its members, it may become road legal. The roll cage design consisted of two different materials, mild steel and chrome moly. Also, several material combination and tube diameters were tested. A deflection for each combination was analysed under a 23.4KN load. Testing was also carried out to test the maximum load possible to bend the main hoop by 50mm.

A dynamic finite element analysis was conducted for a better roll cage evaluation as it provides more assurance regarding its certification and gives a more detailed result. Dynamic testing simulates the worst roll cage collision possible. During the dynamic simulation, a base model of a racing roll cage as well as a full racing version roll cage model were used.

Results and Achievements

Results obtained from Ansys Workbench implied that when loading the structures with 10KN, the welded structure experienced larger deflection than the bolt on sleeve structure. Despite these outputs, for simplification reasons, it was concluded that the first model that is a fully welded structure roll cage will be used in the static analysis and dynamic testing.

From the static analyses, the roll cage showed that chrome moly can withstand higher loads when compared to mild steel.

Also, dynamic testing showed that in case of a front and side impact the drivers and co-driver would be at a risk. Hence, an additional member, was added to support the roll cage.

Figure 1: The built roll cage

Investigating the Heat Transfer Phenomena across Cylinders exposed to Water Waves

Student: Joseph Abela / Supervisor: Prof. Ing. Tonio Sant

Introduction

While significant work has been done in the area of heat transfer across a vertical cylinder the effect of wave action has not been investigated in much detail. Using wave action as a heat transfer mechanism has various advantages with the main one being the fact that sea waves are a free resource. Applications include heat exchangers for oil and gas extraction and subsea nuclear power [1].

Project Objectives

To analyse the variation of the overall heat transfer coefficient with cylinder diameter, cylinder length, wave frequency and wave amplitude.
To investigate the effect of wave conditions on the outer convective heat transfer coefficient.

Project Methodologies

Steel cylinders having diameters of 6, 7 and 8 cm were used. The top and bottom of each cylinder were insulated to ensure heat transfer occurs only across the cylinder walls. The cylinders were attached to a wooden support board and placed in the wave tank.

Water at a temperature of 70°C was poured in all the cylinders and left to cool down to a temperature near the ambient temperature of the wave tank. Thermocouples measured the temperature at the centre of the cylinders (T_c) at three different distances from the bottom of the cylinder. Data was recorded using a Keithley® data acquisition system. The ambient temperature (T_∞) of the wave tank was also recorded.

The experiment was first performed at still water conditions and then repeated for 5 different wave conditions (3 different wave frequencies and 3 different wave amplitudes). For each different wave condition (including still water conditions) 6 repeated readings were taken. The recorded temperatures were used to produce a plot of $\ln\frac{T-T_\infty}{T_0-T_\infty}$ against time, where T_0 is the initial temperature at the centre of the cylinder. A linear regression fit was applied to each plot and the overall heat transfer coefficient, U, was derived from the gradient of the regression.

Results and Achievements

Increasing the diameter from 0.0603 m to 0.07 m produced an increase of 15% in the overall heat transfer coefficient (for still water conditions). Decreasing the distance from the bottom of the cylinder from 0.21 m to 0.14 m produced an increase of 12% in the overall heat transfer coefficient. A wave frequency of 5.80 Hz produced an increase of up to 61.29% in the overall heat transfer coefficient compared to the corresponding value for still water conditions. A wave amplitude of 0.019 m produced an increase of up to 61.29% in the overall heat transfer coefficient compared to the corresponding value for still water conditions.

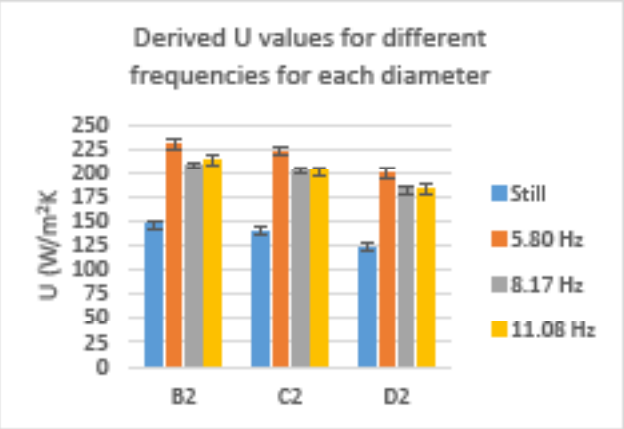

Figure 1: Derived U values for different wave frequencies for each diameter

References

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Kinematics of a Lifting Activity

Student: Juan Abela / Supervisor: Dr Ing. Zdenka Sant

Introduction

Proper lifting techniques are essential when managing heavy loads. Adapting the deadlift form shown in Figure 1 (Left), to everyday lifting, decreases the risk of lower back injury. Maintaining a straight back while lifting however, increases hip flexion which in turn increases reaction forces and moments within the lower joints of the body; Hips, knees and ankles, which are the studied joints in this project.

Project Objectives

Recording lift using Vicon Motion Capture System.
Processing of kinematic data using Molda software and inputting the same data to open source software, AnyBody. Computation of kinetics and analysis of kinematics of two different subjects.

Project Methodologies

Motion capture for two subjects (A & B) was done using the Vicon system, from which kinematic data was obtained for a number of performed lifts. This data was then extracted and analysed using the Molda software. The kinematic data for a selected number of frames was then mapped on the positions from a selected number of frames, onto the generic AnyBody model as seen in Figure 1 (Right) to obtain reaction forces at leg joints.

Kinetic data was then computed using a set of derived Newton-Euler equations for each of the selected frames. Joint angles and moments were plotted with any important events labelled.

Results and Achievements

Kinematic data was obtained successfully, and the results were plotted into graphs as shown in Figure 2, recording the hip experiencing flexor and extensor moments during the lift. The computed results were rational and correlated with data from literature of similar studies [1],[2].
The results reflected the difference in athletic performance of the two subjects. The main differences between the two subjects accounts the stability and the load distribution along the two body halves. The athletically inclined subject B graphs recorded less noise and from the higher acceleration peaks it can be deduced that Subject B was overall more powerful. Both subjects have right leg as the dominant leg, despite Subject B being left handed, however Subject B depends more on his upper body to initiate the lift unlike Subject A.

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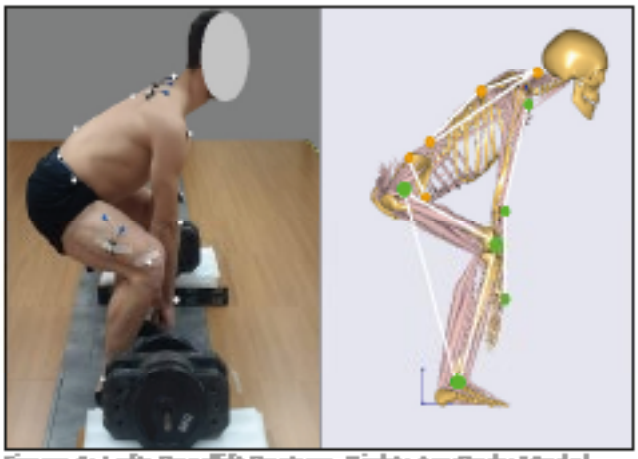

Figure 1: Left: Deadlift Posture, Right: AnyBody Model

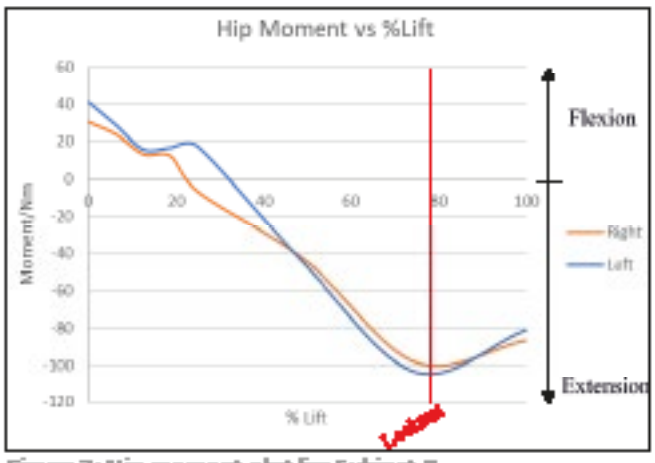

Figure 2: Hip moment plot for Subject B

Wave Attenuation using a Floating Array of Cylindrical Structures

Student: Keith Abela / Supervisor: Prof. Ing. Tonio Sant / Co-Supervisor: Ing. Daniel Buhagiar

Introduction

Wave attenuating devices, namely breakwaters, are well known structures for providing sheltered areas for boats in the near shore, and to mitigate the impacts of coastal erosion. In deep water sites, floating breakwaters may be more cost effective than seabed mounted systems and can provide sheltered areas for offshore renewable energy systems such as floating wind and solar energy farms, hence reducing the impact of hydrodynamic loads.

Cylindrical structures are nowadays very cost effective to produce and when such systems are installed in the form of floating arrays, they may serve as effective devices for attenuating waves.

Project Objectives

The main objectives of this project were to design and construct scaled models of a wave attenuating device consisting of an array of cylindrical structures having different cylinder spacing in order to carry out experiments in a wave tank for different wave conditions and cylinder spacing. Experimental results were then to be validated using those predicted by a numerical model using hydrodynamics software package ANSYS AQWA®.

Project Methodologies

Three different setups were designed having a spacing ratio of 0.95, 1 and 1.5. PVC pipes having an external diameter of 63 mm were used for the cylinders that were attached to a test rig manufactured from medium-density fibreboard. The test rigs were coated with a water-proof coating to avoid the wood from swelling

Experiments were carried out in a wave tank in the Fluids Laboratory at the University of Malta for all three setups, as shown in Figure 1. The experiments were performed for twelve wave conditions, typical in the central Mediterranean region to obtain the wave attenuation characteristics of the models.

The three experimental setups were then modelled in ANSYS AQWA® to obtain results for the transmission coefficient and results were compared with those obtained experimentally.

Results and Achievements

The transmission coefficient was observed to decrease as the spacing ratio decreases. Moreover, the transmission coefficient was also observed to decrease with an increase in wave steepness and Reynolds number while the relative depth and diameter to wavelength ratio did not seem to have a large significant effect on the transmission coefficient.

The results from the numerical model were deemed acceptable within the range of uncertainty values obtained. Moreover, the variation obtained for the transmission coefficient with wave steepness, relative depth and diameter to wavelength ratio showed similar trends to those obtained during experiments. Figure 2 shows the results obtained for a spacing ratio of 0.95.

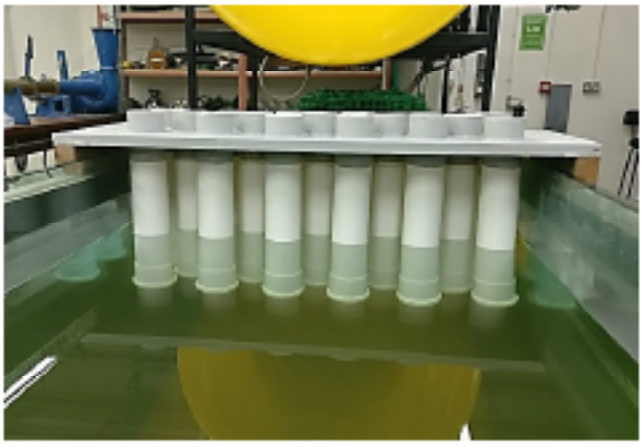

Figure 1: Experiments being carried out on a breakwater consisting of a floating array of cylindrical structures

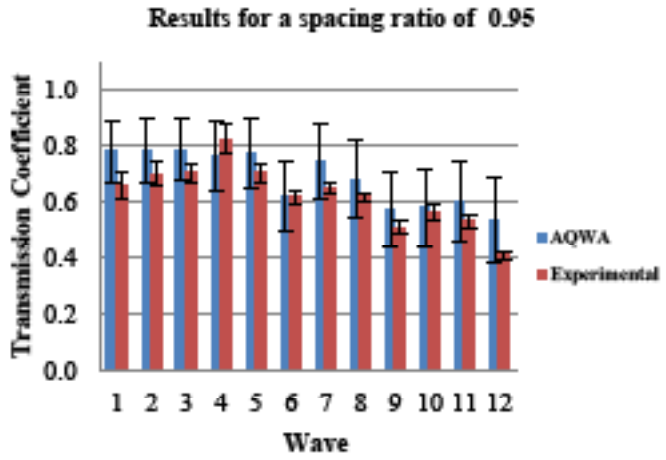

Figure 2: Results obtained for the transmission coefficient for a cylinder array having a spacing ratio of 0.95

Three-Dimensional Multiphase Modelling and Optimization Framework of a Merchant Ship

Student: Mikiel Anton Abela / Supervisor: Dr Ing. Simon Mizzi

Introduction

Currently, optimisation for a marine vessel has been strongly reliant on the production of scaled models, and the use of scaling techniques to calculate appropriate operational characteristics. Such a process is both time and resource intensive, and hence, an advanced solution is desirable within the industry. Due to the recent technological progress, commercial, high-performance, computational power is becoming increasingly cost effective. Therefore, the possibility of having a feasible, all augmented, multi-phase simulating numerical methodology, is more realistic than ever before.

Project Objectives

- Review state of the art computational fluid dynamics modelling for the maritime industry
- Validate the use of CFD software for obtaining operational performance characteristics of marine components as follows
- Provide a single augmented, multi-phase framework model for a partially immersed marine vessel operation, accounting for hull, propeller and rudder interaction.

Project Methodologies

Initially, a thorough validation process was undertaken in order to establish optimal numerical methodologies for simulating complex flows for marine applications. The validation process was implemented for the following marine components:

- Isolated, freestream, NACA0020 sectioned rudder, with and without cavitation effects
- Isolated, freestream Wageningen propeller
- Rudder downstream of propeller
- Partially immersed, isolated, Series 60 hull form

Once a sound basis and optimal methodologies were identified, a single augmented system was developed, incorporating the rudder-propeller-hull interaction, in a three-phase environment.

A transient, multi-phase Fluent model was applied, with the use of the k-ω SST turbulence model. additionally, an open channel flow was incorporated so as to simulate open waters, in which typical merchant ships operate.

Results and Achievements

The validation process concluded that the k-ω SST turbulence model provides accurate results, when compared to established experimental values, for the following properties of interest:

- Coefficient of lift of the rudder, for both the isolated, freestream setup, and the propeller interacting configuration
- Thrust coefficient for the isolated, freestream propeller
- Rudder and propeller characteristics in an integrated system
- Resistance force acting on the hull in a partially immersed, open channel setup

The augmented system was developed, and a suitable framework established for the proper simulation of a single augmented, multi-phase operating environment for marine ship. Suitable agreement with theoretical knowledge for the simulated flow was obtained for two modes of operation for the marine vessel:

- Port operating conditions
- Cruise operating conditions

The developed system allows for the future implementation of the framework in the overall production and advancements of merchant vessels, thus, allowing for a substantial streamlining and reduced overall resources required for the design and optimisation of merchant vessels.

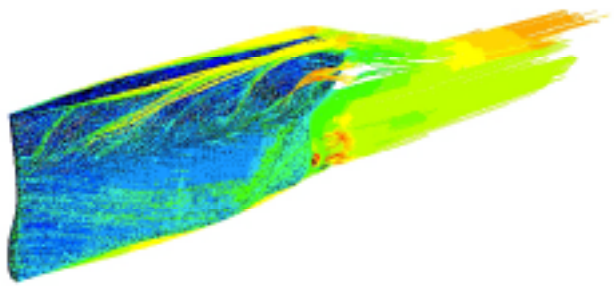

Figure 1: Velocity streamlines flowing over merchant ship

An Investigation on the Thermal Gradients and Distortion Developed due to Different Welding Fabrication Procedures

Student: James Agius / Supervisor: Prof. Ing. Duncan Camilleri

Introduction

In the marine industry, vessels involve a substantial amount of welding on plates to give the vessel a solid structure. The process of fusion welding develops localized heating which gives rise to thermal gradients leading to residual stresses and distortions. The out-of-flatness distortions will reduce the structural stiffness of the panels and also deviate the structure from its intended shape and contours.

Project Objectives

- To implement the necessary changes to the semi-automated welding rig to be able to perform experimental testing of different fabrication procedures;
- To investigate different thermal gradients, welding distortions and output the necessary data analysis;
- To identify and establish the best fabrication procedure leading to the minimisation of distortion.

Project Methodologies

Experimental tests on DH36 steel plates were employed by using an automatic MIG welding rig at the University Of Malta. A distortion measuring device enabled the evaluation of the welding distortion that developed in the 6mm thick plates. Thermocouples aided in the determination of the thermal gradients that were present in the material during welding. This allowed a better interpretation of the cause and effect during welding in terms of residual stress and distortion.

The plates were clamped in three different methods to observe the change in the magnitude of distortion. The three modes of clamping aimed to restrict the plate in the transverse direction, longitudinal direction and both directions simultaneously. Unclamped plates experiments were also performed to have a solid comparison between clamped and unclamped plates. A water cooled experiment was also implemented to observe the changes that occurred when the plates were water cooled. A comparison between the five methods was performed to examine the behaviour and magnitude of the distortion that developed in the plates.

Results and Achievements

Methods of clamping were applied to successfully mitigate the out-of-plane distortion. Results showed that clamped plates exhibit an opposite longitudinal distortion direction to that of the unclamped method.

Local heat extraction was successfully applied both in the longitudinally and the water cooled clamped method. This resulted in a lower thermal gradient which minimised the magnitude of distortion.

The best fabrication procedure was identified to be the transversely and longitudinally clamped method. This method achieved a 60% reduction in angular distortion and 57% reduction in longitudinal distortion than the unclamped method.

This fabrication procedure could be implemented in ship welding techniques to minimise or eliminate the possibility of welds, being the origin of failure in ships as a result of butt welded plates.

Figure 1: Automatic MIG Welding in process

Visualization of ICE Combustion

Student: Hassan Al-Jabri / Supervisor: Prof. Robert Ghirlando

Introduction

Single-cylinder spark ignition (SI) and compression ignition (CI) engines are suitable for study of the internal combustion process by means of various optical techniques. A clear picture of the internal combustion process is important for furthering our understanding of the combustion process. The most straightforward optical method is by using a high-speed camera through the optical window in the engine.

Project Objectives

The aims of this project are to design an optical cylinder head for visualizing spark ignition and to study the combustion process of the Ruston diesel engine. This project is a research tool for the future to be used to increase engine efficiency and reduce engine emissions.

Project Methodologies

The optical cylinder head for a J.A.P. engine was built based on three stages. Firstly, the clearance volume of the original cylinder head was measured by filling the clearance volume with water in order to calculate dimensions for the required cylinder head spacer. Secondly, the spacer design was specified based on field of view, which was critical to enable visibility of all the combustion chamber from the top of the cylinder. Thirdly, the optical cylinder head was designed according to the outer boundary shape of the spacer, and the thickness was calculated in relation to the pressure the window was exposed to. Combustion in the Ruston diesel engine was studied by constructing two adapters for measuring temperature and pressure.

Figure 1: The combustion process through optical cylinder head

Results and Achievements

The results of the combustion performance of the J.A.P. engine were observed through the optical window using a high-speed camera (Figure 1). The combustion performance starts with a small spherical shape close to the spark plug as it normally occurs with spark ignition [1]. Then, the flame shows a turbulent structure during flame propagation. The turbulent flow within the combustion process is important to enhance flame growth [2]. The main two colors evident within the combustion process are blue and yellow-orange. The blue color represents stochiometric combustion, while yellow-orange represents rich-fuel combustion.

The maximum in-cylinder temperature of the Ruston diesel engine was found to be 415 °C with an engine load of 262.40 N. The graph in Figure 2 shows the results of combustion chamber temperature measurements as the engine torque increased. The peak in-cylinder pressure was found to be approximately 40 bar.

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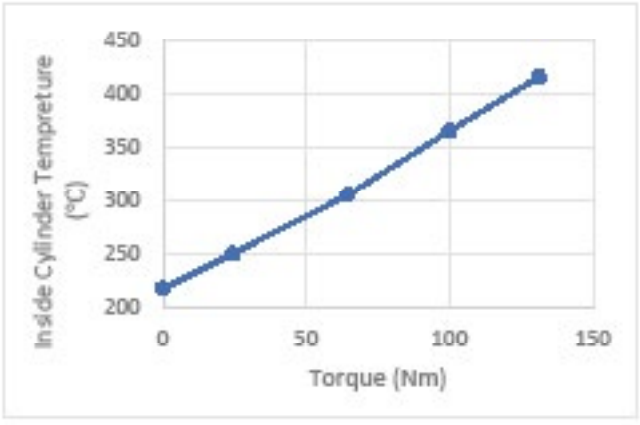

Figure 2: In-cylinder temperature with varying torque

Design Build and Test of an Experiment for Buckling of Slender Rods

Student: Issa Al-Qataiti / Supervisor: Prof Ing. Pierluigi Mollicone

Introduction

Buckling is a stability problem that occur in slender columns that are subjected to a compressive load. It is not enough for engineering students to have only the theoretical knowledge of buckling; it also required have the practical knowledge and hands-on experiences to understand the buckling phenomenon. Therefore, a buckling apparatus is required in the university laboratory to assist students to acquire a better understanding of the buckling phenomenon.

Project Objectives

The intention of the project is to design, build and test experimental apparatus to demonstrate the buckling behaviour of slender rods. Different columns with various conditions are to be tested using the same apparatus to be designed and to be built.

Project Methodologies

Market research on currently available experiments for buckling of the long slender column was accomplished to get the knowledge of the experimental concept including the design and building of the set-up and testing procedure.

The conceptual design of the setup was generated through a morphological chart and sketches, followed by detailed design which consists of calculations, manufacturing and assembly techniques to be used. Calculations were carried out to make sure all chosen components worked under the required conditions with minimal deformation. Meanwhile, the required components were manufactured, such as the top and bottom bases, top end fixtures (fixed and pinned) and some mounts for bottom fixtures. In addition, some components were bought, for instance, the hydraulic system, test columns and fixtures material. Since the project is it's a continuation on Samuel's project [1], some parts were available tab such as, frame including the tube columns and their mounts.

Once the set-up was built and assembled, columns of different materials (Stainless Steel, Brass, Aluminium) were tested using three end condition fixtures (Fixed-Fixed, Fixed-Pinned, Pinned-Pinned). The outcome results for critical buckling loads were compared to theoretical and recommended solutions. In addition, Finite Element Analysis modelling was presented to provide computational solutions for non-linear buckling analysis.

Results and Achievements

Throughout the project and dissertation, the knowledge of Engineering Design was acquired and developed, together with the manufacturing process.
The buckling experimental setup was designed and build to be utilised by students to further understanding of the buckling phenomenon.
The behaviour of columns that experience buckling were looked into and studied in detail.

Figure 1: The buckling experiment set-up

References

[1] S. Bartolo, "Design, Build and Test of a Mechanics of Materials Experiment," *University of Malta, Faculty of Engineering*, 2017.

Numerical Modelling of the Reynolds Number Effects on Upscaled Wind Turbines

Student: Saif Al Saadi / Supervisor: Prof Ing. Tonio Sant

Introduction

Wind turbine size has been growing rapidly over the recent years from small (a few hundred kilowatts) to large scale (a few megawatts) with the newest machines reaching a rating of 12 MW, with a rotor diameter of 220m. This grow in the wind turbine rotor sizes give rise a lot of challenges to the wind energy research such as high Reynolds number effect.

Project Objectives

The main objective of the project is to analysis the effect of the high Reynolds numbers in upscaled wind turbines by Developing a Blade Element Momentum model for simulating wind turbine performance.

Project Methodologies

The BEM numerical code was used in this project to determine the flow condition and the forces in each blade station. The type of solution that used in the BEM numerical code is an iterative numerical approach. It is the most extended for the flow condition with large axial induction factors[1].

This solution based in guessing values for the induction factors a_1 and a_2 from which flow condition and new induction factors are determined specifically

1. input the properties and geometries for the blade
2. dividing the blade into 17 stations
3. finding the chord and the radius for each station of the blade
4. guessing values of for the induction factors a_1 and a_2 and the value is zero for both.
5. calculating the angle of attack and finding the lift coefficient by interpolation from airfoil data.
6. updating the new values of induction factors a_1 and a_2

The process is repeated until the induction factors reach within acceptance limit of the previous iteration. finally, the global and local aerodynamics graphs were plotted.

The airfoil data for high Reynolds number was collected from the AVATAR project up to Re=15M. whereas, the blade properties was collected from NREL 5MW wind turbines.

Results and Achievements

The BEM numerical code was applied for three different large rotors 126m, 150m and 180m. In order to analysis the effect of high Reynolds number, the code was used for small, medium and high tip speed ratio.

After comparing and investigating the result, it was found that at small and medium tip speed ratio, there was not significate effect of Reynolds number in both global and local aerodynamics characteristics for the three rotors.

At high tip speed ratio, the Reynolds number has noticeable effect in the local and global coefficients. for example, the 180m has higher thrust coefficient comparing with the other two rotors.

