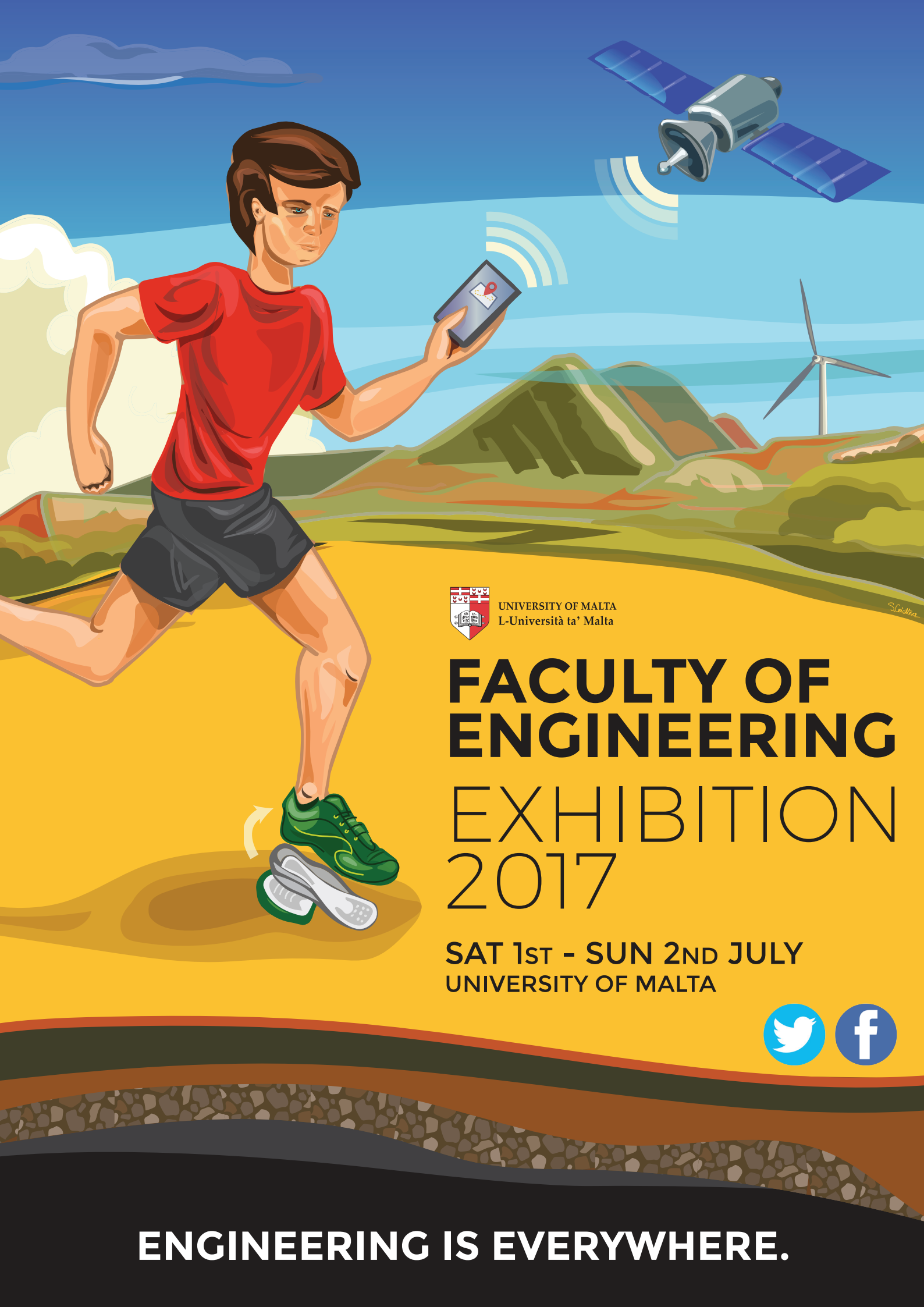
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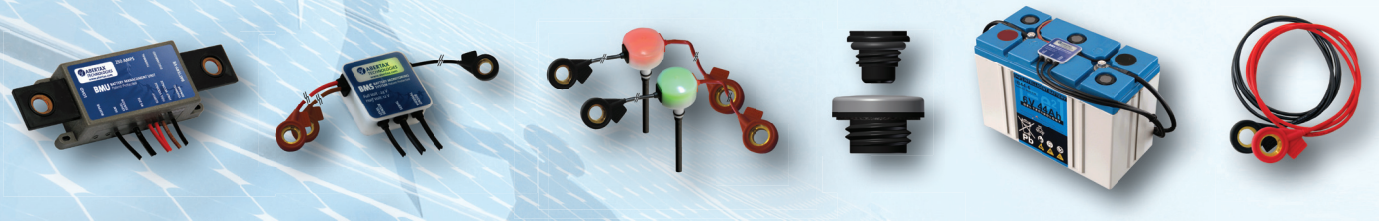