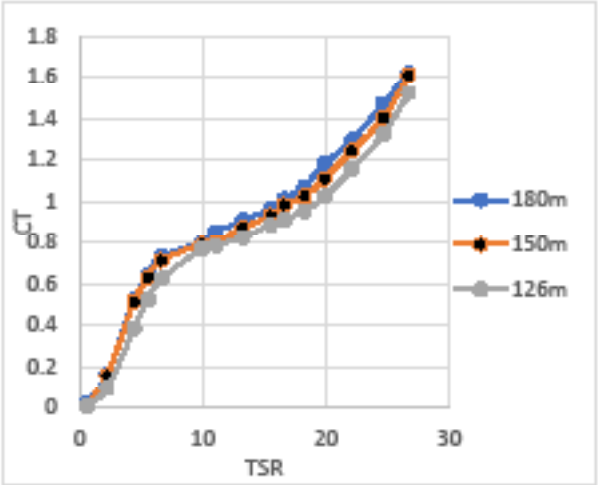

Figure 1: shows the Thrust coefficient for the three rotors

References

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Ecodesign and Energy Label – EU Requirements of Electric Storage Water Heaters

Student: Saad Al Dughaishi / Supervisor: Dr Ing. Christopher Micallef / Co-Supervisor: Dr Ing. Paul Refalo

Introduction

Manufacturing green products has become a necessity in most industries around the world due to their environmental impact and economic value. Appliances should be manufactured taking the environmental impact of both their production and use into consideration. Electric storage Water heaters are appliances where the efficiency is essential to reduce the life cycle energy consumption.

Project Objectives

The objectives of this project were to identify EU Ecodesign and Energy Labelling requirements relating to electric storage water heaters. Design a test rig to verify adherence to these requirements and perform tests to a sample of electric storage water heaters as supplied by MCCAA.

Project Methodologies

EU methodology 2014/C 207/03 'Transitional methods of measurement and calculation for the implementation of regulation (EU) No 812/2013 Ecodesign and for the implementation of delegated regulation (EU) No 812/2013 energy label' [1], was implemented to test the electric storage water heaters. These tests are performed over a 24 hours period and involve seven stages;

1- Installation: electric storage water heater is installed according to the manufacturer instruction [2]

2- Stabilisation: the electric storage water heaters were stabilised to the ambient temperature

3- filling and heat up: the electric storage water heaters were filled and then energies in the out of box mode.

4- Zero-load stabilisation: The electric storage water heaters were kept energised for 12 hours [2].

5- Draw offs: After 12 hours stabilisation of the stabilisation draw-offs stage begins after last thermostat cut-out after 12 hours of stabilisation. Draw off are made according to the declared load profiles in the directive.

6- Re-Stabilisation: The electric storage water heaters were kept energised for 12 hours period [2].

7- Mixed water at 40°C: it is the quantity of water drawn at 40°C which has the same content as the hot water drawn above 40°C.

Results and Achievements

The objective of this project was achieved by carefully implementing the EU test procedure 2014/C 207/03. Results show that the four electric storage water heaters under test matched closely with the data declared in the fitch and with requirements set in EU directives except for one 50 litre electric storage water heater which was overrated.

It was observed that efficiencies of the electric storage water heaters were affected by thermostat temperature setting. When the thermostat temperature was set to maximum, the efficiency of the water heaters was reduced. End users should be made aware of the impact that thermostat settings can have on efficiency.

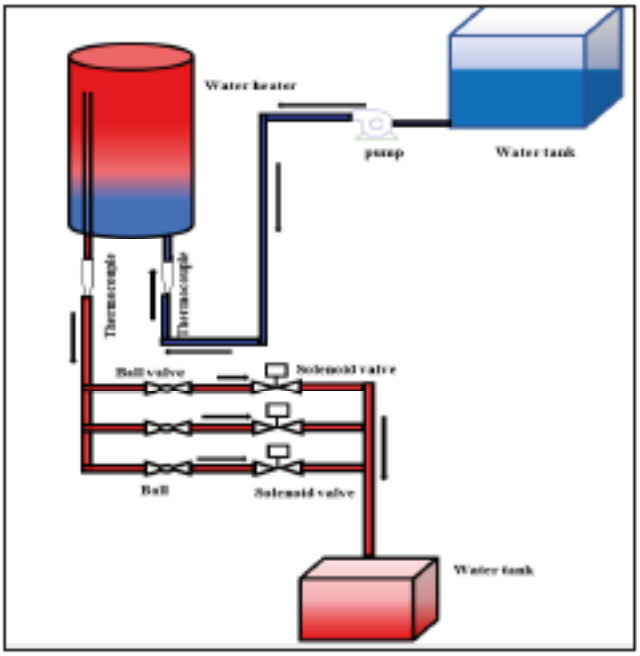

Figure 1: Experimental setup

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[Journal]

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Experimental Characteristics of a Hydrodynamic Rudder

Student: Basel Fael Al-Saimi / Supervisor: Dr Simon Mizzi

Introduction

Cavitation is an undesirable phenomenon commonly encountered in the maritime industry. This phenomenon imparts a significant cost impact to the industry in terms of both maintenance and operations. The cavitation inception could cause deterioration of the control surface and eventually structural failure of the component, including propellers, rudders and other hydrofoils.

Project Objectives

- Investigation of a hydrodynamic rudder characteristics in an installed high-speed water tunnel.
- Finding new method of measuring forces.
- Understand the cavitation phenomenon.
- Investigating the destructive nature of cavitation.

Project Methodologies

The use of shear sensitive liquid crystal coating (SSLCC) to obtain qualitative information on shear stress, was extended to include water tunnel testing, using simple lab equipment. The SSLCC was applied using an airbrush technique to have a uniform layer of coating. The coating was sprayed on three symmetrical hydrofoils including a flat-plate, NACA0020 and HSVA-MP-series. The flat-plate was used to build the foundation of SSLCC calibration.
The SSLCC is sensitive to both the illumination source and the direction of observation [1]. So, the camera was set facing downstream with the smallest angle possible to the flow. The illumination had to be at 90 degrees to the surface under investigation.

Image acquisition was done using a DSLR Canon camera, fixed on a tripod. The images were taken manually, and the perspective transformation was required to start analysing colour changes. The images were then analysed using MATLAB image processing tools.

Results and Achievements

Using the SSLCC it was possible to investigate the change of shear stress along the tested surfaces. The SSLCC react with the change in shear by changing the colour reflected out of the surface. The colour change ranges from red being almost zero shear to blue which represents very high shear. The colour change was analysed using MATLAB image processing tool, by converting the RGB values of the image to Hue values, which are represented in degrees. The analyse of colour change indicate the complex flow patterns and shear stress values changing over the surface.
The shear stress observed was influenced by 3D flow effect, which resulted in different flow patterns than expected. The destructive phenomena of cavitation were observed at high flow speeds. The phenomena were found to impact the test surface and deteriorate the SSLCC layer for NACA0020 profile at maximum flow-rate and angle of incident 20° degrees to the flow.

References

[1] J.-S. Zhao, P. Scholz, and L.-X. Gu, "Measurement of surface shear stress vector distribution using shear-sensitive liquid crystal coatings," Oct. 2012.

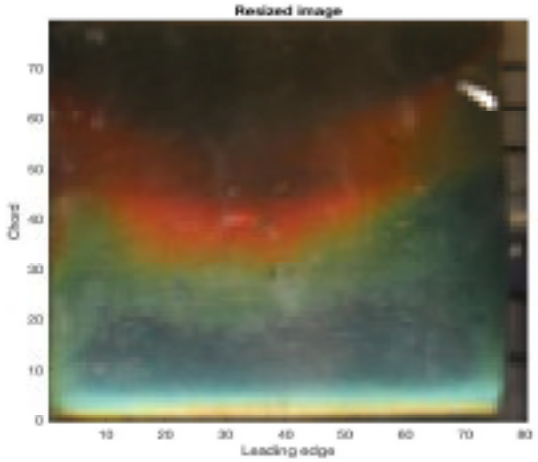

Figure 1 change in colour on HSVA MP 71-20 profile

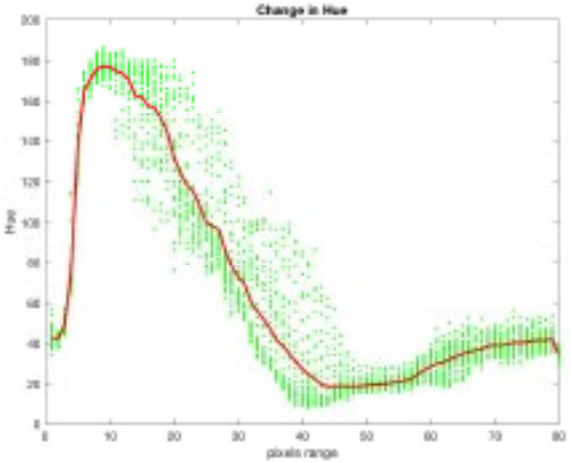

Figure 2 Hue vs Chord plot for HSVA-MP 71-20 hydrofoil

Conceptual Design of a Centralised Floating Energy Storage Platform for Offshore Wind Farms

Student: Andrew Borg / Supervisor: Prof. Ing. Tonio Sant / Co-Supervisor: Dr Ing. Robert N. Farrugia

Introduction

A 2014 report by the Intergovernmental Panel on Climate Change (IPCC) [1] reported that atmospheric levels of carbon dioxide rose by 120 parts per million over the last one and a half centuries. In a day and age when overpopulation and environmental detriment are causing catastrophic effects, renewable energies such as large-scale wind projects far from coastal regions are fast becoming a leading alternative to the world's heavy reliability on fossil fuels. A primary disadvantage of wind energy is its intermittency and thus, the development and simultaneous integration of renewable energy with energy storage systems is a current topic of primary importance.

Project Objectives

The primary objective of this project was to create a conceptual design of an offshore platform after carefully selecting the most suitable energy storage systems, followed by the hydrodynamic analysis of the offshore structure for metocean conditions typical of the North Sea region using the ANSYS AQWA® software package.

Project Methodology

The offshore platform was selected to be a tension leg platform and integrates two different energy storage systems. The first is based on the FLASC concept developed by the University of Malta. FLASC is a patented energy storage system, comprised of a liquid – piston accumulator, where energy storage is achieved through air compression. The second system is made up of vanadium redox flow batteries, installed on the platform deck [3].

The proposed design parameters were selected by means of a MATLAB® model, through which a parametric analysis was carried out. The numerical model generated was hydrostatically validated, yielding highly accurate results. The hydrodynamic validation was qualitatively validated, and the quantitative results were compared to previous works related to offshore platforms.

Results and Achievements

The simulations performed showed satisfactory response to the applied wave and wind scenarios. Furthermore, the results showed the substantial effect that viscous effects have on the floating structure, with the hydrodynamic response improving drastically when included in the analysis. The two loadcases analysed, with and without the additional mass of compressed air, showed very similar response despite causing a 10 per cent variation in the overall mass of the floating structure. Response results obtained were compared to NORDFORSK [2] criteria with a satisfactory outcome, in order to assess the seakeeping criteria of the offshore structure with respect to human effectiveness.

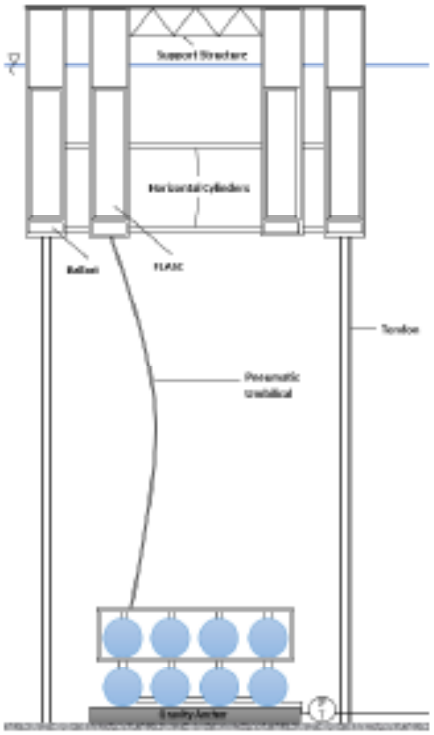

Figure 1: A basic schematic of the conceptual design

References

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[2] "NORDFORSK (1987) - Seakeeping Criteria," p. 1, 1987.

[3] "Renewable Energy Storage - FLASC." [Online]. Available: https://www.offshoreenergystorage.com/.

Assessing the Structural Performance of Remote-Control Transmitter Protection Handles Subject to Impact Loading

Student: Leonie Borg / Supervisor: Prof. Ing. Duncan Camilleri

Introduction

Industrial remote controls are used in harsh environments where both the material and geometry of the industrial handles are challenged through drops against hard surfaces. Customer demands are making remote controls larger and heavier, resulting in an increase in impact forces and moments upon impact.

Project Objectives

Focusing on the remote control transmitter protection handles, the aims of the final year project were:

- Benchmarking of the current design limitations through destructive testing
- Proposing five different plastic composites and analyzing their impact resistance through Izod impact testing
- Experimentation of the chosen plastic composites through drop testing to find a more suitable material than the current one being used

Project Methodologies

Five different plastic composites were chosen based on impact strengths extracted from datasheets, and typical plastic materials used in handheld industrial enclosures. Experimental Izod notched and unnotched testing was then performed on each material specimen to establish which materials exhibit higher impact resistances.

The current top housing material used in industry was tested through drop testing to establish the height at which failure occurs. The five different composites were injection moulded into the current top housing design and drop tests were performed to determine which material would be better for impact loading applications.

The most suitable material was implemented onto finite element analysis to prove that lower stresses occur from the chosen material when compared to the current material being used.

Results and Achievements

From the Izod impact testing it was concluded that the best material for the application is PC + ABS which exhibits the highest impact resistance from all five materials both when notched and unnotched specimen were tested. Drop tests further verify the aforementioned as the top housing did not break from the failure height when compared to the other materials.

Upon drop testing with the current material, PA6 30 % glass fibre, the area of failure was established to be the thin walled cross-sectional area. FEA model proved that this was the case since larger stresses were noticed at that area. When the chosen material was applied to the model the stresses decreased, proving that PC + ABS would be a better impact resistant material.

Figure 1: Izod Impact Testing of Different Plastics

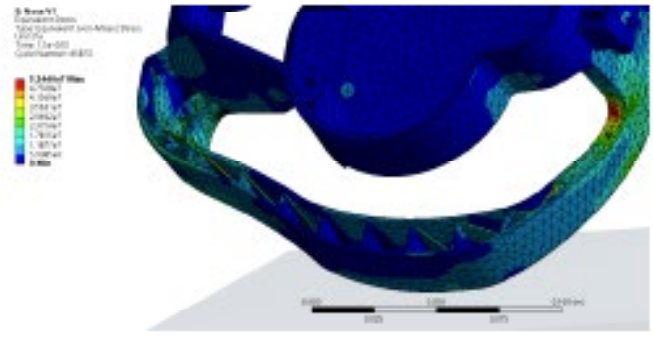

Figure 2: FEA of Remote control transmitter protection handles

Analysis and Improvement of a Preliminary Design of an Offshore Support Vessel

Student: Timothy Borg / Supervisor: Prof. Ing. Claire De Marco

Introduction

Offshore support vessels have become increasingly essential in operations in which the transportation of goods is required to and from offshore instalments such as windfarms and fish farms. The project aims to carry out further work on a preliminary design of an offshore fish farm support vessel and perform various analysis on the enhanced design.

Project Objectives

The main objective is to produce an improved design of the vessel by designing the internal structure and modifying the existing general arrangement whilst keeping compliance to class rules and maritime standards. Further objectives include analysing the longitudinal strength, intact and damage stability and floodability of the vessel.

Project Methodologies

Prior to carrying out the design of the internal structure of the vessel, extensive research was carried out on different types of offshore support vessels and strengthening methods which varied depending on the vessel's size. Class rules provided by Det Norske Veritas (DNV) which are applicable to this type of vessel were consulted before designing the internal structure. It was made sure that the positioning and thicknesses of structural members were compliant to the aforementioned structural rules.

The design of the internal structure was complete using Bentley system's design software, MAXSURF Structure [1] and is shown in Figure 1. The longitudinal strength of the whole vessel was then assessed by first superimposing the mass distributions of separate weight groups. By then obtaining the buoyancy distributions in both still water, as well as in a hogging wave, the bending moments and hence bending stresses were calculated. The latter as well as the design of the internal structure allowed a midship section analysis to be conducted, which was carried out under loading conditions in accordance to maritime standards.

Due to slight changes in the general arrangement the intact stability of the vessel was re-analysed. The damage stability was also analysed after extensive research on different damage scenarios. The stability in both conditions was analysed in accordance to the HSC 2000 Code [2] along with the aforementioned loadcases and damage cases. Finally, a floodable length calculation was carried out to check if additional watertight bulkheads are needed in the design.

Results and Achievements

Results from the longitudinal strength analysis in still water showed that the vessel behaves in a hogging manner and hence to simulate a worst-case scenario, the longitudinal strength of the vessel in a hogging wave was analysed. The maximum bending moment at amidships resulted to be 1.33 MNm. The latter was used to calculate the midship bending stress at the deck and the keel after calculating the midship section modulus and moment inertia. The bending stress resulted to be 7.3 MPa, well below the allowable 120MPa.

The stability analyses showed that in the intact condition, the vessel retains its seaworthiness with regards to stability. In the damaged condition, all criteria is met except for when the engine room floods in the loadcase in which the vessel is relieved from the payload, but has full stores and fuel tanks. Furthermore, in the case of asymmetrical flooding, the vessel's heel remains compliant to criteria with a maximum heel angle of 9°.

The results from the floodable length calculation show that two additional bulkheads are required in the accommodation space and engine room, however, the software used for analysis does not take into consideration the reserve buoyancy in the double bottom spaces and hence in reality, results may vary.

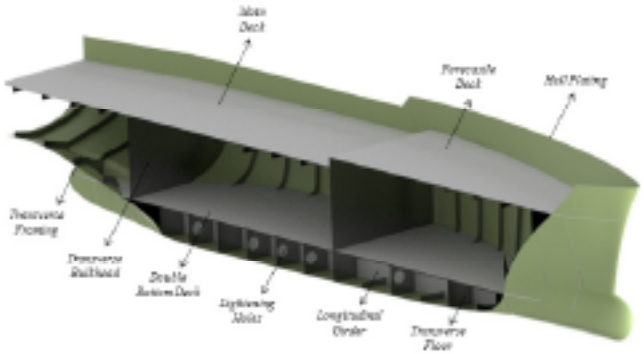

Figure 1: Internal structure design of vessel

References

[Software]
[1] "MAXSURF Structure." Bentley Publishers, 2016.

[Standard]
[2] "HSC 2000 Code – International Code of Safety for High – Speed Craft, 2000 Resolution MSC.97(73)

Application of Dynamic Geometry and Mesh Techniques in Computational Fluid Dynamic Engineering

Student: Eric Borg Saywell / Supervisor: Dr Ing. Simon Mizzi

Introduction

The hydrodynamic performance and flow field of a propeller has been investigated by means of novel computational fluid dynamics strategies and methods. In particular, the focus is drawn on the relative influence of static and dynamic discretization techniques which are then compared with experimental data with actual experimental data in order to validate the global and local hydrodynamic flow quantities of the propeller.

Project Objectives

1. Basic Dynamic Discretization Methods were applied to simple geometrical problems to study and implement various dynamic mesh methods.
2. The hydrodynamic properties of a fixed pitch propeller under steady state conditions were validated by means of a Moving Reference Frame (MRF) method under a constant and static discretization grid.
3. Dynamic Discretization methods and a rotating Sliding Mesh method were utilized to model the same problem for propeller validation. The results obtained from these methods were then compared to the MRF method results of the propeller in the same experimental conditions.
4. These results were then compared and contrasted while highlighting the main advantages and disadvantages of each method.

Project Methodologies

1. Preparation of Geometry: The fluid domain was divided in two. The propeller was modelled inside an Inner Fluid domain were fluid rotation was simulated. An Outer Fluid domain consisted of a static fixed volume.
2. Model Discretization: A hybrid mesh was set up. The propeller and Inner Fluid domain were meshed with an unstructured e-size of 0.025m and 0.1m respectively. An O-Grid Structured mesh was setup for the Outer Fluid domain.
3. Mathematical Model: The k-ω-SST turbulence model was utilised and a velocity inlet and pressure outlet were the main BCs used.
4. Method: MRF, Rotating Sliding Mesh and Dynamic Discretization methods were used to validate the propeller thrust at various Advance Ratios.

Results and Achievements

Problem Specification

Graph Digitization was carried out to obtain values for thrust. Lerbs equivalent profile method was then used to attained values for the advance speed and prop rotational speed as a function of Reynolds Number.

Moving Reference Frame

As theory suggested, the MRF method was the least computationally demanding of the 3 methods.

Sliding Mesh Methods

This method proved to be relatively computationally demanding since the Inner Fluid domain mesh experienced rotation.

Dynamic Mesh Methods

Smoothing, Layering and Remeshing methods were all used to retain mesh quality during the propeller rotation. It was the most computationally demanding though the most versatile method.

Method Validation

All 3 methods achieved conformant results with the experimental data with the largest discrepancy being 6.44% and the least 0.85%.

Validation				
Method	J	T-exp (N)	T-CFD (N)	T-error (%)
MRF	0.5	40.163	41.586	3.54%
	0.4	96.571	97.636	1.10%
	0.3	145.602	147.090	1.02%
Sliding Mesh	0.5	40.163	42.731	6.40%
	0.4	96.571	97.389	0.85%
	0.3	145.602	147.730	1.46%
Dynamic Mesh	0.5	40.163	41.088	2.30%
	0.4	96.571	102.235	5.86%
	0.3	145.602	136.232	6.44%

Post Processing

A number of post processing tools were applied on the propeller to analyse the fluid dynamics it underwent and find zonal areas prone to mechanical failure by cavitation.

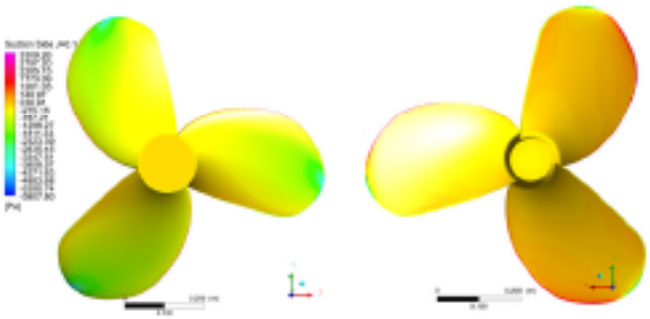

Figure 1: Pressure distribution across the propeller

Easy Stand-Up Aid

Student: Albert Busuttil / Supervisor: Dr Zdenka Sant

Introduction

Indepenence in every-day activity is problematic in people who suffer from somekind of mobility impairment. Being sports injuries, medical conditions or due to ageing. Thus they need some equipment that will provide support or aid, while being affordable. The preservation of this independence helps both mentally and physically.

Project Objectives

In order to help with mobility impairment, a medical aid helping people perform a basic sit-to-stand (STS) motion was to be designed. The device had to be portable, lightweight and also affordable as to be used extensively by the public in need.

Project Methodologies

Firstly, the muscle activity that takes place during STS had to be studied. This would help in the design of the aid to cater for any possible weaknesses that one suffers. This would help both in independence in motion and also muscle rehabilitation if possible. [1]

Furthermore, the 4 Stages of STS were observed. This would help us better understand where the aid would work best. A volunteer undertook the experimental test that provided the necessary data to understand STS by using sensory mats. The Sensory Mats were used to observe the activity taking place on the seat and on the floor during this transition.

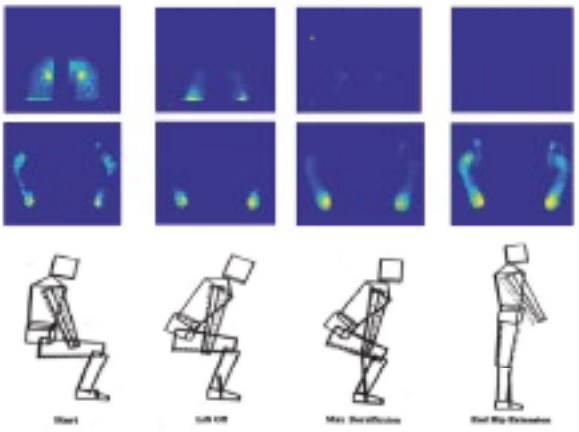

Figure 1: 4 Stages of Sit to Stand Motion and Forcemat Results

Results and Achievements

The 4 stages of STS motion where studied, and the respective activity taking place on the seat and floor were also found. The results were summarized as shown in Figure 1. This helped us understand at which stage the aid will be of use.

Studies show that the hardest part of STS takes place between the 2nd and 3rd stages. This was also confirmed through our study. [2] This means that the aid will help the person lift off, but he/she has to be able to stand independently or with the aid of walking sticks or other walking aids. If this is not possible, the aid would not be suitable for said persons.

The chosen design works with tension spring. This easy concept would make maintenance quick and easy compared to other technologies such as hydraulics. In order to overcome the sudden displacements that occur due to springs, air – pneumatics were introduced. This then dampens the motion of the seat. The final design was drawn as shown in Figure 2.

References

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[2] Kerr, K., White, J., Barr, D. and Mollan, R. (1997). Analysis of the sit-stand-sit movement cycle in normal subjects. Clinical Biomechanics, 12(4), pp.236-245.

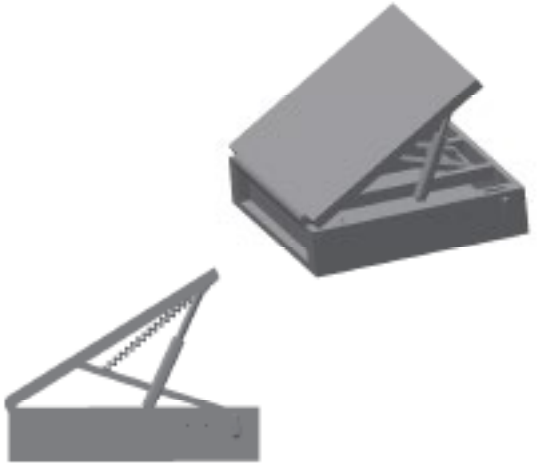

Figure 2: Design of Medical Aid

Solar Cooling

Student: Dylan Camilleri / Supervisor: Prof. Robert Ghirlando

Introduction

The global temperature of the Earth is continuously increasing as a result of CO_2 emissions coming from various sectors such as agriculture. A joint project, ViEnergy [1] was set up with the aims of reducing emissions and energy costs in the wine industry. As part of this project, a vapour absorption system was installed having seventeen solar collectors, over-designed to collect enough heat during cloudy days and early in the morning. Excess heat is generated especially during the summer season, having full solar radiation and vapour absorption chiller working in full operation mode.

Project Objectives

The dissertation is a continuation of a previous mechanical engineering project [2], with the aims of designing, building and installing a sub-system that solves the problems of overheating and perform tests to check that the sub-system works.

Project Methodologies

The sub-system added together with the hot-water generation loop were tested. The circulation pump is switched on at a water drain-back temperature of 95°C and switched off when 70°C is reached, controlled using an electrical digital controller. Thus heat collected from the solar collectors and delivered to the drain-back tank, is circulated through a heat exchanger contained inside a concrete vat and heat is transferred to the water contained in the vat. Since the vapour absorption chiller was not operated, all the heat collected by the collectors was used to heat the water inside the vat. Three sets of temperatures were recorded, of the water inside the drain-back tank, of the water inside the vat and of the solar collectors stainless-steel piping to verify that water vapour formation would be avoided as the latter would damage the solar collectors.

Results and Achievements

When the water temperature inside the drain-back tank, measured using an NTC temperature sensor, reached 95°C, the pump was switched on and the water contained inside the vat started to heat up, as shown in Figure 2, while that of the drain-back tank started to decrease in temperature. The water temperature in the vat increased from 13°C up to almost 27°C and hence the system is able to store heat in the form of hot water for later use. The heated water inside the vat could then be used to prolong the period of operation of the vapour absorption chiller, by reversing the roles of the drain-back tank and the vat, where now the vat would be the source of heat and the drain-back tank as the sink.

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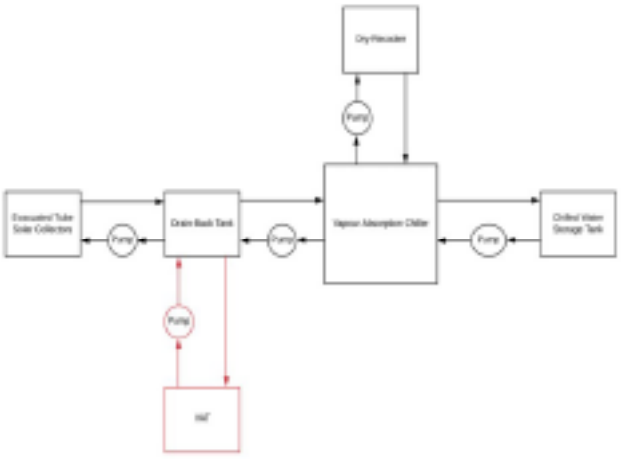

Figure 1: The sub-system modification, shown in red

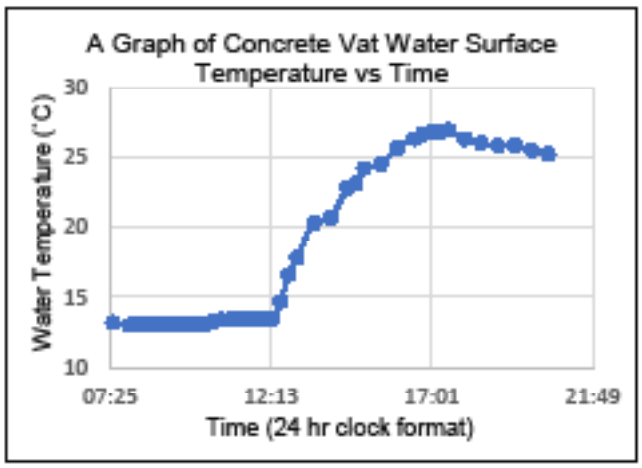

Figure 2: Vat water temperature against time graph

Natural Language Processing for Sentiment Analysis

Student: Luke Camilleri / Supervisor: Dr Kenneth Scerri

Introduction

In today's business and technology world, data analytics has become indispensable, with technologies such as sentiment analysis allowing companies and corporations to gain key insights about consumer perceptions and opinions that can help shape effective strategic and marketing decisions.

Sentiment analysis can be defined as the process of automatically extracting an opinion about a specific topic from the written language.

Project Objectives

The aim of this project was to design and implement a sentiment analysis algorithm capable of extracting sentiment orientation from user generated tweets through the use of suitable natural language processing techniques.

Project Methodologies

In order to implement a sentiment analysis algorithm, the raw tweets extracted from twitter were pre-processed removing any irrelevant information such as hashtags and stop words. Then important information relevant to the sentiment analysis task was extracted from the processed tweets using word vectors that represent the semantic relationships between words. These word vectors were then used as the inputs to the sentiment classifier which was capable of classifying the input tweets in terms of positive, negative or neutral sentiment polarity with respect to a specific topic as shown in Figure 1.

Given the successes being reported in literature of using deep neural networks for sentiment analysis, these were used to implement the sentiment classifier within this dissertation. Multiple deep learning classifiers mainly, feedforward, convolutional and recurrent neural networks were trained and evaluated on two annotated datasets related to the topics of climate change and technology products respectively. The performances of these deep learning models were compared and contrasted with commercially available sentiment analysis tools and contemporary literature in order to evaluate their potential as sentiment analysis algorithms.

Results and Achievements

The performance of the implemented deep learning models compares favorably with contemporary approaches for sentiment analysis of tweets and commercial and freely available tools highlighting the potential of deep learning models when applied to sentiment analysis tasks [1] [2]. The results also underlined the variance in performance of a model when applied to different topic domains, with models performing better when applied to the technology dataset. This implies that it is not easy to extract sentiment from domains that lack clear sentiment indicators and contain subtle nuances such as the climate change dataset, while performing better on datasets that

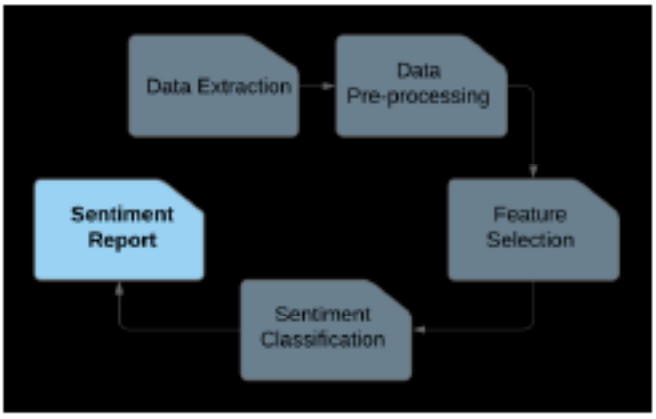

Figure 1: The process of Sentiment Analysis

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Principal Component Variances in Human Hands

Student: Amy Cutajar / Supervisor: Prof. Ing. Michael A. Saliba / Co-Supervisor: Mr Donald Dalli

Introduction

The hand is one of the most complex organs in the human body capable of achieving a total of twenty-one degrees of freedom. Over the years, multiple researchers strived to establish synergistic movements in the human hands with the aim of reducing the mechanical complexity in multi-fingered and prosthetic devices through dimensionality reduction whilst at the same time also retaining a high level of dexterity.

Project Objectives

The main objective of this study was to design, implement and evaluate a set of experiments to investigate and identify the variances in principal components (PCs) in the use of the hand during normal activities involving grasping and manipulation. Principal Component Analysis (PCA) was used to investigate PC variances for both the unconstrained and constrained hand and for the dominant and non-dominant hand.

Project Methodologies

The approach adopted towards everyday task selection was based on literature which established the problems encountered by bilateral upper limb amputees on a day-to-day basis [1]. A total of eleven bimanual tasks were extracted, each involving a number of grasping and manipulation techniques. All tasks were performed by a total of thirty participants, twenty-seven right-handed participants and three left-handed participants, under both free and minimal anthroponorphic conditions. Free conditions require participants to perform tasks using all five digits while minimal anthroponorphic conditions require participants to perform the same tasks but using just the thumb, index and middle finger [2].

All experimental tasks were carried out with participants wearing VMG 30 data gloves. These data gloves are equipped with resistive bend sensors which through the use of a resistive bend sensing technology change resistance when deflected. All resistance values are then automatically connotated to joint flexion and extension angle values by the VMG 30 data glove Software. The complete experimental setup can be observed in Figure 1.

PCA was then implemented on the extracted data through the use of IBM SPSS Statistics Software.

Results and Achievements

A total of eight different PCA results were extracted for the dominant and non-dominant hand of both right-handed and left-handed participants under normal and minimal anthroponorphic conditions. Preliminary results indicate that 5 PCs are required for the dominant and non-dominant hand under normal conditions and 3 to 4 PCs are required for the dominant and non-dominant hand under minimal anthroponorphic conditions. These extracted PCs can be used to design simplified, under-actuated multi-fingered and prosthetic hands which are controlled through a programmed algorithm based on the coefficients of determination generated from PCA.

Moreover, GoPro Footage analysis showed coexistency with the existence of postural synergies in human hands, and also confirmed that hand use for identical tasks varies between different people, therefore indicating that the PCs may also vary. A preliminary attempt was made to classify persons into separate groups according to their PCs through statistical data binning, however this could not be accomplished due to a number of observed anomalies in the data gloves output that will

Figure 1: Experimental setup

References

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Numerical Modelling of Progressive Failure Analysis of Fibre Composites

Student: Matthew Cutajar / Supervisor: Prof. Ing. Martin Muscat

Introduction

Fibre reinforced composite materials have become increasingly popular and continue to be used in a wide range of applications, especially within the automotive industry. As their utilisation in structural applications increases, the need for non-destructive testing approaches continues to receive a lot of attention and importance. Carbon is one such high-performance fibrous material, commonly used as reinforcement in advanced polymer matrix composites. [1],[2]

Project Objectives

The main aim of this project is to put forward a practical aspect of progressive failure analysis methods in order to compliment the amount of literature available. This research aims to develop an algorithm capable of detecting first ply failure and studying progressive ply failure of any fibre reinforced composite.

Project Methodologies

This project employs the features of the software package, ANSYS APDL, which is an acronym that stands for ANSYS parametric design language. It is commonly used for its powerful scripting capabilities and ease of modelling parametric designs. It may also be used for automating lengthy tasks that are replicated for say, every finite element within the model.

Furthermore, powerful functions are readily available and easily accessible, such as the retrieval of information from the post-processor results database. This may range from the location of individual nodes to the maximum stresses being experienced in the component being tested.

Results and Achievements

The algorithm developed is capable of analysing the stresses being experienced in an arbitrary component of random dimensions and material type. Furthermore, the user is able to determine the ultimate load using the failure index and the strength ratio as reference. The algorithm is also able to degrade material constants of damaged or failed finite elements.

The data for each type of load case was compared by plotting Load against Displacement graphs, where the gradient represented the component stiffness. Finite Element Analyses were also carried out in order to observe the stresses being experienced by the component in each scenario.

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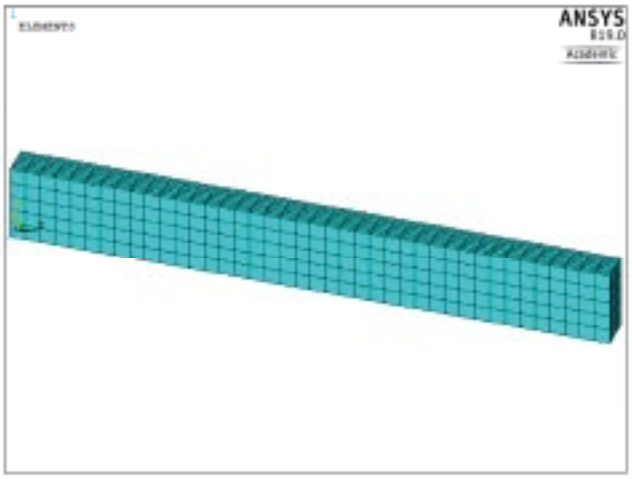

Figure 1 – Arbitrary Fibre Composite Structure

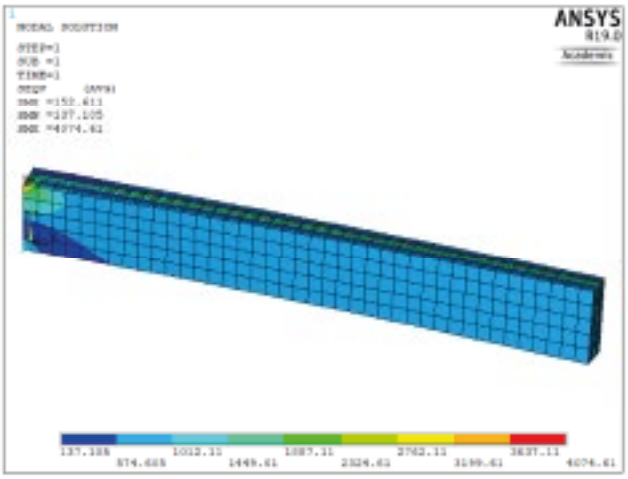

Figure 2 – von Mises Stress plot for Cantilever Fibre Composite Structure under Tension with varying Fibre Orientations

Performance Testing and Inverter Operation of a Groundwater Heat Pump

Student: Matthew Darmanin / Supervisor: Prof. Ing. Mario Farrugia

Introduction

Throughout the year, the earth maintains a relatively steady temperature. Groundwater Heat Pumps (GWHPs) use a groundwater supply as a constant temperature heat source and sink. [1] In previous dissertations, a water well dug in soil rock was used as a geothermal coupling for a GWHP. In this year's project, the GWHP was modified to work with a brick-walled well in a dug rock pit.

Project Objectives

The aim of this dissertation was to rebuild the water circuit and test the heat pump operating in cooling mode. Additional testing was done to investigate the effects of using an inverter in the system. Thermal stratification in the water body was also recorded and analysed.

Project Methodologies

Dimensions of the well were obtained after the well was emptied. LDPE pipes were laid out to connect the well to the double-pipe heat exchanger in the thermodynamics lab. A temperature sensor was installed to monitor the temperature of the well.

Several thermocouples were installed throughout the refrigeration circuit. Pressure gauges were also used to measure the evaporator and condenser pressures. Furthermore, a turbine flowmeter was installed and tested to obtain an experimental value for the refrigerant flowrate. An inverter was added to the system in order to vary the operating frequency of the compressor.

The system was tested in cooling mode under different operating conditions by varying the water flowrate and the inverter frequency. The water flowrates used were 7.5, 10 and 15 litres per minute whilst the inverter frequencies were 35, 40, 45 and 50 Hz. The system was also tested without the inverter. From the temperature and pressure data, the enthalpies at each point of the refrigeration cycle were calculated and used to find the coefficient of performance of the system (COP).

Temperature readings were taken at various depths to record the stratification in the water. Additional tests were done to measure the period of pump operation required to mix the water, removing the stratified layers.

Results and Achievements

The COP of the system working as a heat pump was found to be 2.96 compared to 2.86 from the previous configuration. The highest COPs were obtained at 15 litres per minute, using the inverter at 40 Hz at low loads and without the inverter at high loads. The variation of the COP with the inverter frequency are shown in Figure 1.

The turbine flowmeter was tested with the thermal expansion valve (TXV) and the expected relationship was confirmed in multiple testing conditions. The highest refrigerant flowrates were observed at the highest inverter frequency, as illustrated in Figure 1.

The highest levels of stratification were noticed just after heat pump operation due to the hot water being dumped into the well. Allowing the water to settle caused the temperature difference between layers to decrease. Operating the pump at full capacity for approximately 3 hours removed the stratification and the water reached a uniform temperature.

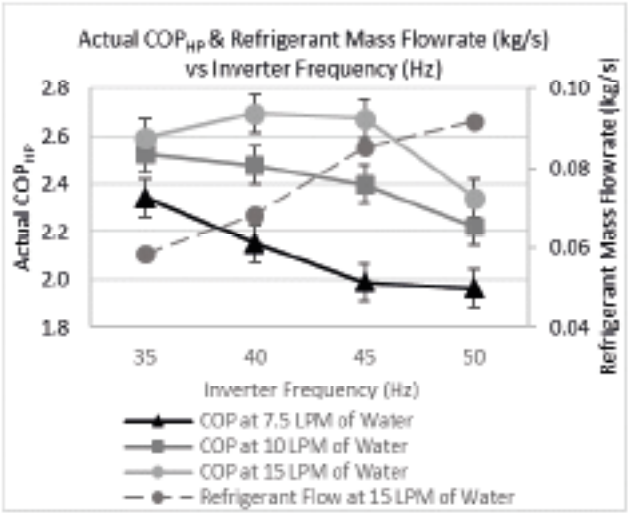

Figure 1: Actual COP_{HP} & Refrigerant Mass Flowrate (kg/s) vs Inverter Frequency (Hz)

References

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Impact of Lightweight Maritime Composite Panels

Student: Mark Defelice / Supervisor: Prof. Ing. Claire De Marco

Introduction

The dissertation presents a study on sandwich and laminate panels and the behaviour of the panels when subjected to low-velocity impact. The multi-layered and two-skin sandwich panels were made from twill flax fibre with 5mm and 10mm foam core in between respectively. The laminates constructed were made from sisal, twill flax and twill glass with POLYLITE® 440-800 E marine resin.

Project Objectives

- Literature review of impact on lightweight composite structures.
- Design and fabrication of various test panels of in-service materials for impact testing.
- Verification of impact experimentation test results with impact theory

Project Methodologies

The experimental impact procedure was carried out in accordance to the (ASTM) D7136/D7136M-05 Standard Test Method for Measuring the Damage Resistance of a Fibre-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event. Three incrementally drop heights and impact mass combinations were set, to enable three different energy levels to cause different damage events to the panels. For the multi-layered sandwich the damage occurred just below the middle layer. To achieve such a pentation a total drop mass of 14 kg from a drop height of 1.5m is required. The two-skin sandwich panel and the sisal laminate were subjected to the same energy levels as the multi-layered sandwich panel so that the impact events can be comparable.

Lower energy levels were used for the flax damage due to low thickness, in order not to cause catastrophic damage so that the damage can be well visualized. Following the impact, the panels were sectioned to visualize the damage, the effect of face thickness and the foam core. The peak force and impact time were recorded, the energy absorbed and maximum indentation were noted and calculated.

The energy balance model was used to calculate the impact force and time periods when the sandwich panels and laminates were subjected to different energy levels. The results obtained from the analytical models were compared to the experimental results and showed the between the peak force and the time period with the drop height.

Results and Achievements

The multilayered sandwich panel reached the maximum peak force and the absorbed the most energy. The two-skin sandwich panel although the peak forces was less than the multi-layered sandwich panel it absorbed nearly the same energy in a longest time period. The sisal laminate absorbed a good amount of the energy. The flax laminate absorbed the least energy. The experimental data was then compared with the energy balance model [1]. Comparison was done with small variations, this showed that the experimental values were correct.

References

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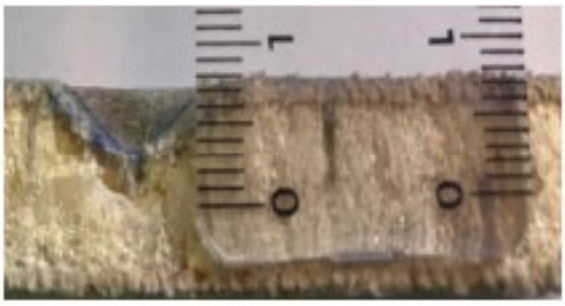

Figure 1: Two-skin sandwich panel subjected to 14 kg mass and 1.5 m drop height

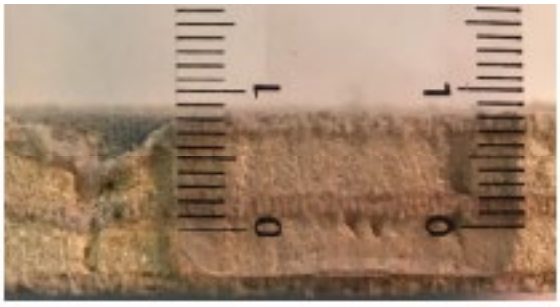

Figure 2: Multi-layered sandwich panel subjected to 14 kg mass and 1.5m drop height

Preliminary Design of a Tugboat

Student: Aaron Demanuele / Supervisor: Prof. Ing. Claire De Marco

Introduction

In a world where trade is exponentially increasing, the need for larger container ships keeps intensifying. Having a very limited maneuverability, a container ship needs additional assistance by a number of tugs in order to steer and berth in a port. As container ships get larger, tugs need to be more abundant and capable. This project aims to provide a design of one such vessel.

Project Objectives

As regards to tug design, the project is meant to:

- Estimate the main dimensions and required power
- Assess the stability on the basis of classification societies' criteria
- Produce a final preliminary design drawing

Project Methodologies

The project started with an analysis of the most generic types of tugs and emerging designs, such that a more familiar approach is achieved during subsequent stages. The ship escorting operations involved in such an industry were deliberately looked into.

The design statement entailed the operations in the Maltese or similarly sized ports. Based on the design statement, the most adequate type of tug was chosen to build subsequent processes upon.

The minimum power requirements were found according to conditions provided in the classification societies' design guidelines and applied for the typical operations engaged in Maltese ports. Subsequently it was verified that the power was enough to cater for the tug's maximum free running speed.

Classification societies classify tugs as an individual class which must adhere to criteria specifically designed for ships engaged in escorting operations. In an effort towards increasing the maneuverability of the tug, the length should be minimal. Variation of the main dimensions was examined through the creation of three different virtual models using Maxsurf Stability [1]. A study of how the criteria requirements vary amidst the iterations was conducted.

Results and Achievements

Ultimately a design with superior maneuverability and in line with all the relevant criteria was rendered.

Tug Sea Hero has an overall length of 25m, a beam of 12m and a design draught of 3.1 m. With an overall power of 5706 kW delivered by three Caterpillar 3512-C engines and three Rolls-Royce US 205-FP20 azimuth thrusters the tug is meant to be used for all types of escorting operations in the port. Redundancy is provided by two winches, one at the aft and one at the fore, each equipped with a suitable fairlead. Stability is augmented by the triangular configuration of the thrusters, one at the aft and two at the fore.

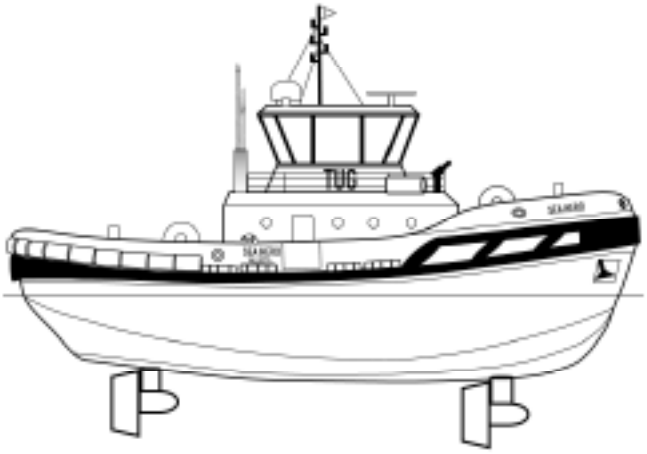

Figure 1: Outboard Profile for Tug Sea Hero

References

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Further Experimentation on the Free-Piston Engine

Student: Max Despott / Supervisor: Prof. Robert Ghirlando

Introduction

Due to recent developments in more sensitive sensors and faster processing power, the free-piston engine seems to be an attractive and promising replacement for the conventional engine. Having a structurally simple machine with less components and moving parts, a Free Piston Engine is expected to have lower energy losses due to friction and therefore better efficiency.

Project Objectives

The opposed free piston engine at the University of Malta has not yet run self-sufficiently. This dissertation aims to perform further experiments on the engine to reach or approach a state of independent operation.

Project Methodologies

Once motoring was attained and the engine was left to operate for a while, it was observed that the piston rotates on its own axis. Due to the geometry of the cylinder block, this results in a serious issue with regards to the obstruction of air flow through the ports.

An external plate with a slot was machined and a pin was attached to the connecting rod. The slot would act as a guide for the pin, preventing the undesired rotation from occurring. This was the simpler and less time-consuming method from the thought solutions as the engine would not need to be disassembled.

The correct operation of the spark delivery system proved to be a difficult task with a number of teething problems. Eventually, the spark signal was being outputted as required.

The fuel delivery system of the engine was structured such that the signal to initiate the pulse of the injector occurs at the beginning of a cycle. This was problematic due to the back e.m.f generated by the solenoid. Therefore, the circuitry was adjusted by adding two diodes resolving the issue.

After the first test run, combustion was yet to occur. To understand why, two separate intake pipes were machined and two separate injectors, one for each intake were fitted. The result observed was that the air fuel mixture was being pushed back up and escaping from the intake pipe. Two reed valves were manufactured and irregular combustion began to occur. A pressure sensor was installed on the cylinder flange to examine if the correct operation was being performed.

An experiment was carried out to calculate the frictional force the engine is required to overcome. Two methods were employed to ensure all results obtained correspond and are as accurate as possible. One method was using a mass spring scales and the other compressed air and, in each case, four different scenarios were tested.

Results and Achievements

During the scavenging process, the pressure inside the combustion chamber was found to be higher than that of the scavenging chamber. This shows that there is the possibility of flow back into the scavenging chamber rather than the opposite.