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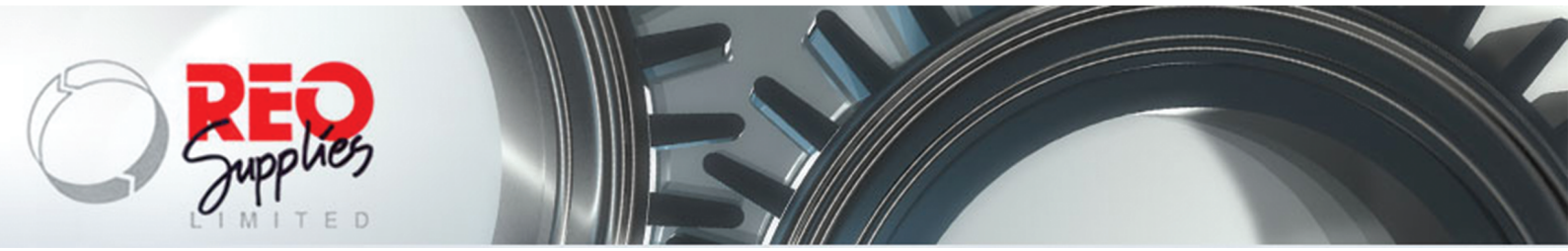

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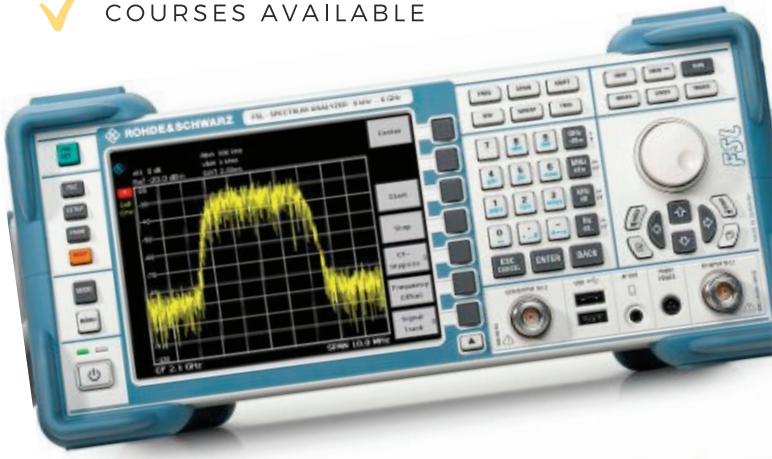

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FOREWORD

On behalf of the Dean and all of the staff of the Faculty, I would like to welcome you to the 28th edition of the annual Faculty of Engineering Exhibition at the University of Malta. This year sees 80 undergraduate students presenting proudly their final year projects – the results of hard work, dedication, and the application of Engineering knowledge acquired over the entire course – as well as numerous other projects being carried out at postgraduate level. A brief look even at the undergraduate project titles immediately reveals the extent of the variety of the areas under study in our Faculty, and therefore one of the main reasons why the B.Eng.(Hons) remains a very attractive and topical course of study at the University of Malta. A number of the projects are carried out in collaboration with industrial partners, therefore enhancing the exposure of our students to the industrial environment and to real problems in the field; while many others are carried out in support of larger internal, and sometimes international, research initiatives, thus giving the students a priceless experience of cutting edge research even during their undergraduate degree. Most of these larger projects will also be on display during the exhibition.

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 the academic staff 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 the many industrial sponsors of the exhibition, without whom this event would not be possible.

Most of all I invite you to visit the exhibits, and to talk to the students about their work, where you will get first-hand information on the nature of the projects, on the work that was involved, and even on the students' ideas on where the work will lead.