It was also noticed that during the period when the scavenging chamber is being filled with a fresh charge, a higher value than atmospheric was recorded which explains why the air fuel mixture was exiting from the intake pipes.

The results obtained from the frictional force experiment clearly indicated that piston and cylinder block at A have an excessive amount of frictional force and amendments would need to be performed if the free piston is to start.

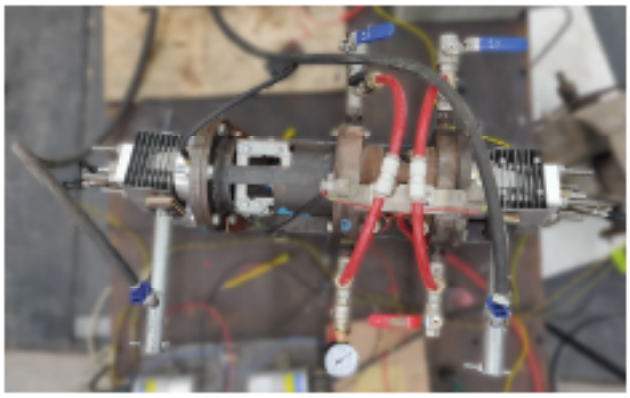

Figure 1: The Free Piston Engine at the University of Malta

Experimental and Numerical Analysis of Contact Pins

Student: Jake Diedo / Supervisor: Prof. Ing. Pierluigi Mollicone

Introduction

This study is in collaboration with Methode Electronics Ltd. where currently, contact pins are being utilised for various products. The contact pins are inserted inside a printed circuit board's plated through hole where contact is established.

Project Objectives

Press-fit pins are a subcategory of contact pins. These are termed press-fit pins since their width is wider than the hole's diameter, thus creating an interference fit. Their design allows them to be spring-loaded, thus obtaining the required contact. The study sets out to investigate the state of the art solutions for such pins, and consequently the aim was to benchmark pins found on the market and establish a relationship between contact pin geometry and their performance parameters. This was obtained through benchmarking and experimental and numerical analyses.

Project Methodologies

The pins were benchmarked by means of a multisensor measurement system, and upon measuring them, it was found that the pin dimensions and plated through hole diameter vary due to manufacturing tolerances which could be quantified. It follows that, different levels of interferences are possible. Experimental tests on the pins were carried out where they were physically inserted in the plated through hole to study the effect of interference on the insertion force.

Finite element models were created to further analyse the effects of the interference fit on the deformation of the pin. The finite element models were used to study the different deformation mechanisms of different pin types and their effect on the insertion force. Different designs and interference fits resulted in different levels of spring-loading by the pin. Furthermore, the influence of friction on the magnitude of the insertion force was studied by implementing it in the models.

Results and Achievements

The quantification of the force profiles of different pin geometries was achieved. It was concluded that different pin geometries and varying interference levels between the pin and PCB hole, play a large role on the insertion force magnitude and on the force displacement profile. It was also determined that friction heavily affects the force magnitude, however it was not possible to validate the value of friction.

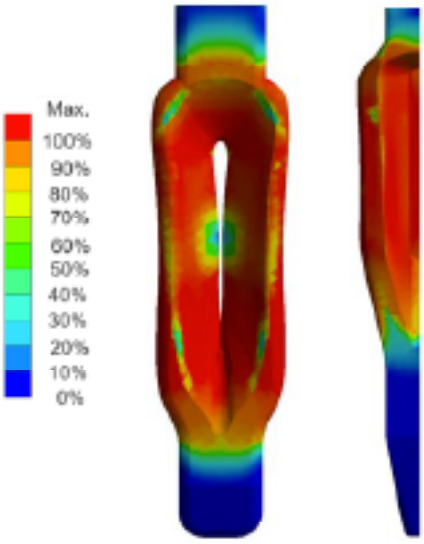

Figure 1: Finite element models of two different types of contact pins. The legend shows the percentage of the yield stress present in the pins

Experimental Analysis of GFRP Composite Pipe Bends

Student: Michael Dimech / Supervisor: Prof. Duncan Camilleri

Introduction

Composite materials are phasing out the use of metal-based materials for numerous components. Traditional materials are being replaced in the search for mechanically superior solutions a typical composite material can offer in industries such as the automobile industry, the naval industry, the energy generation industry (that is replacing metal-based piping systems with composite piping systems) and civil applications.

Project Objectives

The following study carries out a detailed experimental analysis of a number of pressure vessels containing a pipe elbow. Each elbow was of similar composition and manufactured using the hand-layup process. The elbows would undergo testing for two types of loads – internal pressure and bending.

Project Methodologies

A test rig was developed and constructed (Figure 1) together with a hydraulic circuit, hydraulic pump and valves to control the loading applied on the pipe elbow specimen. The hydraulic circuit of the rig was designed to apply such loads using five different configurations applicable to reflect the loads that such components can undergo during service. To monitor the mechanical performance of the pipe elbows during testing, strain gauges and an accelerometer were used to determine failures occurring in the elbows, such as first ply failure (FPF). Pressure transducers were used to monitor pressure inside the test specimen and in the actuator used to enact a bending moment on the elbow.

The test specimen was created with the following layup: [T/CSM/CSM/CSM/W/CSM/T]. The four layers of CSM give the elbow hydrostatic pressure strength, whereas the singular bi-axial woven roving layer (W) gives the elbow tensile strength in hoop and axial directions. The tissue layers (T) enhance the water retention properties of the pipe elbow.

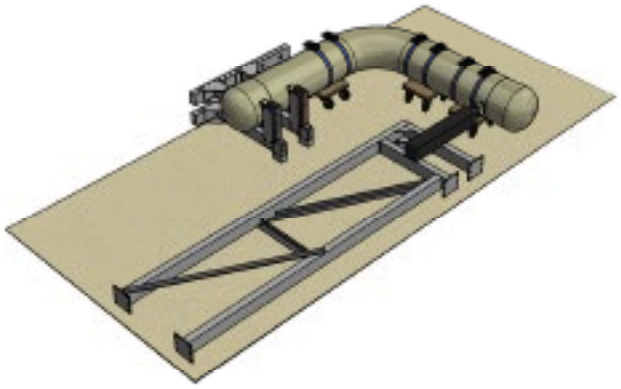

Figure 1: Testing rig for composite pipe elbows

Results and Achievements

The testing carried out in this study continues on the foundation laid out by previous researchers on GFRP pipe elbows. The testing rig constructed proved to be successful in supporting the test specimens as they were loaded, as were the devices used to acquire data with regards to the test specimen. The accelerometer was successfuly capturing any sign of FPF during testing, and the strain gauges were registering noticeable changes in the elbow. The majority of the pipe elbows tested would not experience signs of ultimate failure (such as rupture (Figure 2)) and remain elastic. This scenario was a result of the unexpected increase in mechanical properties of the pipe elbows when compared to numerical data, even when the pressure outputted from the pump was increased to encourage failure in the pipe elbow relative to values used in numerical analyses. The test specimens involving the manufactured pipe elbows, containing 5 layers, would support twice to three times the load when compared to pipe elbows containing three layers as used in the numerical analyses carried out by D.Camilleri and B.Ellul [1].

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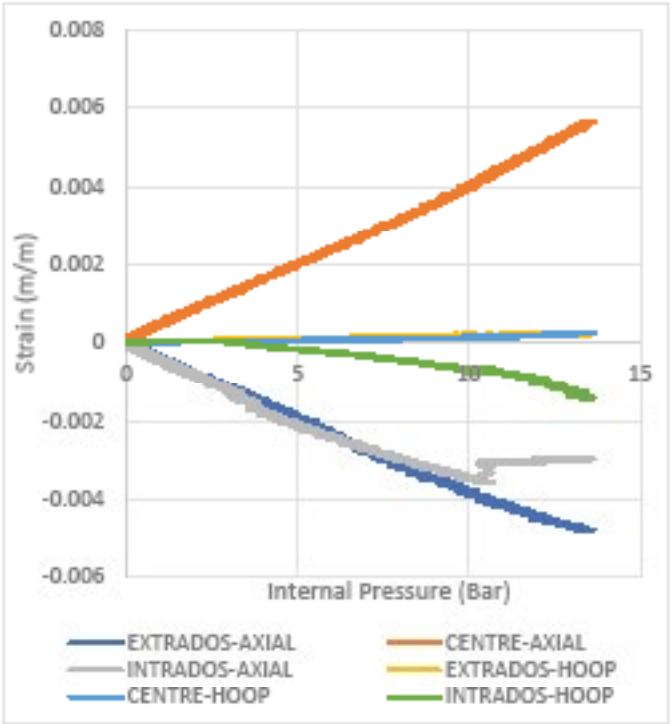

Figure 2: Results of a sample pressurization only load case

Design of a Bicycle Frame using Composite Materials

Student: Giuseppe Farrugia / Supervisor: Prof. Ing. Martin Muscat

Introduction

Composites are optimum materials to reduce weight without compromising structural integrity. The bicycle frame designed in this study uses a unique shape to accomplish the higher speeds than traditional bikes due to their higher power-to-weight ratios.

Project Objectives

The objective of this study is to produce a unique design for a bicycle frame with the aid of analytical equations of classical laminar theory and also by using ANSYS Workbench. [1][2] The solid modelling for the frame design to be used for impact testing will be done using ACP, while using Explicit Dynamic features for the crash tests in the ANSYS Workbench software.

Project Methodologies

Using standards, the bicycle design was developed in Autodesk Inventor for road racing and also for city bicycle environments due to the lack of seat tubing. This design was passed through several analytical calculations along with software structural simulations to achieve the best possible design shape. [3] A material selection process was conducted to achieve the most efficient material to provide weight reduction when compared to traditional bicycles without loss of strength and also being able to within the environmental conditions.

The classical laminar theory method was applied to get a range of possibilities for the lay-up scheme for the composite material. The ACP was then initiated were the solid model composite was built using the lay-up orientations set from the classical laminar theory. The solid model was processed through the static structural feature and the ACP post-processing setups to find the failure criteria of the design.

The impact testing was processed using the explicit dynamics feature in the Workbench software which allowed for the frame to have a full frontal impact. Two types of impacts were implemented on the bicycle frame, one being a full frontal vertical wall, and the other being an inclined plane parallel to the front fork of the bicycle frame. The impact tests were produced with different materials of varying hardness to produce a wide range of results at different speeds.

Results and Achievements

The bicycle frame of relatively low weight is fully able to withstand the necessary forces including the safety factors set by the standards. The bicycle was below the Tsai-Wu failure criteria threshold thus maintaining the stresses in the system.

The impact tests showed the bicycle being slightly deformed in the head tube due to the lack of the front fork part which would prevent deformation. At low speeds, the bicycle was able to remain intact with low amounts of damage thus showing the compressive resistibility. However at higher speeds, which are experienced during road races, the frame experienced permanent deformation without splintering and causing harm to the user.

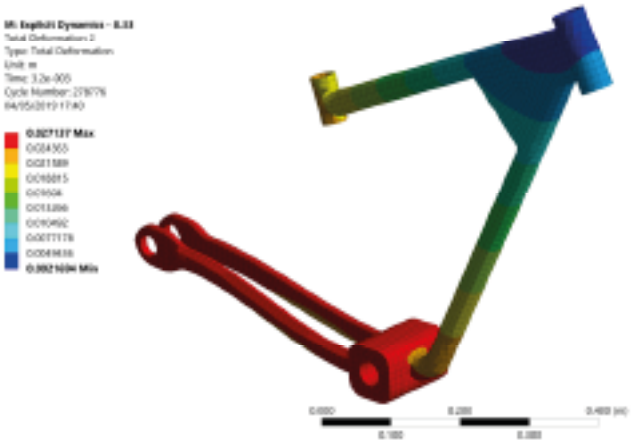

Figure 1: Impact Testing using a Steel Parallel Wall at a speed pf 30km/h

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Fluid Flow in Rotating Ducts

Student: Mark Fenech / Supervisor: Dr Christopher Micallef

Introduction

Cooling channels are a common feature in modern industry, featuring in a wide array of applications from ventilation to heat exchangers to automotive applications. In certain cases, such as rotating machinery, the cooling channels rotate on a rotor. This has an effect on the fluid flow inside the cooling channel and ultimately the efficiency of the channel itself.

Project Objectives

The objective of this project was to investigate the effect of rotation on axial and radial ducts by examining the axial velocity profile of the flow.

Design of Equipment

Rotation was carried out on a pipe elbow, with air flowing through the pipe. The axial velocity of the airflow was measured and recorded using in-house hot wire anemometry; a technique based on the principle of Constant Temperature Anemometry (CTA). The hot wire was attached to a probe configuration and inserted into the pipe during rotation. A clamp setup was designed in order to assemble the probe configuration to the pipe elbow. This provided a locking mechanism on the probe during rotation, and allowed for the traversal of the probe across the pipe diameter when the pipe is at rest. Prior to testing, the hot wire was calibrated to a wind tunnel against known airflow velocities.

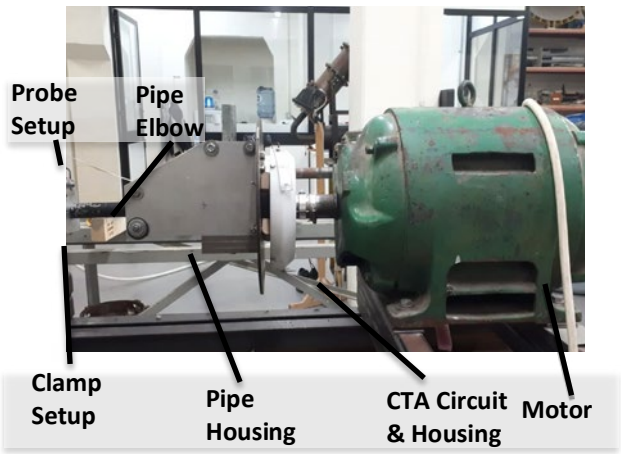

Figure 1: Equipment Setup Utilized

Project Methodology

The hot wire was inserted into the pipe elbow at two different locations along the pipe during rotation to investigate the airflow for two different modes of rotation of the pipe; axial rotation and radial rotation. At each location, the hot wire was traversed linearly across the diameter of the pipe to extract an axial velocity profile across the entire diameter of the pipe cross-section. The wall that acted as the outer radius of the pipe bend was take as the base of the diameter (0mm). The pipe was rotated at various angular speeds and multiple velocity profiles were recorded for different speeds.

Results and Achievements

When the pipe rotated axially, a parabolic velocity profile was present across the diameter of the pipe where the axial velocity is lowest at the wall of the pipe and highest at the center. Interestingly, the velocity varied rapidly at locations near the wall, implying that this area was most affected by secondary cross-stream flows generated by axial rotation and viscosity forces from contact with the wall. When the pipe was rotating radially, secondary flows generated caused an uneven distribution of the flow. The velocity at the center and near the wall of the diameter was constant. For the half of the diameter closer to the outer radius of the pipe bend, this speed increased reaching a maximum at the midpoint between the wall and the center. On the other half however, the inverse occurred and the speed dropped, reaching a minimum at the midpoint. The results also conveyed that turbulence suppression occurred at high rotational speeds.

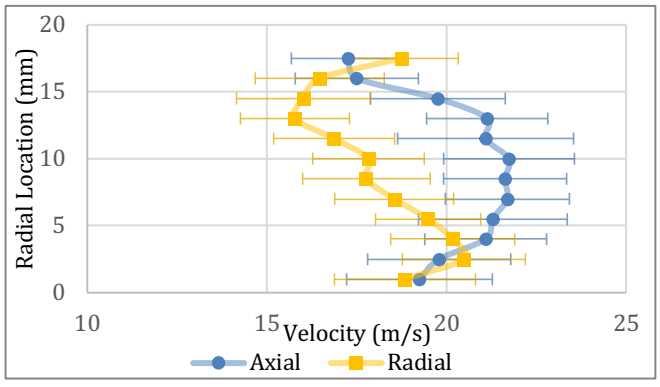

Figure 2: Velocity Profile of Axially & Radially Rotating Duct at 1800rpm

Carbon Fibre Laminates and Sandwich Panels for the Development of a Monocoque Formula SAE Chassis

Student: Benjamin Formosa / Supervisor: Prof. Ing. Duncan Camilleri

Introduction

The University of Malta Racing team is a Formula Student competitor, who's aim is to design, build, test, and race a formula style car against teams from other universities. The core component of the car is the chassis, which must be strong and stiff to withstand the loads applied to it. It should also be as light as possible, as weight has a significant impact on performance. Progressing to a carbon fibre monocoque can aid to achieve these goals.

Project Objectives

To determine:

- the most suitable carbon fibre manufacturing method.
- the most suitable core material for use in sandwich panels.
- the material properties of the chosen composites through material testing.

To design an initial chassis concept, and analyse it through a finite element analysis (FEA)

Project Methodologies

The manufacturing methods being compared were wet layup, resin infusion and prepreg. The core materials analysed were closed cell foam, aluminium honeycomb and Nomex honeycomb. All materials, epoxy and bagging equipment were purchased from Easy Composites, a supplier in the UK. Samples were manufactured using a laminated chipboard or aluminium mould, with the appropriate release agent. Templates were printed and taped to the laminates allowing them to be cut accurately. Cutting was done using a handsaw, wearing the appropriate safety equipment in a well-ventilated room.

Material testing done consisted of tensile, compressive, shear and 3-point bend testing. All tests were done according to EN ISO standards and were done on the Instron 4206 Universal Testing Machine. The data gathered was used to determine the material properties of each type of sample, and hence allowed for the selection of the optimal one.

FEA was carried out using *Ansys Workbench*, with *Ansys Composite Pre/Post Processer* to define the characteristics and the overall performance of the different fibre layup sequences and to analyse the results. An FEA was first carried out on the samples that were tested to validate the numerical models. Following this, an FEA was carried out on the monocoque. The design was done according to FSAE rules, based on the 2020 chassis. The number of layers and orientation of the fibres was adjusted until a chassis which could safely withstand all the expected load cases was found.

Results and Achievements

Comparing the data from all the samples tested, it was found that prepreg fibres have the best material properties, especially when loaded in direct tension. It was also found that Nomex honeycomb would provide the optimal core material.

In general, the FEA done on the samples returned similar results to the physical tests performed, with a variation as low as 1.6% between the test and the analysis when comparing the force required to achieve first-ply failure. This verified the model. The chassis analysis, pictured in Figure 1, was used to determine the optimal number of plies and their orientation, with different sections having different number of layers in order to reduce weight and cost. The final chassis, having a factor of safety of 3 had a torsional stiffness of 641 Nm/degree and weighed approximately 15.14 kg.

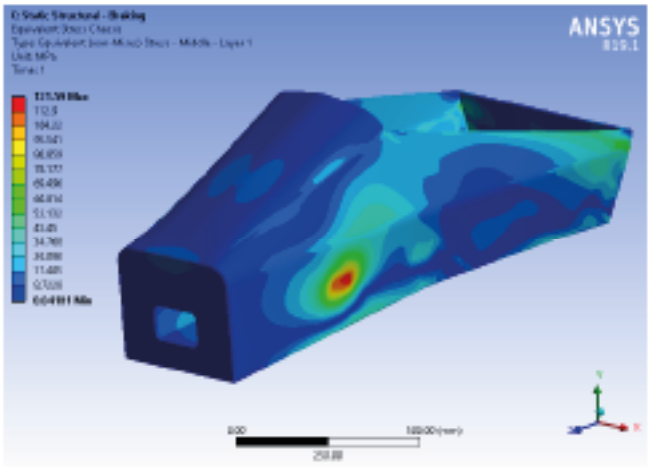

Figure 1: Stress Distribution Through the Chassis During Hard Braking

Performance of Composite Maritime Sandwich Structures

Student: Mark Galea / Supervisor: Prof. Ing. Claire De Marco

Introduction

Sandwich construction, consist of two thin faces, adhered to a thick, light weight core the resultant construction given correct material selection offers high resistance to traverse loads and minimal weight, making it ideal for light weight applications.

Project Objectives

The aim of this dissertation is to establish if flax fiber reinforced plastic (FFRP) faced sandwiches possess comparable properties to glass fiber reinforced plastic (GFRP) faced sandwiches. If so FFRP faces could be utilized in the marine industry, hence producing a greener build since flax fibres are derived from natural renewable resources. Another comparison made is between single and multiple layer FFRP faced sandwiches, to attain the effect of multiple layers.

Project Methodologies

To attain the mentioned comparisons testing and theory were utilized. Testing on the specimens consisted of 3-point, 4-point bending and edgewise compression tests, conducted in accordance to the relevant ASTM standards. The specimens were constructed using vacuum bagging and consist of equal mass fiber content, fiber weave, marine grade foam core material, core material thickness, and fiber orientation.

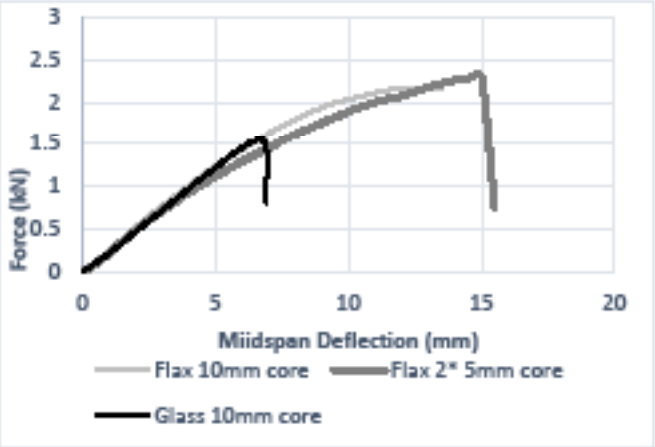

Figure 1: Force vs Displacement 3pt Bending Test

Results and Achievements

From the 3-point bending test and theory, it was concluded that multiple layer FFRP faced sandwich specimens were able to sustain greater loads when subjected to a shear dominant load as in figure 1. When loads due to bending moment were dominant such as in the 4-point bending test it was noted that single layer sandwiches attained better performance as noted in figure 2. The superior bending moment resistance of the single layer sandwich was also noted in the edgewise compression test, since a larger buckling force was withstood by the single layer FFRP faced sandwich specimens.

GFRP faced sandwich samples produced, possessed a lower weight and face thickness when compared to the respective single layer FFRP sandwich samples. Also, the GFRP faces possess better mechanical properties as noted in the 4-point bending test results and these better properties produced specimens more resilient to bending moments as noted tin 4-point test results figure 2 when compared to the equivalent single layer FFRP faced sandwich specimens.

FFRP faced marine sandwiches offer a lower resistance to bending moments when compared to GFRP faced sandwiches, yet FFRP is a viable greener alternative especially where weight sensitivity is not such an issue. Additionally, in critical locations where shear loads are dominant multiple layer sandwiches can be utilized.

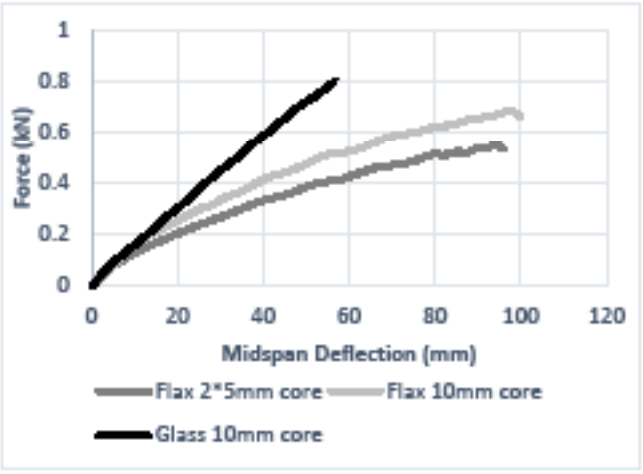

Figure 2: Force vs Displacement 4pt Bending Test

Optimising Steady State and Transient Aerodynamic Vehicle Performance using CFD and Race Track Analysis

Student: Jamie Mangion / Supervisor: Prof. Ing. Mario Farrugia

Introduction

Aerodynamics have become essential in any form of motorsport category. The thought of attaching an inverted aerofoil on a vehicle appeared in the 1950's. Aerodynamic technology has been continuously developed at an unprecedented pace, through CFD simulations and wind tunnel testing, improving the vehicle performance significantly.

Project Objectives

The main objectives of this project were to devise and simulate a low drag aerofoil setup using CFD and validate results against published data. The aerodynamic effects of an open or closed side mirrors were also investigated. An aerodynamic package was designed on the Toyota GT86 which included a front splitter, a smooth underbody and an aerofoil. Using Optimum Lap simulation, the performance gains of this package were found for the Racalmuto race track circuit.

Project Methodologies

Prior to implementing an aerofoil to the vehicle, extensive research was carried out on the design and meshing parameters for such geometries. The Toyota GT86 side mirrors were designed. Two separate cases were considered, one when the mirrors were attached to a flat symmetry plane and the other when the mirrors were attached to the vehicle. Thus, any drag difference arising from the two cases can be measured. The aerodynamic package was analysed with the GT86 body, which pressure contour can be noted in Figure 1. Finally, CFD results were transferred to Optimum Lap.

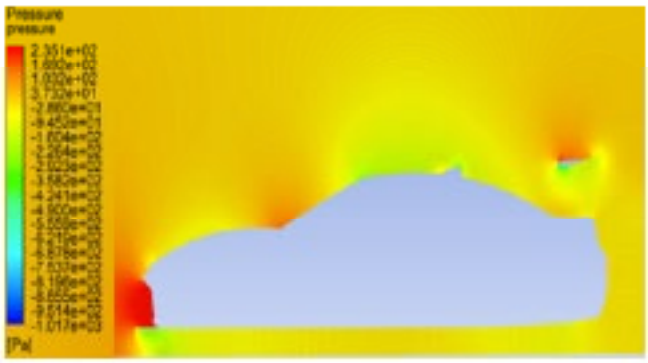

Figure 1: Pressure Contour around the GT86 vehicle with the aerodynamic package

Results and Achievements

Results from the aerofoil came really close to the validated results by XFOIL. Velocity streamlines showed that tip vortices were being created which reduced the overall efficiency of the aerofoil. As such endplates should be implemented.

Results from the side mirrors has shown that the body reduces the drag being experienced by the mirrors. An overall contribution of 9.5 percent was simulated which is very close to CFD and Wind Tunnel results verified by Olsson [1]. Closing the side mirrors does reduce the drag force by 2 percent. This value can be increased if a more aerodynamic shape was designed in the closed position.

The CFD results obtained for the standard GT86 vehicle showed that lift was being generated. Attaching a front splitter, aerofoil and a smooth underbody to the vehicle, lead to creation of downforce. At 20m/s (72 km/h), 329N of downforce and 75 N of drag were being created by the aerodynamic package when compared to the standard vehicle.

Optimum Lap simulations revealed a 1.1 second gained around the Racalmuto lap. The vehicle velocity comparison around the track can be noted in Figure 2. The black line represents the velocity of the standard vehicle, while the lighter coloured line is the velocity result due to the implementation of the aerodynamic package.

References

[1] M. Olsson, "Designing and Optimizing Side-View Mirrors," Chalmers University of Technology,2011

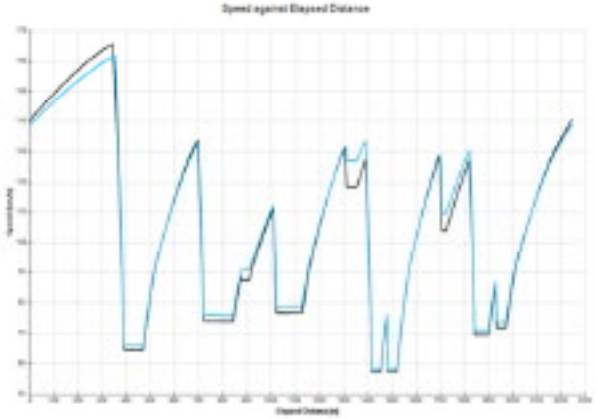

Figure 2: Comparison of the vehicle speed around Racalmuto with the without the aerodynamic package

Analysis of Chest Behaviour

Student: Michaela Micallef / Supervisor: Dr Ing. Zdenka Sant

Introduction

This dissertation is a continuation of a pilot study where behavior of a sternal model following median sternotomy was modelled using FEA [1]. A model where forces at the re-united sternal halves could be reproduced and measured would permit validation of this study. To that end, is first essential to develop an approach to simulate thorax deformation during quiet breathing.

Project Objectives

The primary objectives of the study were to process the displacement data obtained in VICON over a number of quiet breaths and to apply this to a 3D model of the thorax and analyse its distortion with respect to time over a singular respiration cycle.

Project Methodologies

Reflective markers were placed systematically around the subject's thorax in preparation for the recording of displacement data of the chest, during quiet breathing using VICON motion tracking software in the lab with the aid of physiotherapy students. The experiment was carried out and a .csv file was exported for processing.

Data processing was first initiated in Excel however this was deemed unfeasible due to the large data volume. Thus, MATLAB was used in order to interpolate the individual datasets and generate polynomial equations describing the average displacement with respect to time for each marker.

The CT scans of the rib cage provided in stereolithography format were first subjected to a mesh clean-up in ANSYS® SpaceClaim and then converted into a solid body assembly. Following this, the costal cartilage was built using beams.

Once the model was imported into ANSYS® Workbench, material properties were applied according to types of bone and the model was meshed. The posterior ends of the ribs were constrained appropriately in order to simulate articulation with the spine, and the polynomial equations generated in MATLAB were applied to prescribed locations corresponding to the markers applied in the VICON. The model was then solved for the whole inhaling process.

Results and Achievements

The project objectives set at the beginning of this study were tackled however restricted to data processing solely in the z-direction due to time constraints. A maximum displacement of ≈42 mm occurred on the distal ends of the floating ribs on the right-hand side and on the costal cartilages of the 9th and 10th ribs on the left-hand side. The remainder of the anterior of the rib-cage spanning ribs 1 – 10 experienced a relatively symmetrical vertical displacement, as illustrated in yellow in Figure 1 below. On the posterior site of the rib cage, vertical displacement decreases as one gets closer to the spine. This dissertation confirms that Finite Element Analysis can be a viable means of simulating thorax deformation during quiet breathing, supporting the possibility for future validation of the sternal model on median sternotomy.

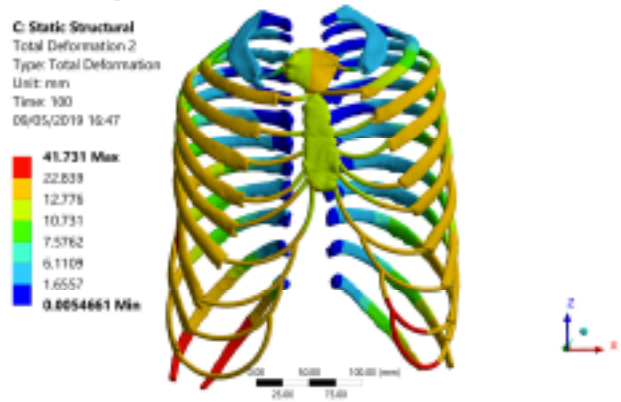

Figure 1: Total deformation of the human thorax during a quiet inhale as depicted in ANSYS® Workbench

References

[1] Farrugia R., 'Modelling of Sternotomy via Finite Element Analysis', University of Malta, 2014.

Waste to Energy on a Fishing Vessel

Student: Nathan Povo / Supervisor: Dr Ing. Christopher Micallef

Introduction

In recent years, more effort is being made to reduce the amount of fuel used by fishing vessels; both to reduce the costs of operation and to reduce the amount of carbon dioxide released. One way of reducing the amount of fuel used is to utilise the waste heat from the internal combustion engine of the vessel as an energy source for an ammonia-water vapour absorption system.

Project Objectives

The aim of this project was to investigate the operation of an ammonia-water vapour absorption system on a fishing vessel by constructing a mathematical model using the TRNSYS simulation environment.

Project Methodologies

A set of functions, based on the study of Pátek [1], were written in FORTRAN to calculate the thermodynamic properties of ammonia-water. A mathematical model was created to model an ammonia-water vapour absorption system. A FORTRAN program was written to simulate the mathematical model. The model and, by extension, the property functions were verified and validated against other models, such as the model in [2].

The FORTRAN model was used to create a TRNSYS component which was implemented in the simulation of a fishing vessel. The simulation, shown in Figure 1, was constructed with the aforementioned model, ambient air data, sea water temperature data, heating fluid for the desorber, and a fish-freezing sub-system.

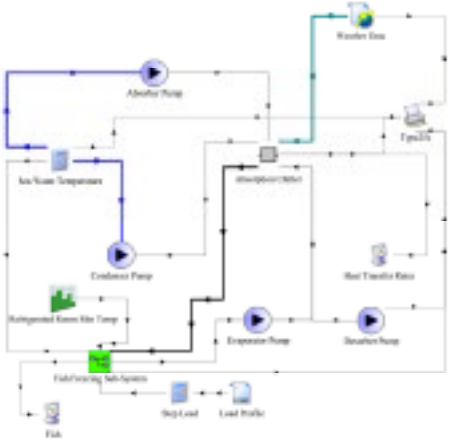

Figure 1: TRNSYS simulation schematic

Results and Achievements

A parametric analysis of the vapour absorption system model was performed to determine the effect each parameter had on the model's outputs. The parameters analysed include the evaporator outlet vapour quality, the sea surface temperature, the ambient air temperature, the desorber heating fluid temperature, the evaporator temperature, the heat exchanger effectiveness, and the solution mass flow rate.

Various load profiles were applied to the TRNSYS simulation of the vessel. Each load profile varied the fish quantities added to the refrigerated space and the time step between the additions of fish. With a sea surface temperature of 25 °C, an average air temperature of 31 °C, a desorber heating fluid of 170 °C, a minimum evaporator temperature of 5 °C, an evaporator vapour quality of 0.975, and a refrigeration effect of 5 kW, the system was able to freeze an hourly addition of 200 kg of fish. Figure 2 shows the variation of the temperature of the fish in the refrigerated space throughout the simulated 24 hr period. Note that no fish were added for the first 3 hours and the last 6 hours.

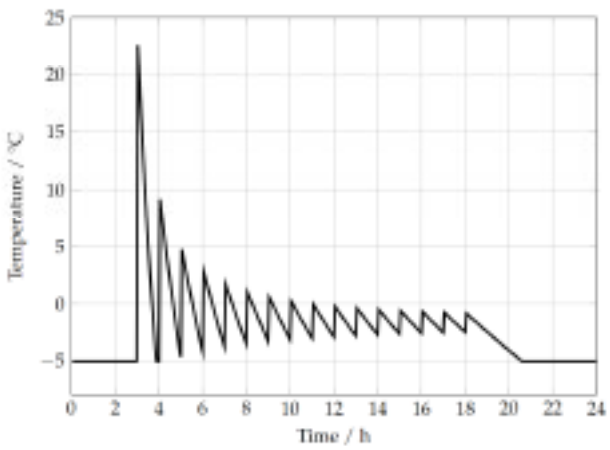

Figure 2: Temperature of fish in the refrigerated space

References

[1] Pátek J. and Klomfar J., "Simple functions for fast calculations of selected thermodynamic properties of the ammonia-water system," International Journal of Refrigeration, May 1995, Vol. 18, No. 4, pp. 228–234.

[2] Herold K., Radermacher R., and Klein S., Absorption Chillers and Heat Pumps, 2nd ed. CRC Press, 2016.

An Optimization Analysis of a Cowling Design between a Water to Air Heat Exchanger and Extraction Fan

Student: Nicholas Sammut / Supervisor: Dr Ing. Christopher Micallef

Introduction

A major challenge when designing race cars is the provision of the lightest possible cooling system, whilst keeping engine temperatures within operating limits. Until now, the idea of an optimized cooling system has not yet been addressed in UoMR. The idea is that the design of a cowling between the heat exchanger and extraction fan will increase the flow of air through the radiator, translating into better rates of heat transfer.

Project Objectives

The main objective was to simulate the current radiator setup using ANSYS FLUENT, along with the proposed setup by implementing a cowling. Another objective of this project was to validate the CFD models experimentally to enable future simulations to be conducted by the team.

Project Methodologies

The approach taken was to model the heat exchanger as a porous medium. To achieve this, ANSYS FLUENT requires the user to define two important parameters; the Inertial and Viscous Inertial Coefficients [1]. These were obtained experimentally using the Wind Tunnel.

Next, a simulation was set up by modeling the current setup. This was followed by the CFD analysis of various cowling designs at a range of car velocities. The chosen shroud design was manufactured from carbon fibre by a wet lay-up. The cowling was then validated experimentally by measuring flow velocity and static pressure.

Results and Achievements

From CFD simulation, it was found that the introduction of a shroud between the radiator and extraction fan significantly increased airflow through the heat exchanger at lower speeds. This phenomenon was most notable at an inflow of 0 m/s; the car being stationary. In this condition, the cowling was shown to increase the mass flow rate of air by over thirty per cent. It was also found that the physical geometry of the shroud had little effect on the mass flow rate. Furthermore, the drag imposed by having a shroud was found to be insignificant.

The short convex shroud was manufactured and validated successfully showing discrepancies of under eighteen per cent between simulated and experimental results. Not only did this confirm the reliability of the CFD simulations, but it was concluded that modeling the heat exchanger as a porous medium is an accurate and efficient approach and should be the method to follow in the team's future simulations.

References

[1] ANSYS® FLUENT User Guide Release 18.1, Porous Media Conditions, ANSYS, Inc.

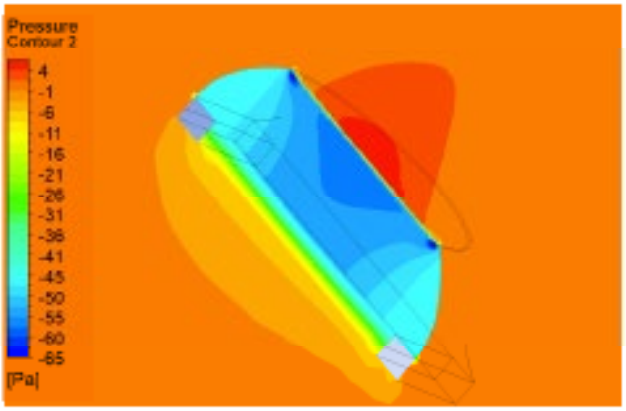

Figure 1: Pressure Contour of Cowling Design

Figure 2: Cowling Implementation on UoMR Racecar

Pool Heating System – Feasibility Study

Student: Alexander Tanti / Supervisor: Dr Ing. Christopher Micallef

Introduction

Between March and December, Neptunes Water Polo and Swimming Club [WPSC] operates an outdoor swimming pool, which is heated to a temperature of 27 °C during the colder months. High running cost and high heating loads prevent pool heating in January and February. A Gas fired Combined Heat and Power (CHP) system and a gas fired water Boiler are currently used to supply heat to the pool water.

Project Objectives

The aim of this project is to understand the current pool set up, to calculate the peak and average heating loads on a monthly basis, to investigate similar pool heating systems in Malta and to perform a feasibility study of an alternative system.

Project Methodologies

Flowrate readings were taken by means of an ultrasonic flow meter. By performing an energy balance of water flowing through the Boiler system heat exchanger (BSHE), both the BSHE's output and the CHP system's heat output were obtained. Visual Basic (VBA) code was used to analyse daily temperature readings to obtain the true heat losses during a 19-day period in December 2018 and a 10-day period in April 2019. A VBA prediction model was built based on the potential heating loads shown in Figure 1, to predict past heat losses. Past weather data from 2016, 2017 and 2018 was applied to the VBA prediction model to understand the variation in peak and average monthly heating loads. True and predicted heat losses were compared in order to estimate peak and average monthly heating loads.

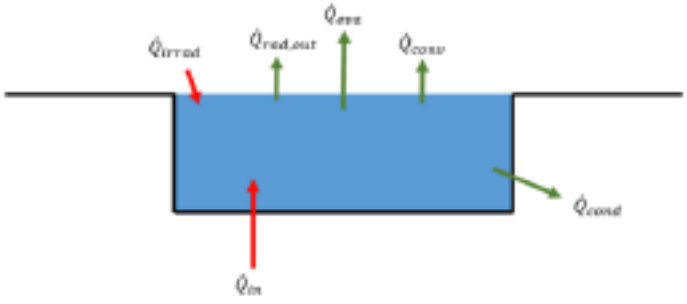

Figure 1: Schematic of Potential Heating Loads on pool water

Results and Achievements

True heat losses showed that the pool's heating load was actually much lower than that predicted by the VBA prediction model and that established during the performed case studies. The main reason for such discrepancy was identified to be the location of Neptunes WPSC. Neptunes WPSC is surrounded by tall buildings on its west side, which act as wind barriers for Westerly winds. A study conducted by the National Statistics Office established that winds blowing from West Southwest, South Southwest, North Northwest and Northwest are the most dominant in Malta and other wind directions are of no dominance [1]. Furthermore, wind highly affects the water evaporation rate and since evaporation heat losses were established as the main means of heat loss, lower wind speed at pool's water surface resulted in the mitigation of heat losses.

An alternative system was proposed based on information gathered through the literature review and through two case studies performed on pool heating systems at the Tal-Qroqq National Pool Complex and at Hilton Malta. The proposed system is shown in Figure 2. A feasibility study of the proposed system established that running cost would be more than halved and all expenditure needed would be repaid in less than two years time.

References

[1] Galdies C., 'The Climate of Malta: statistics, trends and analysis 1951-2010' National Statistics Office, Valletta, 2011.

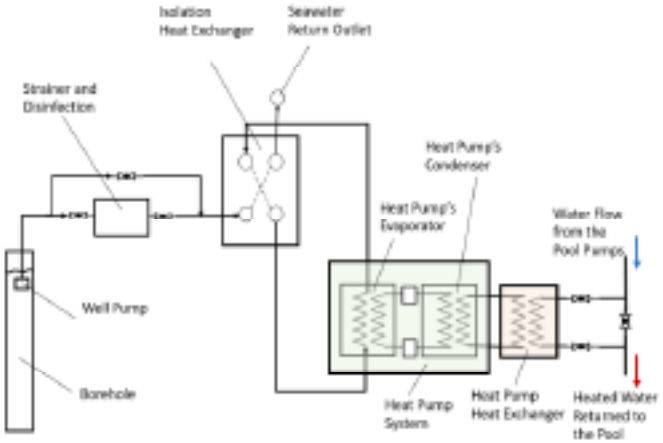

Figure 2: Schematic of the Proposed System

Control of the Compressor Air Mass Flow Rate on the Turbocharger Hot Gas Test Stand

Student: Matthew Joseph Vella / Supervisor: Prof. Ing. Mario Farrugia

Introduction

The operating characteristics of a turbocharger are typically shown on two types of performance maps, i.e. the compressor map and the turbine map. For the past four years, a Hot Gas Test Stand which enables the measurement of data used to produce such charts, has been undergoing development.

Project Objectives

The focus of this project was to further improve the turbocharger performance maps produced by the test stand, by establishing Standard Operational Procedure (SOP) and controlling the compressor mass air flowrate using an Electronic Throttle Body (ETB) together with an adjustment to the control time.

Project Methodologies

The safety and accuracy of the tests carried out were enhanced by formulating a SOP which included a set of equations to be applied in order to produce the performance maps [1]. Furthermore, the response of the ETB plate movement was increased by shortening the control time, thus correcting the error faster between the desired throttle plate angle and the measured angle.

Two control system configurations were developed and tuned on LabVIEW in order to be able control the compressor mass air flowrate control using the ETB. The two configurations tested were the PID control on its own and PID with feedforward control. An analytical graphical review of the characteristics and a comparison of both systems were done; hence the desired gain constants were obtained. The effects of different control time on the test stand were analysed, in order to choose the most suitable control time for the system.

Following a particular test matrix, a number of tests using the ETB were performed on the test stand. The test matrix was designed in such a way to allow the system to settle down and reach steady-state. The data gathered was first filtered from noise and then analysed. The equations stated in the SOP were used to correct the data before being plotted on the map.

Results and Achievements

The optimal control time of the PID algorithm within the ETB was found to be 20ms, while the optimal control time of the overall system was found to be 100ms. Both control times were determined after performing a series of tests. The results obtained from the comparison between the control system configurations illustrate how the concept of feedforward was more effective.

As a result of the implementation of the ETB and its control system, the compressor mass air flowrate of the turbocharger was achieved. Subsequent to this achievement, a compressor chart was produced, as can be seen in Figure 1.

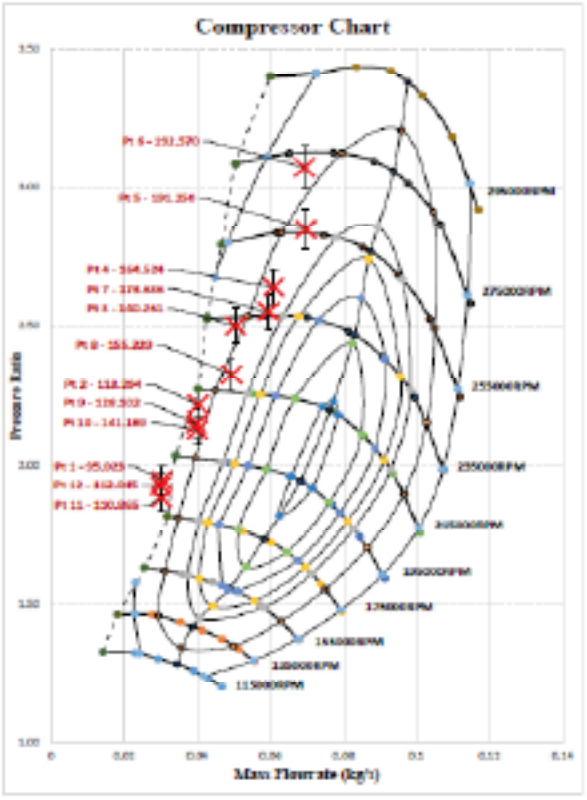

Figure 1: Compressor Performance Map with plotted measured and corrected data

References

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Comparative Evaluation of Design Builder and TRNSYS Software as applied to the Energy Performance of a Building

Student: Michele Vella / Supervisor: Prof. Ing. Robert Ghirlando / Co-Supervisor: Dr Ing. Charles Yousif

Introduction

Back in 2016/17 a study was conducted by Zachary De Giovanni [1] to install an air conditioning system at Stella Maris Church. The Priest had accepted the proposal of Prof. Ghirlando to analyse the thermal performance of the church. Zachary used Design Builder as the energy modelling software, were these kinds of softwares are on rise and used extensively. It was decided to model the same church using TRNSYS as the modelling software and compare the results obtained.

Project Objectives

The project objectives are the following:

- To create a model of the church using TRNSYS software.
- Check for different methods and algorithms used by the TRNSYS and Design Builder.
- To validate the model with measurements taken inside the church.
- To test for various simulations at different cooling configurations.
- To obtain the most efficient and effective HVAC sizing of the church.
- To compare and contrast with the results that were obtained in Design Builder.

Project Methodologies

An extensive literature review was carried out to find out what is energy modeling and what inputs can be processed in the simulation engine to be able to give an output. The accuracy was also discussed together with the interoperability of these type of programs. Scientific papiers were also assessed as they have shown that different programs lead to different conclusions. Study conducted by the Institute of Sustainable Energy [2] has shown why such temperatures and relative humidity are felt in the church because of the construction of the walls and how the internal gains effect the temperature.

Different algorithms and methods to calculate the same parameters were assessed together with their mathematical concept, such as the convective heat flux, long wave radiation, infiltration and the comfort model.

Google Sketch Up was used to model the church geometry from the architecture drawings provided by A. Mollicone as shown in Figure 1. The model produced was then transferred to TRNBuild. Within TRNBuild details of the building had to be specified, such as the materials used to create walls, windows and doors. Then TRNSYS Simulation Studio was used to carry out simulations and the data processed by the simulation engine was plotted.

Results and Achievements

The same parameters that were calculated in Design Builder were also calculated in TRNSYS. The results obtained were also tabulated to facilitate the comparison analysis. TRNSYS shown higher solar gains of 32 KW when compared to the 22KW of Design Builder. On the other end the internal gains were lower in TRNSYS. The cooling temperature of TRNSYS could not be established since a runtime error was being shown during simulation for the comfort outputs. In Design Builder the ideal cooling temperature was found to be at 23°C, having a cooling capacity demand of 110KW. When the same temperature was set in TRNSYS it resulted in 90KW demand. Also, TRNSYS took longer to cool since it had lower cooling rate but used more energy to keep the cooling temperature stabilised since the solar gains were higher.

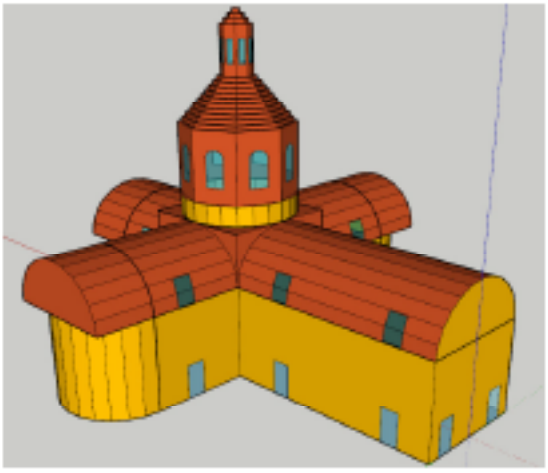

Figure 1: Software model created using Google Sketch UP

References

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Computational Modelling of the Lumbar Spinal Segment of L3-L5 Vertebrae

Student: Victor Zammit / Supervisor: Dr Ing. Zdenka Sant

Introduction

The reliance of human movement on the spine results in back pain being the leading cause for disability, even in young adults, and is estimated to cost in excess of $100 billion a year (in the United States) [1]. Furthermore, an experimental evaluation of the human spine remains a high risk, invasive procedure which alters the behavior of the spine being examined.

Project Objectives

In this study, the key objectives were to computationally model the healthy L3-L5 lumbar spinal segment in 3D to analyze the effect of loading application on stresses, strains and deformations experienced by the spinal segment.

Project Methodology

1. Preparation of geometry: surface repair of the vertebral models was carried out in order to ensure suitable volume meshing. The endplate surfaces of the vertebral bodies were then used to create the intervertebral disc (IVD) geometry.
2. Discretization of the model: the model was meshed with the e-size of 1.5 mm. Shell elements and node matching were implemented to model the assembled structure of the spine.
3. The load and constraints were applied to the model to simulate its behaviour.

Results and Achievements

L3-L5 Spinal Behaviour due to the Standing Posture

Bulging of the disc was noted to occur to an amplified degree in the annulus regions of the discs, with the nucleus experiencing less lateral bulging, due to its comparatively higher Young's Modulus. Regions of increased elastic strain were noted in the centers of the vertebral bodies

Externally Loaded, Standing L3-L5 Spine

The introduction of an external load to the standing posture did not significantly alter the behaviour of the spine in comparison to the unloaded standing posture. Although a relatively anisotropic shearing strain field was noted to occur at the endplates, a pattern was noted to coincide at the junction of the annulus lamellae to the nucleus

Effect of Flexion on the Spine

Flexion resulted in the generation of amplified bending moments acting on the spine, together with the axial compression experienced due to the loading. The zygapophyseal joints limited the degree of rotation experienced. Higher stresses and strains were detected at the anterior-most regions of the spine during flexion.