Michael Saliba

Deputy Dean, Faculty of Engineering

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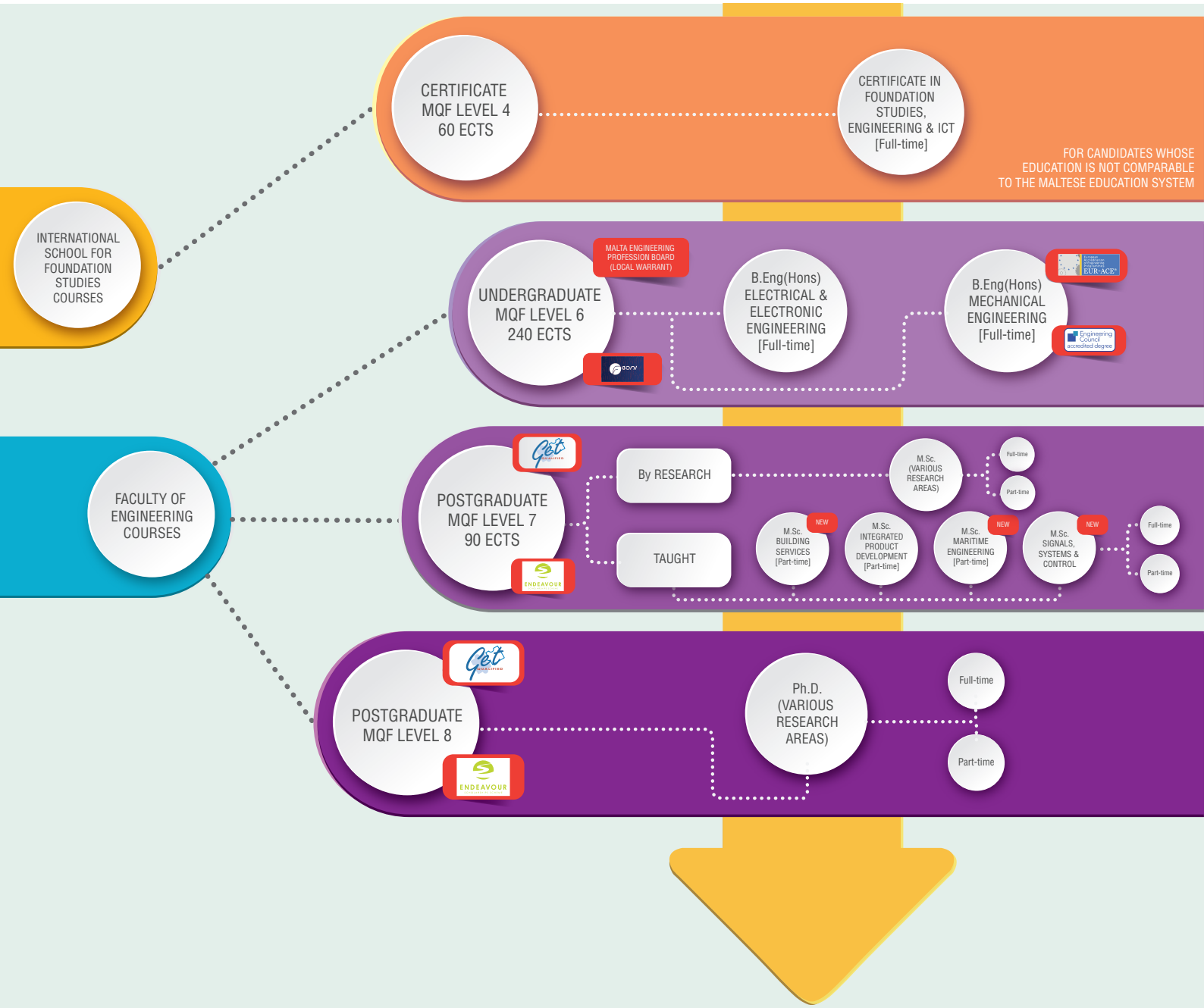

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Year 3 and 4

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a) 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); or

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.

Master of Science in Electrical Engineering by Research

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.

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 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).

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.

For a list of Ph.D. Research areas, please refer to: http://bit.ly/2oXj3At

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
- Water Tank for Electric Outboard Testing

Electrical Machines Laboratory

- 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 Boat
- Solar Catamaran
- 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

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

CNC Laboratory

CNC Vertical Milling Machine 2 ◘ 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)

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

Department of Mechanical Engineering

Thermodynamics Laboratory

Laboratory experiments for thermodynamics and heat transfer

Testing beds of 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)

Heat transfer in pipe facility

Supersonic nozzle setup

Labview and Keithley data acquisition systems

Structural Mechanics Laboratory

Strain gauge based experiments:

Strain gauge and monitoring of structural components

Tensile, compression and impact testing

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

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 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 components (e.g. 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

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

Fluids 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

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)

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

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 with 5 bar overpressure
- Laser Added Manufacture Centre
- Air Furnace
- Low temperature foundry furnace
- Martempering/ Austempering salt bath
- 3-axis CNC machining station
- Universal forced convection drying oven