Herniation of the L4-L5 IVD

No significant changes in stress magnitudes were detected. However, higher stresses were borne by the vertebral arches and the cortical layers in the herniated nucleus model.

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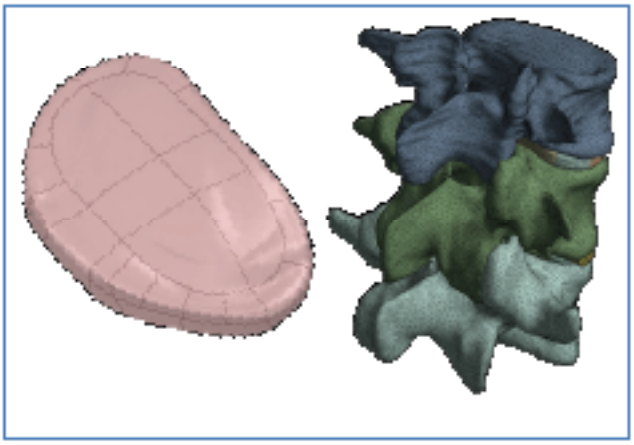

Figure 1: left: IVD generated, right: meshed model

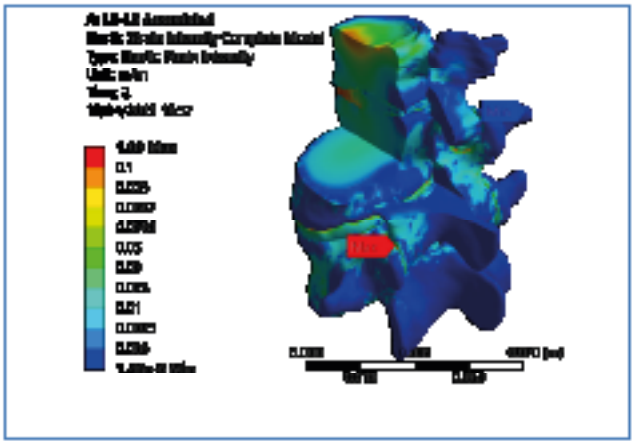

Figure 2: Stress intensity in the L3-L5 spine model

Modelling Friction Stir Welds for Airframe Structures

Student: Julian Zampa / Supervisor: Prof. Ing. Martin Muscat

Introduction

The aviation industry is continuously striving to design more efficient aircraft in order to reduce the overall operating cost as well as minimize its environmental impact. Commercial aircraft have reached excellent levels of aerodynamic and engine efficiency and another major contributing factor that can be improved is the gross weight of the aircraft. This has instigated the investigation of replacing the riveting joining method currently used in the industry with friction stir welds for the primary airframe structure of large, commercial aircraft.

Project Objectives

- To investigate the feasibility of implementing the friction stir welding process as the main joining method of airframe structures
- To carry out relevant static and fatigue analysis to validate the use of friction stir welding applied to large, transport category aircraft under realistic conditions.

Project Methodologies

The problem was first approached by carrying out a literature survey on the general friction stir welding process; highlighting the key benefits and drawbacks as well as the mechanical and fatigue properties of the produced welds.

Further studies were undertaken on the effects of weld features which influence fatigue and strength in order to design welds capable of withstanding flight running loads. Following this it was essential to select the appropriate fatigue-life evaluation method suitable for the application and a brief outline of the selected method was given.

A Finite Element Model of an aircraft fuselage section was then created, based on the Airbus A320 aircraft as illustrated in Figure 1, and analysed for static and fatigue loads according to relevant aircraft standards in order to determine the feasibility of using friction stir welded joints as the primary joining method in such applications.

Results and Achievements

The fuselage of a modern aircraft is made up of three basic components; the outer skin, the stringers, which are longitudinal stiffeners designed to resist axial loads, and the transverse chords which are designed to resist shear and torsional loads.

It was inherent that the analysis was carried out using the highest possible loading experienced by an aircraft in flight. These load conditions, both static and fatigue loads, were identified and implemented based on EASA CS-25 regulations for certifying this category of aircraft. From these regulations it was also possible to define the allowable limits which would validate the implementation of friction stir welds as the main joining method for the airframe structure. The Finite Element model was a two-metre-long quadrant (90°) modelled after the top-mid section of the fuselage generated using ANSYS Mechanical APDL. The model was constrained using the relevant symmetry boundary conditions and loaded statically with the highest tensional, compressive and shear forces the aircraft is exposed to during flight. From a fatigue perspective, the aircraft was simulated to be under pressurisation conditions in combination with a standardised 'load pattern' experienced in any one flight from which the operating life-cycle of the aircraft could be determined. From the analysis carried out, both from the static and fatigue perspective, it was concluded with confidence that friction stir welding as the main joining method for large transport category aircraft is highly plausible and demands further investigation as all set criteria were fulfilled and surpassed.

Figure 1: Graphic illustration of the modelled Airbus A320 fuselage section

An Investigation of the Deposition of Graphene on Various Application-Oriented Substrates

Student: Matthew Attard / Supervisor: Ing. Anthea Agius Anastasi / Co-Supervisor: Dr Daniel Vella

Introduction

Graphene, a single layer of carbon atoms structured in a hexagonal lattice [1], was realized in 2004 by micro mechanical exfoliation. Since then, the nanomaterial evoked a staggering amount of interest due to its exceptional properties [1]. Other synthesis methods, such as chemical vapor deposition, have also been developed with the aim of mass producing, defect free, monolayer graphene for research and manufacturing purposes [2].

Project Objectives

The focus of this work was to optimize the transfer process of graphene synthesized through CVD, by varying the individual transfer process parameters and quickly characterizing the effects through relatively simple techniques. Such objectives were met by transferring the graphene sheet onto application-oriented substrates such as silicon wafers and perforated substrates facilitating the implementation of graphene in different applications for future research.

Project Methodologies

To reach the objectives of this work, monolayer CVD graphene on copper was transferred onto different application-oriented substrates. A wet transfer technique was adopted, which briefly involved depositing PMMA on the graphene surface, etching away the copper substrate, placing graphene/PMMA stack on the final substrate, annealing, and finally dissolving the PMMA away. Certain parameters in each of these steps were varied in one way or another to optimize the process. This optimization was conducted using silicon wafers with a thermally grown oxide layer of 300 nm as the substrate due to the increased contrast obtained when using optical microscopy. Furthermore, a MATLAB code was developed to measure the percentage of defects present on the transferred graphene sheet.

After optimizing the method, the graphene was deposited on other substrates such as TEM grids and perforated silicon nitride wafers. Throughout the study, the use of three main characterization techniques – optical microscopy, Raman spectroscopy, and scanning electron microscopy (SEM) utilizing both the in lens and secondary electron detectors – was essential for a holistic analysis in this investigation.

Results and Achievements

This study effectively optimized the wet transfer technique by focusing the research efforts into creating a repeatable process for the transfer of graphene onto different application-oriented substrates.

It was also realised that the most important factor affecting the quality of transferred graphene, besides conducting the procedure in a clean environment and utilising chemicals of high purity, is the step involving the deposition of PMMA on the graphene surface. If excessive handling is done on the CVD graphene sheet before this step, graphene will form a relatively high density of cracks as seen in Figure 1. Furthermore, when depositing graphene onto perforated substrates, the most crucial factor affecting the coverage of graphene over the holes besides the initial quality of graphene, is the diameter of the holes, with larger diameters incurring reduced coverage due to the increased surface tension.

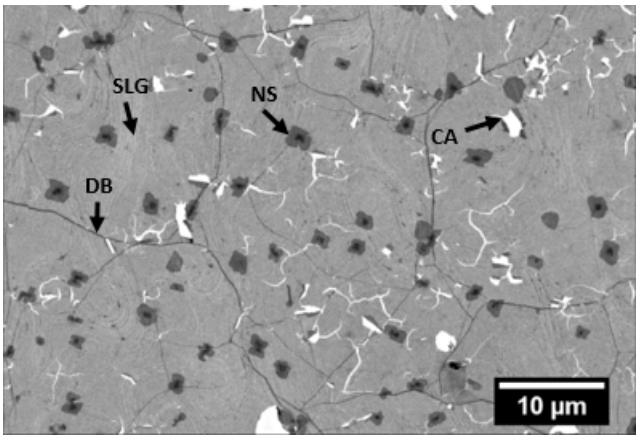

Figure 1: InLens SEM image of monolayer graphene (SLG), consisting of CVD graphene's domain boundaries (DB), nucleation seeds (NS) and cracked area (CA) present due to the excessive handling during the PMMA deposition step

References

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Investigating the Benefits of using Wood Ash as a Filler in Polymer Matrix Composites

Student: Samuel Attard / Supervisor: Dr Ing. Stephen Abela

Introduction

More people, locally and internationally, are using fire heaters and cookers due to an increase in the standard of living and this inevitably leads to a higher volume of wood ash being generated. The volume of wood ash is becoming increasingly harder to manage. Currently the main use of wood ash is as a fertilizer additive due to its high level of useful minerals [1]. However very little attempts have been made to use it for altering the mechanical properties of composites using wood ash.

Project Objectives

This project presents a study on the effect of adding wood ash in polymer matrix composites on its properties. The main objective of this project is to try and follow the success of fly ash which is being used as a filler material in Portland cement due to its engagement in pozzolanic activity [2]. If such attempts would be successful, wood ash could be used to reduce the cost of composites while at the same time offering a novel solution in the disposal of a material where a waste material essentially becomes a raw material. The objectives of this project include preparing wood ash collected from domestic fire stoves and manufacturing composites with and without wood ash to compare various mechanical properties in order to assess the viability of using wood ash as a filler in polymer matrix composites.

Project Methodologies

Two batches of samples were made using the hand layup technique. The first batch consisted of emulsion bound chopped strand mat glass fibre of aerial density 450g/m^2 in a polyester matrix with various amounts of wood ash added. The second batch consisted of powder bound chopped strand mat glass fibre of aerial density 300g/m^2 in an epoxy matrix with various weightings of wood ash added. Their mechanical properties were tested in order to assess the effect of the filler on the composites. These tests included tensile, 3-point bending, impact and hardness tests that were conducted according to the BS 2782 – 03, ASTM D790, IS0 180/U and ASTM D785 – 03 respectively. Following this two samples, one epoxy and one polyester, which showed the worst overall properties were chosen for SEM imaging. The samples were cut from their respective tensile sample and were cut, they were then mounted to an aluminum base by means of carbon tape and gold coated in order to make the samples conductive for SEM viewing.

Results and Achievements

The results recorded showed mixed outcomes. A reduction in density with increasing amounts of wood ash was recorded for both polyester and epoxy samples. Wood ash has a general negative effect on the composite's mechanical performance when a weighting of 0.61 and 0.69 percent is exceeded for the polyester and epoxy samples respectively. Properties such as the young's modulus, flexural modulus, impact strength and hardness suffered through the addition of wood ash beyond this weighting. Below this weighting a slight improvement in these mechanical properties was recorded. When the specific properties were plotted slightly better results were obtained due to the lower density of the wood ash when compared to the resins.
SEM imaging confirmed conclusions put forward by various similar studies.

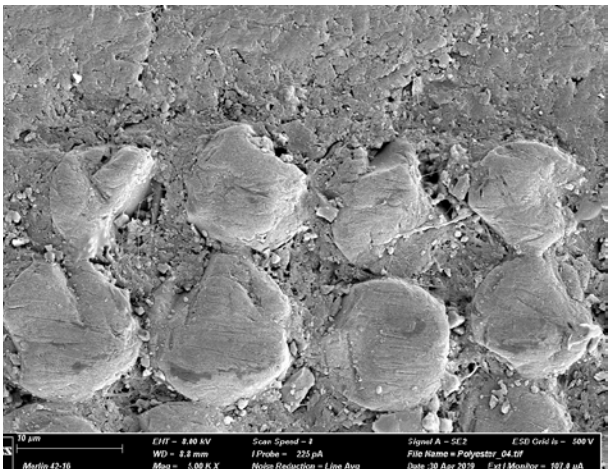

Figure 1: SEM image of the polyester tensile test sample A5.2 at a 5000x magnification

References

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The Effect of Laser Shock Peening on Austempered Ductile Iron

Student: Luana Bonnici / Supervisor: Dr Ing. Ann Zammit

Introduction

Austempered Ductile Iron (ADI) is a material possessing very good properties, such as a high tensile strength and fracture toughness when compared to the as-cast ductile iron (DI), making it an ideal material for automotive components [1]. Several surface engineering processes involving cold work can be applied to improve the surface properties, such as better fatigue or wear resistance. One such process is laser shock peening (LSP), a process which aims at improving these properties by the induction of compressive residual stresses which can be generated from plastic deformation by means of a high energy laser beam (Figure 1) [2].

Project Objectives

The objectives of this project were to understand the process of LSP, while determining the effect of LSP on the residual stresses, microstructure, hardness and surface roughness of ADI.

Project Methodologies

Austempering heat treatment was first carried out on the as-cast DI. This involved austenitising at 900°C for 2 hours, followed by austempering at 360°C for 1 hour and then, cooling to room temperature.

The ADI was then subjected to a LSP process, using various laser spot overlaps ranging between 20 and 60% and power intensities between 5 and 25 GW/cm^2.

Multiple material analysis techniques were employed to be able to study the effect of LSP process on ADI, such as microscopy, hardness testing, x-ray diffractometry (XRD), profilometry and residual stress measurement.

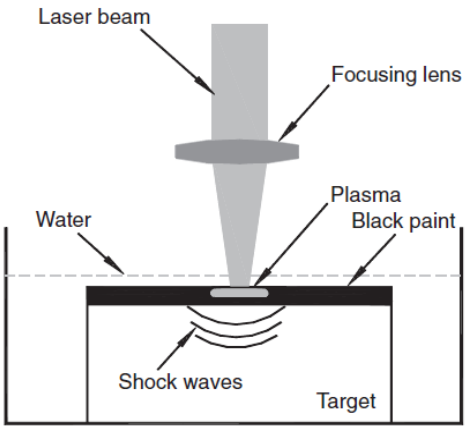

Figure 1: Schematic for the setup of LSP [3]

Results and Achievements

A microstructural change from a pearlitic to an ausferrite matrix was observed following the austempering heat treatment, providing a 14.9 % increase in the hardness of ADI. However, no phase transformation occurred by the LSP process.

The surface roughness was increased by 66.4 % when the laser spot overlap increased from 20 to 60 %. LSP increased the surface hardness by 33.4%, but no difference was observed for the surfaces peened with different overlaps. Hardness-depth profiles along the depth showed that the hardness of the LSP-ed specimens increased for a depth of 1 mm.

The LSP process resulted in creating residual compressive stresses which varied in magnitude from -380 to -470 MPa (Figure 2). As both the laser spot overlap and the laser power intensity were increased, higher compressive stresses were obtained, showing that the LSP process is a suitable surface treatment to improve the bending fatigue resistance of the ADI.

References

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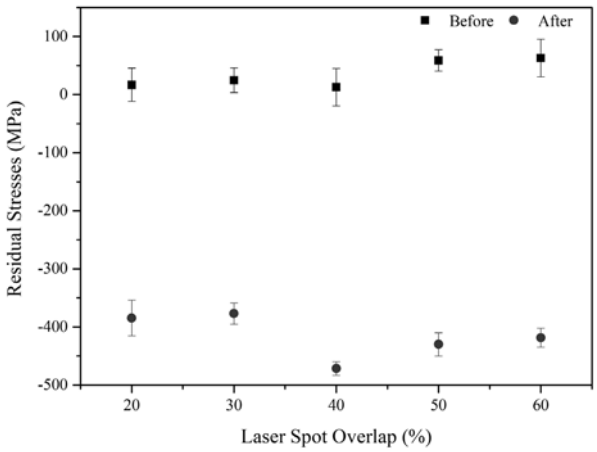

Figure 2: Residual stresses before and after LSP at different laser spot overlap

Porous Coating Applied to a Biodegradable Substrate

Student: Karl Galea Naudi Borg / Supervisor: Prof. Ing. Joseph Buhagiar / Co-Supervisor: Dr Daniel Vella

Introduction

Porous biodegradable metallic scaffold implants mimic the structure of natural bone to exploit bone regenerative effects. However, scaffolds comprised of solely biodegradable metallic materials lack the bioactive characteristics necessary to initiate bone formation and adhesion effectively. Therefore, the application of a calcium phosphate-based coating upon the scaffold aims to improve the overall bone forming abilities of the implant system. Furthermore, biodegradable scaffold implants are progressively resorbed by the host body throughout the application time, leaving behind healthy bone in its place. Fluorapatite, FA ($Ca_{10}(PO_4)_3F_2$) is a calcium phosphate which is suitable as a coating material for scaffolds as it exhibits excellent bone forming abilities and helps to improve bone mineralisation [1].

Project Objectives

The research objective was to optimise the coating procedure of a sol-gel derived FA coating upon a potentially bioresorbable porous iron (Fe) substrate. Sol-gel synthesis followed by a dip coating procedure was implemented to coat substrates, some of which had a complex geometry.

Project Methodologies

The FA coating medium was synthesised via a sol-gel process. The procedure involved the stoichiometric reaction of calcium nitrate (dissolved in ethanol) with hydrolysed triethyl phosphate (TEP) and ammonium fluoride. The generated sol showed a pH of ≈0.5 and required neutralising to a pH of 7.5, to minimise corrosion of the reactive substrate. Different concentrations of ammonia and diethanolamine (DEA) were utilised as neutralising agents. The FA coating was applied to solid Fe coupons, Fe foams and solid AISI 316LVM (control). The samples underwent a dip coating procedure and then were subject to a drying and sintering treatment at 250˚C or 500˚C under a reducing atmosphere. The coated samples were characterised by X-ray diffraction (XRD) and scanning electron microscopy (SEM).

Results and Achievements

The principal obstacle was to limit the corrosion of the substrate during processing as even within a reducing atmosphere, the coating medium imparted extensive corrosion damage on the Fe specimens. Reducing the water content of the FA sol, by preparing the neutralising agent in ethanol rather than water, significantly minimised substrate corrosion.

The optimal results were obtained when implementing either a 5% (v/v) ammonia or 10% (v/v) DEA neutralising agents, performing 3 dip coating operations proceeded by a 500˚C heat treatment. In both cases, as shown in Figure 1, a uniform FA coating was obtained that displayed nano-crystalline features. The presence of nanometric geometries infers a high degree of micro-porosity that develops bone forming abilities and allows the body fluid to reach and react with the underlying biodegradable substrate. Furthermore, both coating sols offered sufficient fluidity to penetrate and coat the internal pores of the scaffold structure. XRD analysis of the Fe coupons showed that no radiopaque oxide phases were generated during coating Moreover, the DEA neutralised sol offered the added benefit of improved corrosion resistance and subsequently higher control during processing.

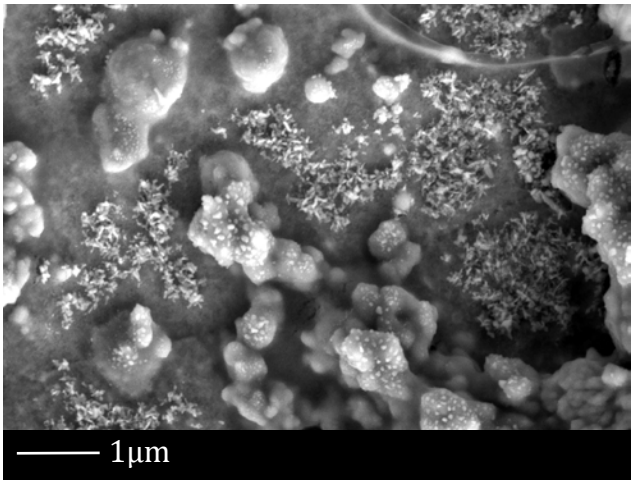

Figure 1: SEM image of the nano-features produced with the 10% DEA coating after 500˚C

Acknowledgments

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Tribocorrosion Response of HiPIMS TiB_2 Coated 316LVM

Student: Nathaniel Buttigieg D'Ugo / Supervisor: Prof. Ing. Bertram Mallia / Co-Supervisor: Antonino Mazzonello

Introduction

Around 1 million total joint replacements (TJRs) currently take place globally every year. Overall increase in life expectancy, younger patients, and average bodyweight put emphasis on the increasing importance for longer lasting, higher quality bearing surfaces for joint replacements [1].

Tribocorrosion is an important contributor to many problems encountered during TJR lifetime. This concerns material loss due to the combined effect of mechanical wear and corrosion, whose interaction (known as *synergy*) serves to accelerate material loss to a greater extent than the effect of either one alone.

Project Objectives

This research was carried out to analyse the behavior of a non-naturally occurring, ceramic coating that exhibits *superhardness* called titanium diboride (TiB_2). The coating has been subjected to sliding wear tests that simulate the movement of the human body, whilst submerged in a saline solution at 37 °C.

Project Methodologies

A number of cylindrical 316LVM samples were coated with TiB_2 by means of a physical vapour deposition (PVD) process variant known as *High Power Impulse Magnetron Sputtering* (HiPIMS). The coating was characterised using EDS, XRD, nano-scratch, and nano-indentation to investigate the chemical composition, crystal structure, deformation response, hardness, and adhesion. The test materials were subjected to static corrosion testing, and reciprocating sliding corrosion-wear testing at 1 Hz sliding frequency against an inert alumina ball under different electrochemical conditions to enable determination of the corrosion-wear synergy. Testing was carried out in Ringer's solution at 37 °C. The dimensions of the resulting wear scars were measured using profilometry and the amount of corrosion was estimated from measured electrochemical parameters so that the mechanical and corrosion contributions and their synergies were determined. SEM and EDS were used to study the material loss mechanisms and resultant scar morphologies.

Results and Achievements

TiB_2 has received limited attention in tribocorrosion research. Here, it was discovered that despite its high hardness, high corrosion and mechanical wear resstance, TiB_2 forms a thin passive oxide in saline environments, leading to material loss when subjected to reciprocating sliding against Alumina due to the cyclic removal and reformation of the oxide film. This form of synergistic material loss is known as *Type I corrosion-wear*. Under an anodic potential of 0.1 V vs. SCE, the material loss of the coating led to coating perforation. Delamination in such region increased substrate loss by the hard coating debris due to third body wear mechanisms [2].

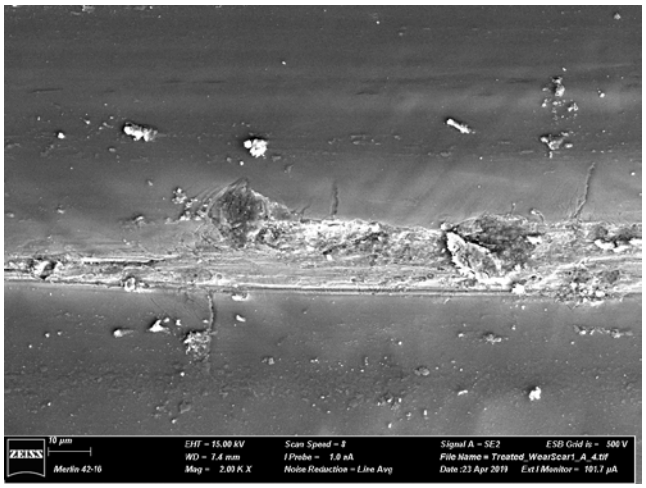

Figure 1: SEM image at 2000 magnification of scar generated by corrosion-wear testing of the TiB_2 under anodic potential showing coating perforation and three body damage of the exposed 316LVM substrate

References

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Surface Characterisation and Corrosion Response of Nano-Textured 316L Stainless Steel for Implant Applications

Student: Jacques Yves Caruana / Supervisor: Prof. Ing. Bertram Mallia

Introduction

One of the earliest and most commonly used implant biomaterials is 316L stainless steel. It offers a good combination of low cost, mechanical properties, corrosion resistance, and relative inertness in the human body [1]. However, recent years have seen the emphasis in biomaterials shifting from bio-inertness to achieving specific tissue and cellular response [2]. Nano-texturing of the surface by processes like anodic oxidation is one of the recently identified methods for the enhancement of cell response. For percutaneous implants such as external bone fixation pins, or long term intravenous catheters, this would provide enhanced healing and a skin seal with the implant, preventing infection.

Anodising of 316L SS enables the production of surfaces covered in an arranged, ordered array of nano-pores with nanometric diameters, which can be tuned according to the anodising parameters employed. These structures result in changes including the surface energy, surface chemistry and topography, which impact the adherence and proliferation of cells and proteins on the surface [2].

Project Objectives

The aim of this dissertation was the analysis and characterisation of 316L stainless steel anodised under two sets of anodising conditions to achieve nano-textured surfaces with nano-pore sizes of ~50 and 200 nm diameter. The chemical composition, topography, wettability, and corrosion response were investigated for untreated, and two types of treated samples (designated as UT316L, 50nm, and 200nm respectively).

Project Methodologies

Untreated and anodised 316L samples were provided by the Middle East Technical University (METU) in Turkey; these were anodised in a solution of 5vol% perchloric acid and ethylene glycol under 40 V for 10 minutes and 80 V for 4 minutes for 50nm and 200nm samples respectively. The surface topography was analysed using optical and electron microscopy. EDS, and XRD techniques were also used to investigate the composition and crystal structure. Nano scratching was done to assess the adhesion and deformability of the thin oxidised surface. Water contact angle testing was used to test surface wettability, while corrosion response was investigated via potentiodynamic & potentiostatic electrochemical corrosion tests in Ringer's Solution at 37 ^{0}C to simulate human bodily fluid.

Results and Achievements

The anodised surfaces were confirmed to comprise of a nano-textured surface containing nano-pores using high magnification SEM. The pore size increased with increasing anodising voltage. It was also noted that nano-pore size exhibited variation on different samples treated under the same conditions. Figure 1 shows a 50nm sample which exhibits a honeycomb-like lattice topographic structure, with an average pore diameter of 68.8±7 nm. The anodised surfaces had improved hydrophilicity compared to untreated samples; average water contact angles for 50nm, 200nm and UT samples were 62.8±5.1^0, 62.7±7.4^0, and 72.0±8.5^0 respectively.
EDS analysis suggested that the coating thickness was too small to be detected, while the amorphous nature of the oxide meant that XRD analysis could not detect such a layer.
Corrosion testing showed propensity for localised corrosion, which was probabilistic in nature.

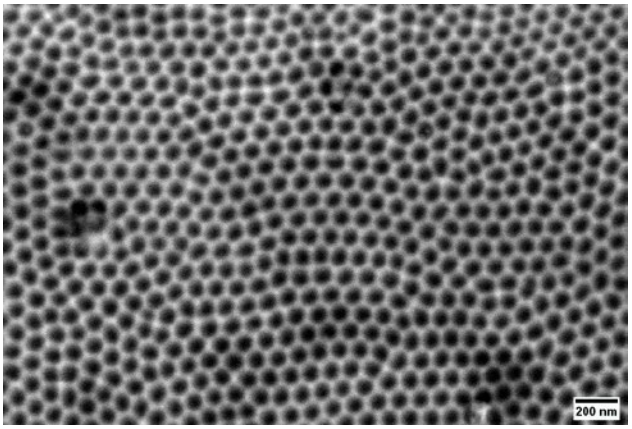

Figure 1: 100KX magnification of 50nm sample with ~68 nm pore diameter, showing a honeycomb-like structure

References

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Real Time Measurement of Photocatalytic Activity of Materials and Coatings

Student: Gianluca Chetcuti / Supervisor: Prof. Ing. Maurice Grech / Co-Supervisor: Dr Ing. Stephen Abela

Introduction

In a typical household, up to 30% of the water consumption is used for toilet flushings. In an attempt to reduce fresh water consumption, grey water from showers and sinks can be photocatalytically treated and the resulting second class water used for flushings [1].

Project Objectives

To establish whether photocatalytic activity brings about a measureable change in water conductivity and if this change in conductivity could in fact measure and be used as a real time assessment of the ongoing photocatalytic activity. If this were possible then this simple measurement would enable control of the photocatalytic treatment and serve as a forewarning of the need for maintenance or indeed replacement of the photocatalytic surface.

Project Methodologies

During photocatalytic water treatment, semiconductor materials release an electron when illuminated with radiation of sufficient wavelength (energy). The electron takes place in a reducing reaction that generate radical that serve to breakdown the organic pollutants present in the water [2]. In attempt to answer the project's research question, the conductivity of water was measured during the photocatalytic water treatment so as to establish whether the generation of the electron-hole pair and subsequent reactions cause a measurable change in water conductivity. A setup was constructed to carry out water conductivity measurements under UV irradiation. Tests were carried out using photocatalytic and non-photocatalytic samples and the readings compared.

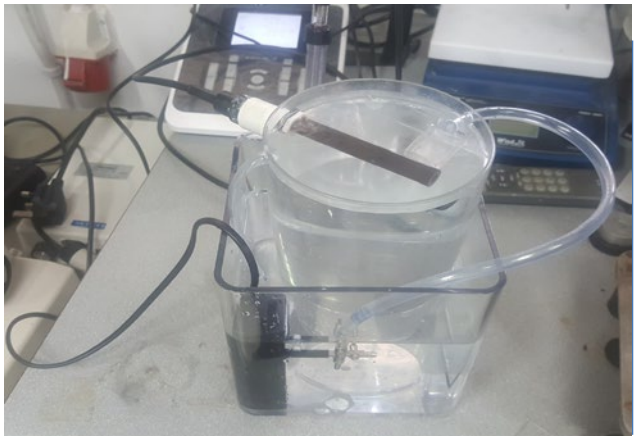

Figure 1: Setup to measure water conductivity

Results and Achievements

The results obtained are shown in Figure 2 below. It was observed that photocatalysis did in fact cause an increase in conductivity. The photocatalytically generated radicals convert the organic pollutants into carbon dioxide and this contributes to the increase in conductivity. Measurement was a complex matter and using it as a means of controlling the photocatalytic activity may be more difficult than anticipated. The rise in conductivity with time despite the termination of UV radiation confirmed that other factors could be contributing to the rise in conductivity. These factors may include contamination of the water, excessive carbon dioxide absorption and photodegradation of the equipment or sample under UV radiation. It appears that other measuring techniques should be investigated.

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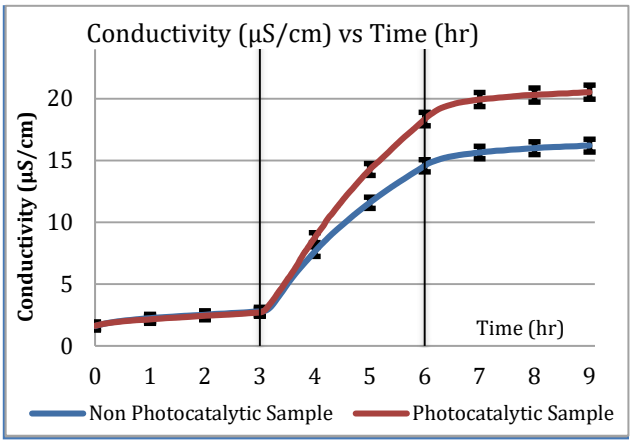

Figure 2: Variation of water conductivity with time

3D-Printing of Porous Biometallic Implants

Student: Rachel Galea / Supervisor: Prof. Ing. Joseph Buhagiar / Co-Supervisor: Dr Arif Rochman

Introduction

Generally, bone is characterized by an open-cell porous structure. Implants need to be designed and manufactured in a way that mimic bone as this would allow the regeneration of bone tissue and restore bone function at a damaged site [1]. When there is huge loss of bone or non-union fractures, a support structure, termed scaffold, is required in order to bridge the gap and allow for bone regeneration. There are a number of additive manufacturing methods that can create metallic scaffolds. However, these tend to be capital intensive.

Project Objectives

The aim of the project was to test a proof of concept that creates scaffolds by an additive manufacturing process. The idea and objective of the project was to test a hypothesis that metallic scaffolds can be built by extruding a sequence of metallic and a water soluble salt extrudates. The salt extrudate after debinding and water leaching becomes a pore while the metallic extrudate after sintering becomes the strut.

Project Methodologies

Macro-porous scaffold preforms were fabricated using an extrusion-based manufacturing technique. This involved the fabrication of a layer-by-layer construct of alternating metallic and space holder extrudates next to each other, for the creation of a scaffold green.

A binder (paraffin-wax-polyethylene and stearic acid) was mixed with a metallic powder (AISI 316 or commercially pure iron) and NaF powder in order to create the metallic and space-holder extrudates respectively. The extrudates were then subjected to binder burn-off at 500°C followed by first stage sintering at 900°C in a tube furnace. After first stage sintering, the scaffold green was immersed in distilled water to leach out the salt. The scaffold green, was then dried at 110°C and later subjected to second stage sintering in the tube furnace at 1200°C. The metallic extrudates after processing became the struts while the space-holder extrudates become pores.

For each processing stage, the scaffold extrudates were analysed using X-Ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Energy-dispersive spectroscopy (EDS) for elemental analysis.

Results and Achievements

The proposed proof of concept proved to be suitable to achieve a basic open-celled porous metallic scaffolds. The most promising metallic material for the proposed proof of concept was made with Fe and NaF powders. Figure 1 shows the first scaffold prototype created together with SEM imaging. The micrograph showed that after first stage sintering the iron struts had minimal micro-porosity and effective bonding. EDS analysis on the salt leached microstructures revealed relatively minor traces of NaF. This meant that salt leaching was done successfully. The created scaffold struts after sintering at 1200°C had relatively good inter-particle bonding and effective adhesion between subsequent layers of the build-up. Finally, EDS confirmed that the struts were composed of alpha-iron and had no oxidation.

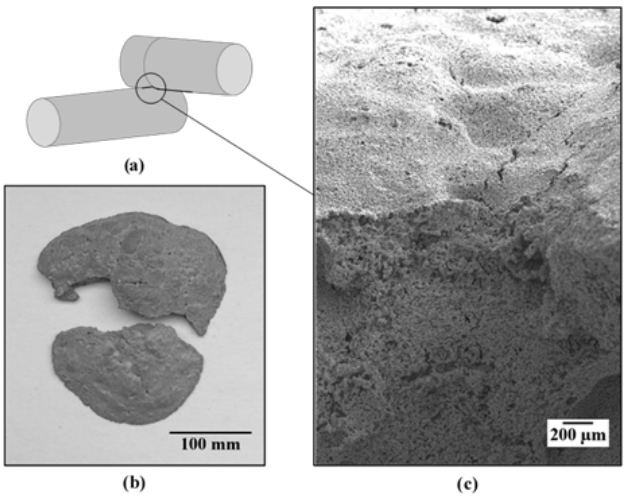

Figure 1: 3D schematic representation (a) of the metallic scaffold with the black circle indicating the area on the scaffold where the SE-SEM image (c) was captured and (b) a macro-image of the iron scaffold after NaF leaching and second stage sintering

References

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Characterisation of Aluminium – Copper Brazed Joints

Student: Jurgen Gatt / Supervisor: Prof. Ing. Maurice Grech

Introduction

This study has been carried out in collaboration with Seifert System Inc, a leading company in the production of HVAC systems intended for industrial applications. Currently the outlet of the copper compressor fitting is brazed to a copper heat exchanger. In an effort to cut down costs, Seifert seek to replace the copper heat exchanger with one made of aluminium. This would require a copper – aluminium braze.

Project Objectives

The main objective of this study is to investigate the effect of brazing parameters on the microstructure and type of intermetallic formed and the subsequent impact on the mechanical properties of the brazing joint.

Project Methodologies

In this study, a conventional torch was used to braze Aluminium 6060 (EN AW6060) and Copper, Cu-DHP (EN CW024A) using as filler a Harris 4047 eutectic alloy containing 88% Aluminium and 12% Silicon.

Two orientations namely, copper in aluminium and aluminium in copper were considered. For either orientations, gap sizes of 0.08mm, 0.10mm and 0.12mm were tested. For each condition, three swage lengths measured as 5.0mm, 6.5mm and 8.0mm were applied.

The effect of these brazing parameters was assessed by carrying out, both mechanical and metallographic testing. Samples were subjected to Pressure and Tensile testing whilst Penetration of the brazing filler was measured by making use of stereomicroscopy.

Furthermore, microstructural analysis was carried out using both optical and scanning electron microscopy. In an attempt to identify the type of intermetallics formed on either the copper or aluminium side of the joint, chemical and phase characterisation of the various areas of interest was carried out using Energy Dispersive Spectroscopy and X Ray Diffraction.

Results and Achievements

It was noted that the brazing parameters had a major influence on the soundness of the joint attained. It became apparent for example that the effect of thermal conductivity and coefficient of thermal expansion the was reversed with orientation[1].

The formation of columnar prismatic structures was noted between the aluminium and brazing filler interface. This related to what was found by other researchers, including Xia et al. who claimed that such structure is made up of α-Al Solid Solution [2].

As can be seen in Figure 1, two Intermetallics formed between the copper and brazing filler interface. The layer closest to the copper was identified as Cu_3Al_2 and that adjacent to the brazing region as $CuAl_2$. Other researchers, including Xia et al. made similar observations [2].

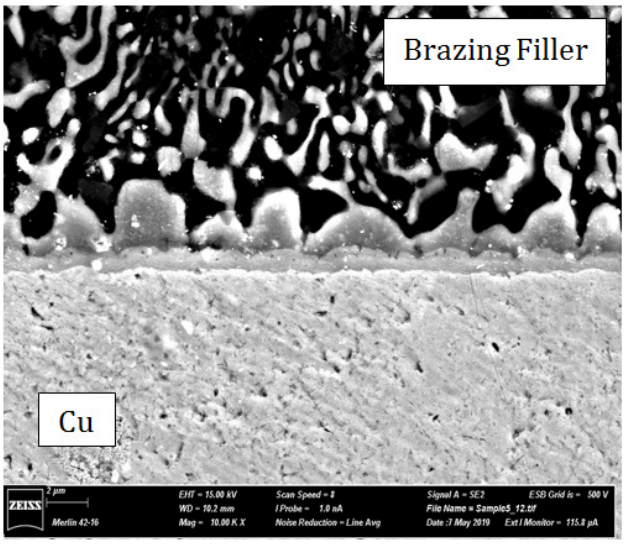

Figure 1: Intermetallic Formation between the Copper and Brazing Filler Interface. Brazing Parameters: Copper in Aluminium Orientation, Gap Size 0.1mm, Swage Length 8.0mm

References

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Diffusion Analysis of Solid-State Batteries

Student: Amy Gauci / Supervisor: Dr Ing. Stephen Abela

Introduction

The rapid technological advances combined with the increased environmental awareness leading to further interest in electric vehicles both serve as motivation for further development in battery technology. Solid electrolytes are a possible solution to increase the energy density as well as the safety of batteries, eliminating the dangers associated with the flammable liquid electrolyte while offering the possibility of using a lithium anode, which would significantly increase the energy density. While typically solids do not exhibit good diffusional properties, some have a less uniform crystal structure allowing superior ionic motion through point defects.

Project Objectives

The aim of this project was to analyse the diffusion of lithium ions through two solids, studying its variation with temperature, as well as calculating the conductivity. This was done to ultimately determine whether the conductivity is comparable to that exhibited by liquid electrolytes, that is within the range of 0.1 to 10 Sm^{-1}, which would make solid electrolytes a viable alternative.

Project Methodologies

Molecular dynamics simulations were carried out using LAMMPS. The MSD of lithium ions as a function of time was found for Li_2O as well as lithium lanthanum zirconium oxide, or LLZO, at different temperatures. The diffusion coefficient and ionic conductivity were then determined from the gradient of the MSD versus time plot and using the Nernst-Einstein equation [1]. Figures 1 and 2 display the MSD versus time plot for Li_2O and LLZO respectively.

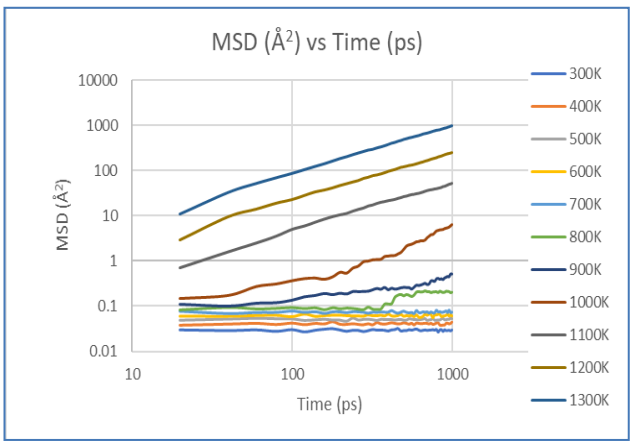

Figure 1: Graph showing MSD (Å²) vs Time (ps) for Li_2O

Results and Achievements

At low temperatures Li_2O behaves like a typical solid having limited ionic motion. As the temperature starts to increase, lithium ions start to gain more kinetic energy, enabling them to overcome the energy barrier needed for diffusion to occur. Above 1000K, the rate of diffusion increases significantly as its structure becomes more disorganised. The results obtained closely match reported literature. However, Li_2O only exhibits high diffusion and conductivity comparable to liquids at very high temperatures, so it is not ideal for batteries.

Similarly, in the case of LLZO the rate of diffusion becomes significantly high at around 1000K, as it starts to transform from the structured tetragonal phase into the more open cubic phase. While results show that the conductivity of tetragonal LLZO at low temperatures is still not sufficient, when it transforms to cubic LLZO it shows superior diffusional properties comparable to liquids. Thus, cubic LLZO is a very promising solid electrolyte in terms of ionic conductivity. Other studies have shown that cubic LLZO can be stabilised at lower temperatures through doping, reaching conductivities that are two orders of magnitude higher than the tetragonal phase [2]. Future work could therefore focus on modelling the diffusional properties of doped LLZO.

References

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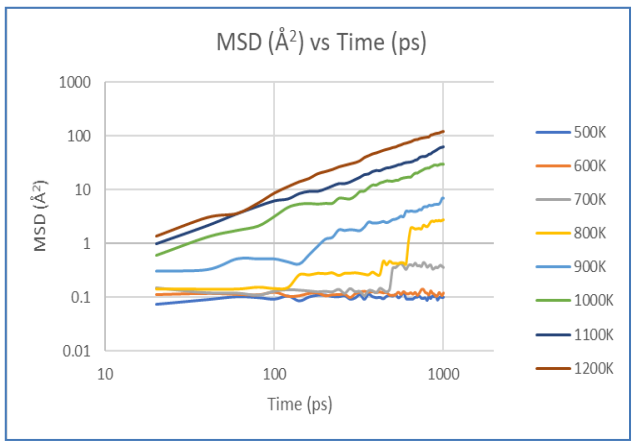

Figure 2: Graph showing MSD (Å²) vs Time (ps) for LLZO

Characterisation of Roman Pottery from Malta

Student: Jamie Grech / Supervisor: Dr Daniel Vella / Co-Supervisor: Dr Ing. John Betts

Introduction

In the field of archaeometry, a large number of characterisation techniques are available for the study of archaeological materials. Application of the right techniques can reveal the material history (material, production method & use) of an artefact [1]. Although the Maltese Islands are rich in archaeological heritage only a few characterisation studies have been carried out on pottery, in particular on Roman coarse ware. In this study, four Roman pottery samples prepared as embedded cross-sections were examined for their constituent materials, while five clay samples were also analysed and compared to two of the pottery sherds.

Project Objectives

The main aim of this study was to develop a procedure to characterise Roman period pottery. Four Roman period pottery samples excavated from three sites in the Maltese islands: (i) Foreman Street (Gozo) (ii) Għar ix- Xiħ (Gozo), and (iii) Tas- Silġ (Malta), were characterized and compared. Further to this, a material comparison between the two fired Roman pottery samples, excavated from Foreman Street, and the clay material recovered from Gelmus Hill (located close to Foreman Street) was done in an attempt to locate a possible pottery production site.

Project Methodologies

Four pottery shards and five clay samples were supplied for further study. These samples were made available by the Department of Archaeology of the Faculty of Arts, University of Malta. The procedure developed to characterise the pottery samples was a combination of the following:

(i) Optical Microscopy to categorize and list the different inclusion types identifiable in the fragments, (ii) Scanning Electron Microscopy coupled with Energy Dispersive Spectroscopy (SEM-EDS) to obtain high magnification images of the pottery samples while identifying the elemental composition of the inclusions and matrix,

(iii) X-Ray Diffraction (XRD) and micro-Raman Spectroscopy (µ-RM).

XRD was employed to gather information about the crystalline phases occurring in the bulk material. µ-RM allows for the chemical analysis of specific phases (inclusions and matrix) within the material fabric.

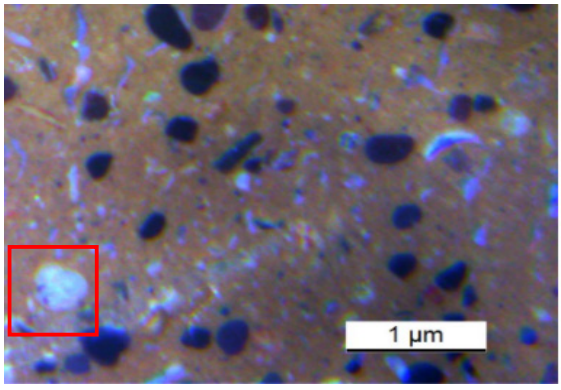

Figure 1: Image of pottery sample P14 with a calcite inclusion enclosed in a red box

Results and Achievements

The procedure developed enabled the possibility to discover the elemental make-up of the major constituents within the pottery samples.

The most abundant materials found within the pottery fragments were siliceous materials, iron oxides and carbonates. X-Ray Diffraction studies identified traces of glauconite and anorthoclase in the pottery samples. These two minerals play an important role in determining whether the pottery samples were in fact produced locally, imported or if certain minerals, such as anorthoclase, were imported to be used as temper in the local mixture.

References

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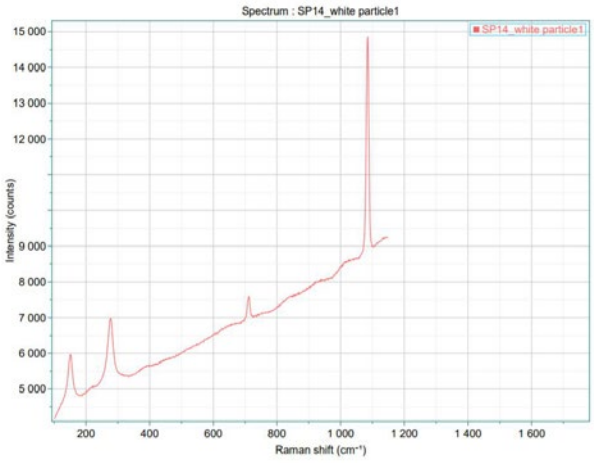

Figure 2: Raman spectrum of calcite inclusion in sample P14

Photocatalytic Titanium Dioxide Films by the Sol-Gel Process for Water Treatment Applications

Student: Jeanice Mallia / Supervisor: Dr Daniel Vella / Co-Supervisor: Ing. Anthea Agius Anastasi

Introduction

In this preliminary study, a titanium dioxide (TiO_2) photoactive thin film was prepared by the sol-gel process and applied to transparent fused silica glass by a dip-coating process. The film was designed to function as a photocatalyst for the breakdown of organic species in greywater.

Project Objectives

The main objectives of this study were to prepare a stable TiO_2 sol, deposit the sol by dip coating, establish a heat treatment procedure to transform the film into a photoactive one, and to characterize the films for their physical, chemical and mechanical properties.

Project Methodologies

The preparation of a TiO_2 sol involves mixing of a metal alkoxide precursor in an appropriate solvent. Therefore, the first part of this work was dedicated to varying the precursor concentration and solvent until a stable sol suitable for dip coating was obtained.

In the second part of this work, the sol was applied to fused silica glass substrates, and dried to obtain an amorphous xerogel film. Multilayer films were deposited to increase film thickness. The films were then subjected to a heat treatment process to transform them to in polycrystalline, and photocatalytically active structures.

Surface topography and film defects of the heat treated TiO_2 films were observed using optical and electron microscopy. Further characterization was carried out using Grazing Incident X-Ray Diffraction and Raman Spectroscopy.

UV/Visible spectrometry was employed to determine the optical transmittance of the films. The geometrical thickness of a 1 layer film was obtained by an ellipsometic. The structural integrity and wear resistance of the films were assessed via a Nanoscratch test.

Results and Achievements

The sol providing a good compromise between stability and film formation was identified and was composed of 0.56 wt% TiO_2. Heat treatment conditions which best produced photoactive films involved heating to 500°C at a rate of 10 °Cmin^{-1}, for 30 minutes in open atmosphere. The resulting structure of the films consisted mainly of anatase. As expected, an increase in film thickness, obtained by depositing multilayer films, led to a drop in %transmission in the wavelength range 300 to 400 nm. A 9-layer film absorbed more than 95% of wavelengths in the UVC range (λ ~ <200 – 280 nm). This was deemed to be an important result since high absorption of UVC will induce good photocatalytic properties. The thickness of a single layer of TiO_2 was estimated to be around 63 nm by the ellipsometric technique. The wear properties were improved with increasing number of layers.

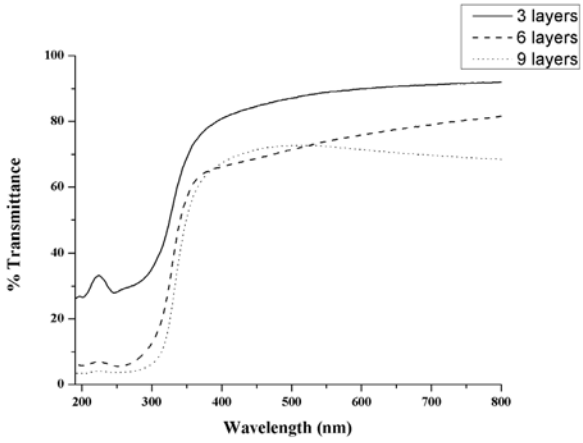

Figure 1: A plot showing the decrease in transmittance with increase in film thickness, and a high absorption in the UVC region

The Effect of Duplex Shot Peening on the Wear Resistance of Austempered Ductile Iron

Student: Noel Pace / Supervisor: Dr Ing. Ann Zammit / Co-Supervisor: Dr Ing. Glenn Cassar

Introduction

Austempered ductile iron (ADI) is a used in a vast range of applications including components used for automotive and military equipment. ADI possesses very promising properties such as good fatigue and wear resistance [1]. One type of wear phenomenon is scuffing which occurs in inadequately lubricated systems and as a result, the surfaces in contact cold weld together and then tear as the surfaces move away from each other. The scuffing resistance of the ADI is highly comparable to that of steel, with the ADI having better economic and manufacturing benefits.

Project Objectives

The objectives of this project were to study the effect of single and duplex shot peening (SP) on the microstructure and the scuffing resistance of ADI.

Project Methodologies

Test coupons were machined from as-cast ductile iron keel blocks. These coupons were transformed into austempered ductile iron by austenitising the material at 900°C for 120 minutes, followed by rapid quenching in molten salt at 360°C. The material was kept isothermally at this temperature for 90 minutes and left to cool in air. Single SP and duplex SP surface treatments were carried out on the surface of multiple samples. For single SP, S330 shots were accelerated towards the surface at an intensity of 0.32 mmA while for duplex SP, S330 shots were targeted at the same intensity followed by S110 shot media at 0.47 mmA. Finally, boundary lubricated scuffing tests using a pin-on-disk setup were carried out at incremental loadings of 2 kg every 120 seconds.

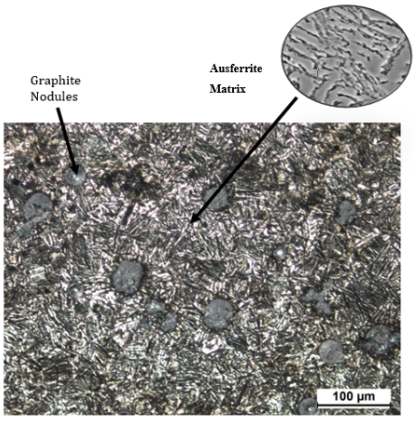

Figure 1: The resulting microstructure of as-ADI

Results and Achievements

The austempering heat treatment produced a microstructure consisting of graphite nodules dispersed in an ausferrite matrix as shown in Figure 1 [2]. The hardness of duplex SP ADI increased by 33% compared to as-austempered ductile iron. This is a result of austenite to martensite transformation, together with work hardening of the surface by the SP process. By duplex SP, the surface roughness R_a increased from 1.2929 µm to 0.0342 µm. Specimens processed with single SP produced the roughest surfaces at an R_a *of* 1.3895 µm. This increase in surface roughness is a result of the dimples that form in the surface after SP.

Figure 2 depicts the results obtained for the scuffing tests and shows how single SP and duplex SP did not improve the scuffing resistance of the ADI. It was concluded that the reason behind this was the fact that the improvements in hardness achieved with the shot peening processes, were counterbalanced by the increase in the surface roughness.

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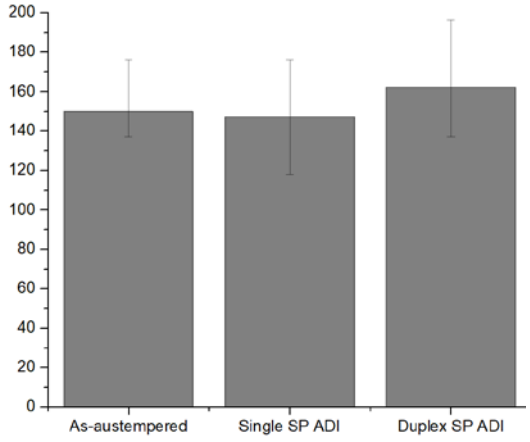

Figure 2: The scuffing load with relation to the Ra value

The Effect of Heat Treatment Process Parameters on the Microstructure and Impact Properties of X46Cr13

Student: Martha Sammut / Supervisor: Prof. Ing. Maurice Grech

Introduction

This study was conducted in collaboration with Methode Electronics Ltd. X46Cr13 is a martensitic stainless steel supplied in its annealed form and is used to manufacture torque sensors. This process is carried out using vacuum furnaces and in batches of over a tonne in weight.

Project Objectives

One of the main requirements for such application is the magnetic properties, however mechanical properties and primarily impact properties are also critical. This research therefore seeks to establish the effect of heat treatment and in particular 'double austenitising' on the microstructure and impact properties of X46Cr13.

Project Methodologies

K. Srivatsa et al. claimed that double austenitising leads to a simultaneous improvement in tensile and impact properties [1]. It was therefore decided to compare the impact and microstructural characteristics of samples subject to single and double austenitising treatments. Some samples were austenitised at 1040°C for 45 minutes whilst others were austenitised at 1040°C for 45 mins and 980°C for 45 mins, as well as 1060°C for 45 mins and 980°C for 45 mins. All hardening samples were tempered twice at temperatures between 200°C and 700°C. Samples were characterised using different techniques, namely the optical microscope, SEM, EDS, XRD and impact testing machine. The microstructural analysis involved identifying the carbides present, measuring the grain size, carbide size and carbide density. The results were correlated to those obtained by the XRD and impact testing.

Results and Achievements

Metallographic analysis of samples subjected to a double austenitising treatment showed an increase in carbide quantity and size when compared to their counterparts austenitised once at 1040°C. It was however difficult to corroborate this using the X-Ray diffraction technique as quantities of carbides being measured were of the same order of magnitude as that of the instrument's accuracy. Optical micrographs also showed that double hardening treatment led to a finer grain size.

In fact, the average grain diameter for samples austenitised once at 1040°C/45 mins was 39.89 µm whilst that for samples double austenitised at 1060°C/45 mins and 980°C/45 mins was 19.81 µm.

It was shown that increasing the tempering temperature led to M_3C carbides transforming into M_7C_3 and eventually to $M_{23}C_6$. Samples tempered at 500°C were found to start showing signs of sensitization, a phenomenon that was fully developed as the tempering temperature increased to 700°C.

Results seem to suggest a marginal increase in impact energy following double austenitisation process. This is however dubious as the error bars overlap.

Microstructures of samples subjected to different austenitising cycles, but similar tempering temperature were very similar and a change in performance, if any, can only be attributed to changes in grain size, which were noticeable.

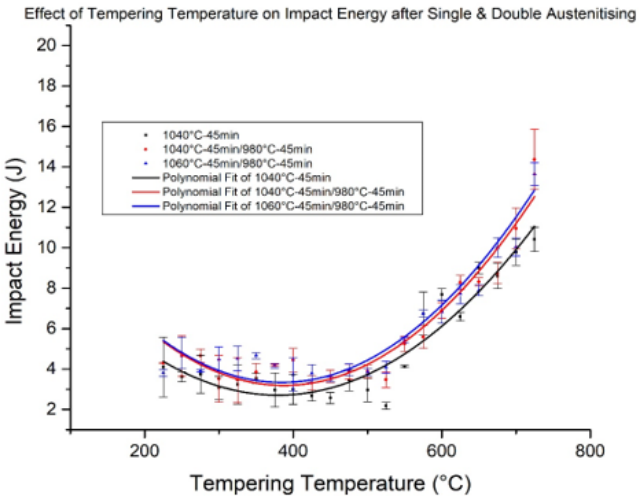

Figure 1: Plot of impact energy against tempering temperature for samples which have been subjected to single and double austenitising treatments. The error bars represent the standard deviation of the three averaged values of impact energy

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CoCrMo(C)/CrN Dual Layer Coating for Biomedical 316LM

Student: Sultan Almarbuii / Supervisor: Prof. Ing. Bertram Mallia / Co-Supervisor: Mr Antonino Mazzonello

Introduction

The demand for surgical procedures involving medical implant devices drives research on implant materials to further their performance. Austenitic stainless steel, 316LVM, is a popular implant material due to its cost-effectiveness, good corrosion resistance and mechanical properties. This biomaterial however displayed poor tribocorrosion resistance and is susceptible to localised corrosion in chlorine containing environments. Surface engineering through the application of coatings is a potential tool to enhance its performance and applicability. In this work a dual PVD layer consisting of CrN layer followed by an outer CoCrMo(C) S-phase layer (S/CrN) was the subject of the investigation.

Project Objectives

The main aim of the project was to characterise and investigate the corrosion and tribocorrosion response of S/CrN coated 316LVM in the as-deposited and two post deposition heat treatment conditions in an environment mimicking the human body.

Project Methodologies

Mirror polished AISI 316LVM stainless steel samples were coated with S/CrN using magnetron sputtering PVD. The coatings were post-deposition heat treated using two sets of conditions. The first heat treatment was carried out in a reducing environment containing 95% N and 5% H (S/CrN-HTR). The second was carried out in a partial vacuum of air - slightly oxidising environment (S/CrN-HTO). Both treatments were carried out at 600°C. The structure, composition, nanohardness, scratch response, corrosion behaviour and tribocorrosion response against alumina of the uncoated substrate and the as-deposited and heat treated coated 316LVM were investigated.

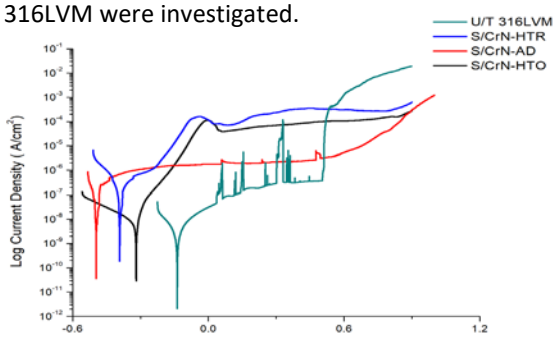

Figure 1: Potentiodynamic scan for S/CrN, S/CrN-HTR and S/CrN-HTO

Electrochemical potentiodynamic static corrosion testing and reciprocating sliding tribocorrosion testing were carried out in full strength Ringer's solution. Tribocorrosion tests were carried out against an alumina counterface under a frequency of 1Hz and a normal load of 3N under both open circuit potential (OCP) and anodic potential (AP) conditions to study the various contribution to material losses.

Results and Achievements

S/CrN exhibited higher hardness (17.4GPa) than the U/T 316LVM sample (4.4 GPa). Coating hardness was further increased to a similar hardness of ~22.6GPa following either of the heat treatments. The as-deposited and heat treated samples displayed good adhesion and deformation damage resistance during the nano-scratch testing. S/CrN displayed better corrosion response to the uncoated 316LVM (Figure 1). Heat treatment of the coatings resulted in restricting the passive region with S/CrN-HTR displaying the least corrosion resistance. At the high potential transpassive dissolution and localised corrosion occurred.

Tribocorrosion evaluation under OCP and AP electrochemical conditions, showed that S/CrN-HTO exhibited the best tribocorrosion response (Figure 2). This was attributed to the largely inert chromium oxide (Cr_2O_3) layer formed on its surface during heat treatment which supressed the main synergistic material loss contributor for the untreated, S/CrN-AD and S/CrN-HTR test materials involving the cyclic formation and removal of the passive film referred in literature as Type I corrosion-wear synergy.

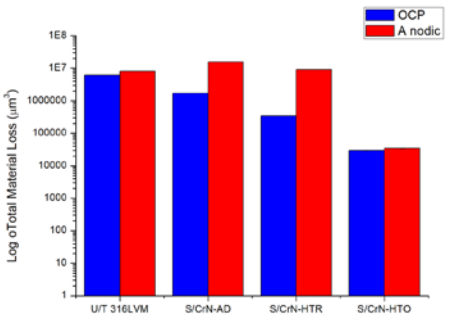

Figure 2: Total volume material losses, determined for corrosion-wear track areas for the different four materials studied in this work under OCP and AP conditions

Development of a Non-Magnetic Fe-Mn-Ag Biodegradable Alloy

Student: Matthew Sultana / Supervisor: Prof. Ing. Joseph Buhagiar / Co-Supervisor: Ms Christabelle Tonna

Introduction

Recently, biodegradable metallic implants have been gaining interest within the biomedical sector. A suitable alloy made from Fe-Mn-Ag developed with powder metallurgy techniques could result in an antiferromagnetic implant which would degrade within the body at an optimal rate while also being compatible with MRI.

Project Objectives

The objectives of this project were to develop a procedure to prepare alloyed Fe-35Mn powder using ball milling and to study the effect of various processing parameters on powder morphology and composition.

Project Methodologies

In this work, the effect of the ball milling of Fe-35Mn powder on the resultant particle size and circularity was studied. A set of milling runs with different properties, such as milling time and speed, were set up to analyze the variation of the process with respect to the resultant particle size and circularity with a statistical technique called the 'Taguchi Method'. The analysis was based on the fact that smaller, more circular particles would have a larger surface area which would help drive diffusion and densification in the early stages of sintering [1].

A second test was designed to study the effect of individual variables of the ball milling procedure with the intention of obtaining the optimal parameters for alloying Fe and Mn powders and producing the non-magnetic austenite phase. The powder produced with the most optimal parameters from this test was then mixed with silver powder. Coupons were prepared via uniaxial pressing and sintered at a temperature which exceeds the melting temperature of silver, so as to aid in the diffusion of the other particles and inhibit the formation of micro-pores through liquid-phase sintering [2].

The resultant powders and compacts were imaged with the use of optical microscopy and scanning electron microscopy (SEM) to observe the results of the milling and sintering. Characterization was done with X-ray diffraction (XRD) to determine whether the austenite phase was obtained.

Results and Achievements

The Fe and Mn powders were successfully mechanically alloyed with the use of ball milling, forming the non-magnetic austenite phase with only small amounts of ferrite present. This was confirmed with X-ray diffraction of the resultant powders, as can be seen in Figure 1, along a non-alloyed powder.

The Fe35Mn5Ag compact prepared indicated that the silver was homogeneously distributed within the coupon however some micro-porosity remained. The resultant alloy shows promise in being a suitable material for biodegradable implants.

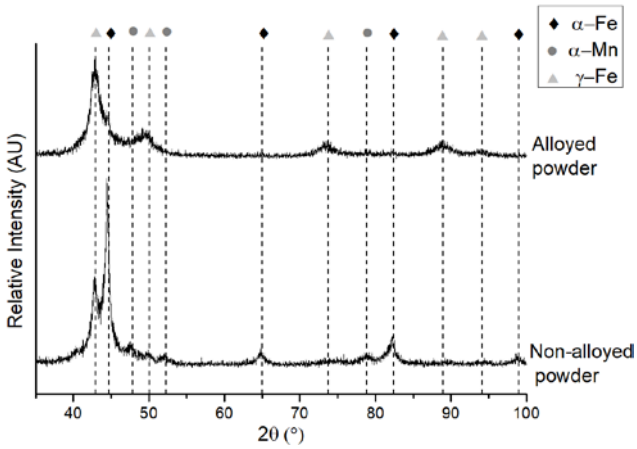

Figure 1: XRD scans of an alloyed and a non-alloyed powder

Acknowledgements

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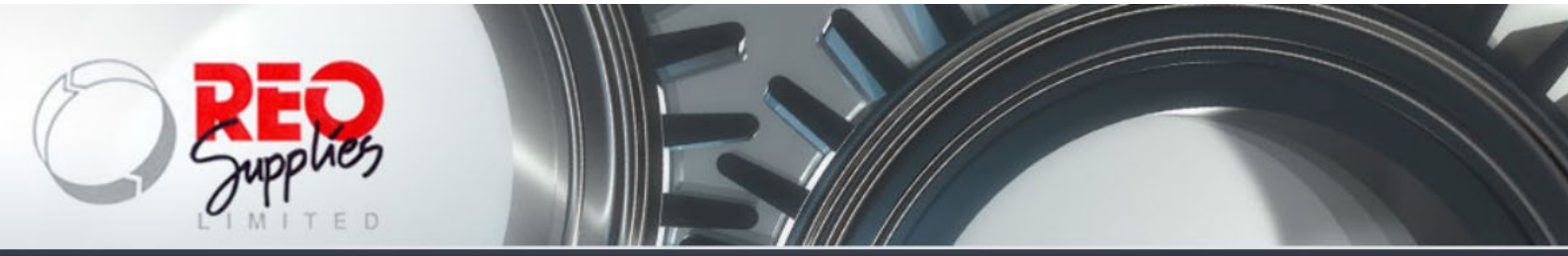

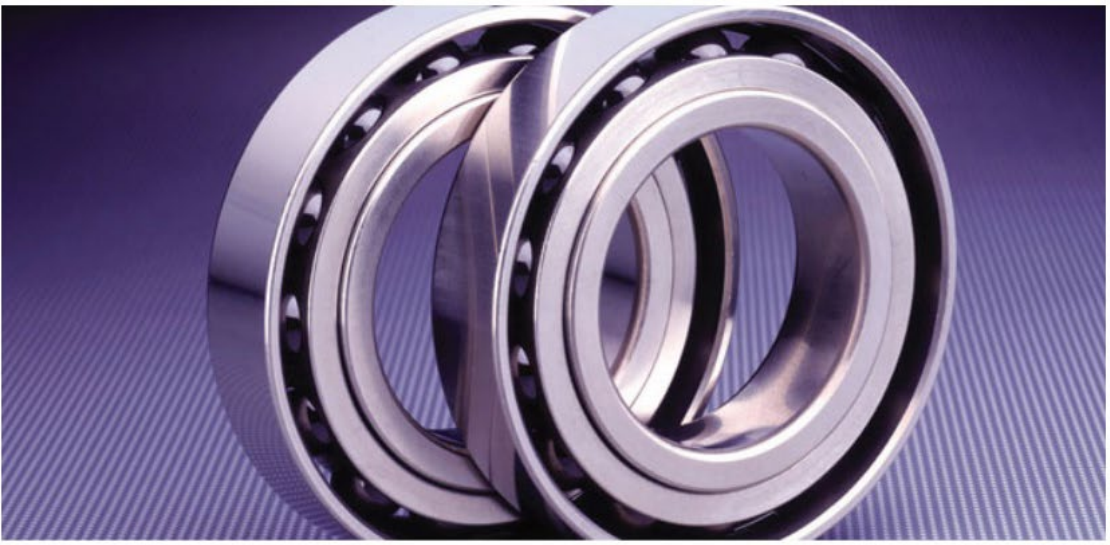

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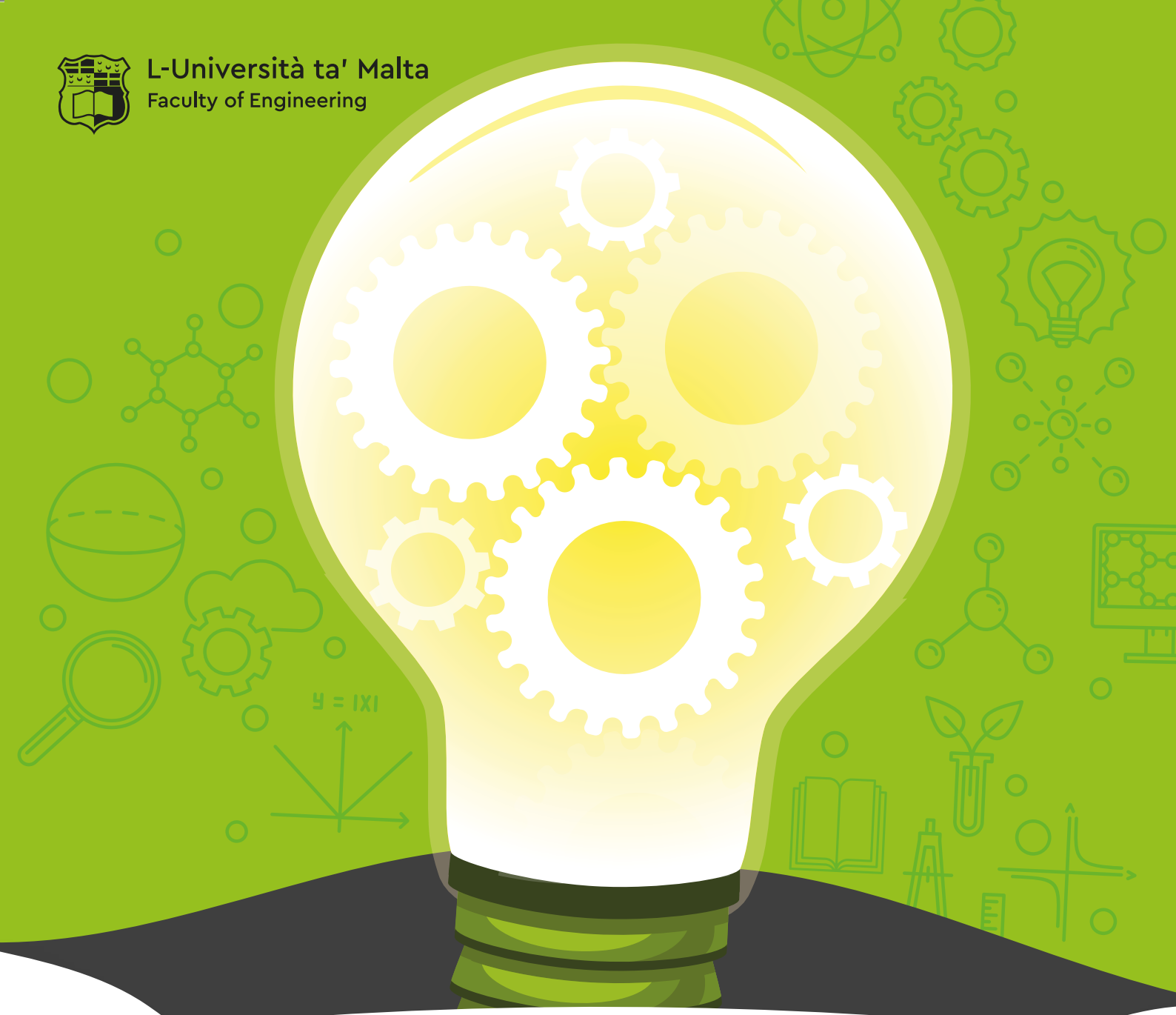

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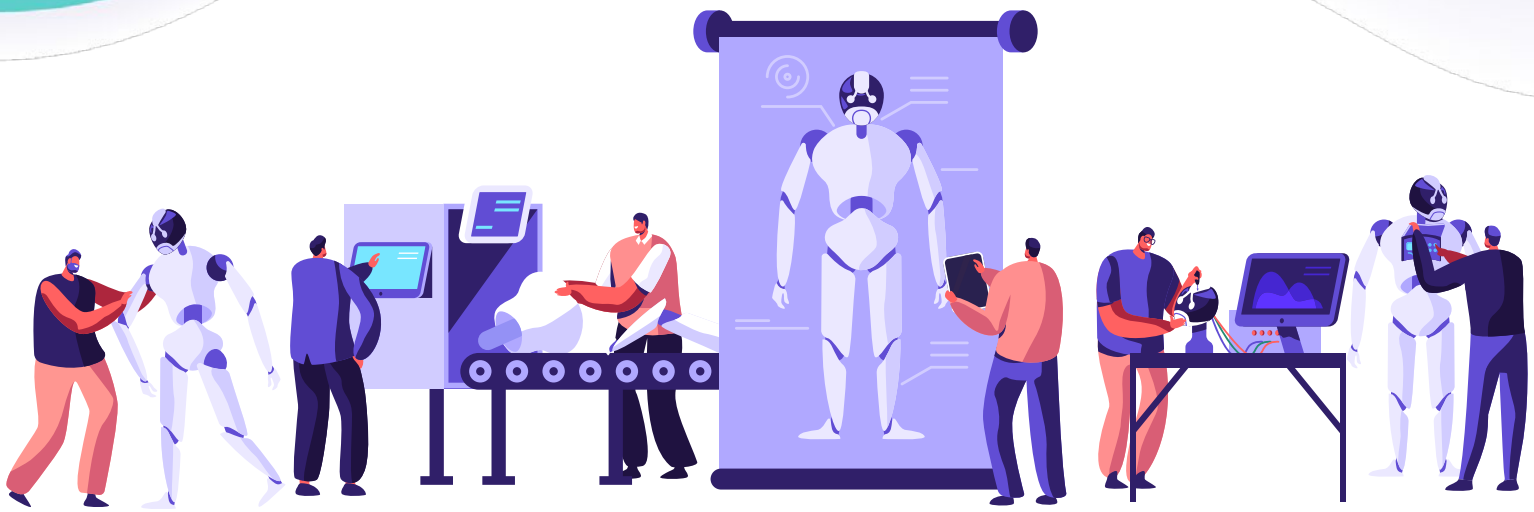

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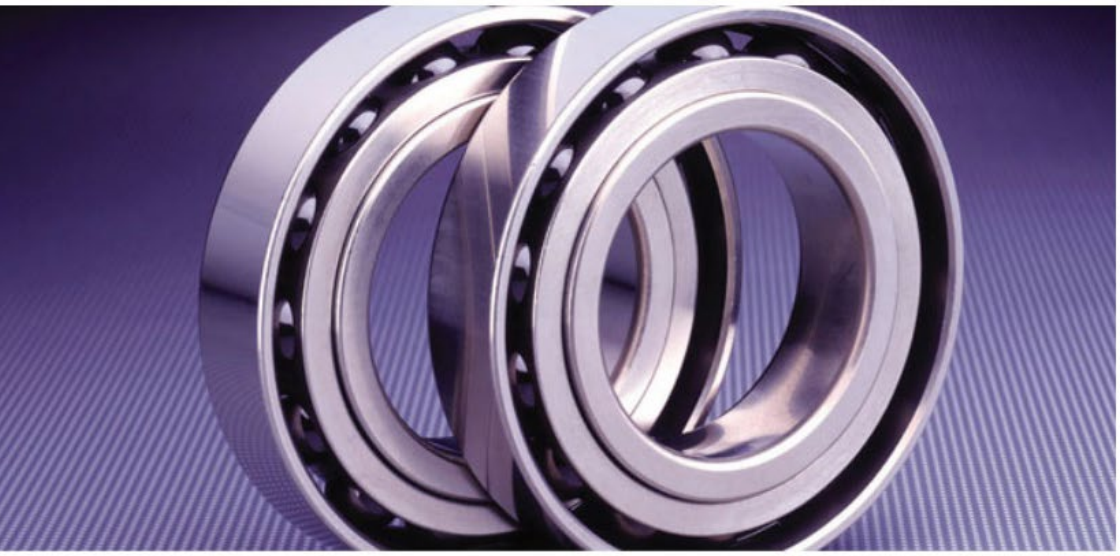

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