Mechanical Testing Equipment

- Tension/ Charpy Impact tester with digital acquisition
- 5 ton multipurpose mechanical testing centre
- 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
- Rotary bending fatigue tester
- Gear tribological tester

Calibration Equipment

- Load cell calibration system
- Temperature calibration system

Sample Preparation Equipment

- NC precision cut off saw
- Thermosetting cold mounting station
- Hot mounting phenol sintering station
- Manual/ automatic sample polishing stations
- Automatic electro polishing station

Characterisation Equipment

- Optical microscopy with real time image acquisition
- Incident light microscope with Nomarsky, UV and dark field attachments
- Side projected light stereo microscope
- Support metallographic microscopes
- Confocal microscope with 3 excitation lasers and multispectral analyser
- Potentiodynamic wet cell corrosion testers
- Laser Induced Breakdown Spectrocopy (LIBS)
- Dilatometer with inert gas chamber
- 3D stylus surface profilometer

Scanning Electron Microscope (SEM) with:

In-lens backscattering detector

In-lens secondary electron detector

External secondary electron detector

Solid state angular selective backscatter detector

Electron Probe Micro-analysis (EPMA) within SEM including:

Energy dispersive spectroscope (EDS)

Wavelength dispersive spectroscope (WDS)

Electron Backscatter Diffraction (EBSD)

Ultra high vacuum Integrated Characterisation Facility including:

Surface analysis by electron kinetic energy analysis (XPS) through:

- Hemispherical electron energy analyser
- Ag/ Al Monochromated X-Ray source
- Ag/ Mg X-ray source
- High intensity electron source
- Low energy UV source (UPS)
- Rastering ion source
- Large area ion source

Quadrupole mass spectrometer

Low energy electron diffraction (LEED)

Secondary electron detector

Surface analysis by surface probe microscopy through:

- Atomic force microscopy (AFM)
- Scanning tunnelling microscopy (STM)

X-ray diffraction analysis with:

θ/ 2θ Goniometer

Parallel beam/ Bragg Brentano optics

Variable temperature (cryo to 450 °C) reaction chamber

High temperature reaction chamber

Thin film attachment

Capillary attachment

4 axis + tilting attachment

SDD/ scintillating detectors

X-ray powder diffraction with:

θ/ 2θ Goniometer

Cu/ Mo primary X-ray source

Bragg Brentano optics

Variable high temperature reaction chamber

Nano Indentation equipment with:

Wet cell attachment

Resistive high temperature reaction chamber

Peltier cooled low temperature attachment

Dynamic testing attachment

Piezo nanopositioner

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 November 2016, Mr Daniel Sant and Mr Nathaniel Barbara 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 Daniel Sant and Mr Nathaniel Barbara 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 presented these awards.

From left: Mr Nathaniel Barbara, Mr Kenneth Pullicino, Dr Ing. Andrew Sammut, Mr Daniel Sant

United Nations Educational, Scientific and Cultural Organisation (UNESCO) University Twinning and Network Programme (UNITWIN)

Launched in 1992, the UNESCO UNITWIN Programme promotes international inter-university cooperation and networking to enhance institutional capacities through knowledge sharing and collaborative work. Through such a network, higher education and research institutions all over the globe pool their resources, both human and material, to address pressing challenges and contribute to the development of their societies. In many instances, they serve as think tanks and as bridge builders between academia, civil society, local communities, research and policy-making. They have proven useful in informing policy decisions, establishing new teaching initiatives, generating innovation through research and contributing to the enrichment of existing university programmes while promoting cultural diversity. In areas suffering from a dearth of expertise, these Networks have evolved into poles of excellence and innovation at the regional or sub-regional levels. They also contribute to strengthening North-South-South cooperation.

The University of Malta is proud to have been one of the four founding partners of the UNESCO UNITWIN Network in Humanitarian Engineering and IT working with Coventry University (UK), Massey University (New Zealand) and Arusha Institute of Accounting (Tanzania).

Humanitarian Engineering is using engineering and computing in a culturally sensitive and sustainable way to address issues that limit opportunities and development in communities. It can be applied on a local, national or international level and is not necessarily restricted to being a reaction to a disaster or crisis. UNESCO encourages UNTWINs to engage in activities that support the delivery of the 17 UN Sustainable Development Goals (SDGs).

The University of Malta had made significant contributions to the educational strand of the UNESCO UNITWIN with over 30 Humanitarian Engineering projects in this Final Year alone. Most department contains projects that contribute to the UN SDGs and the UNESCO UNTWIN.

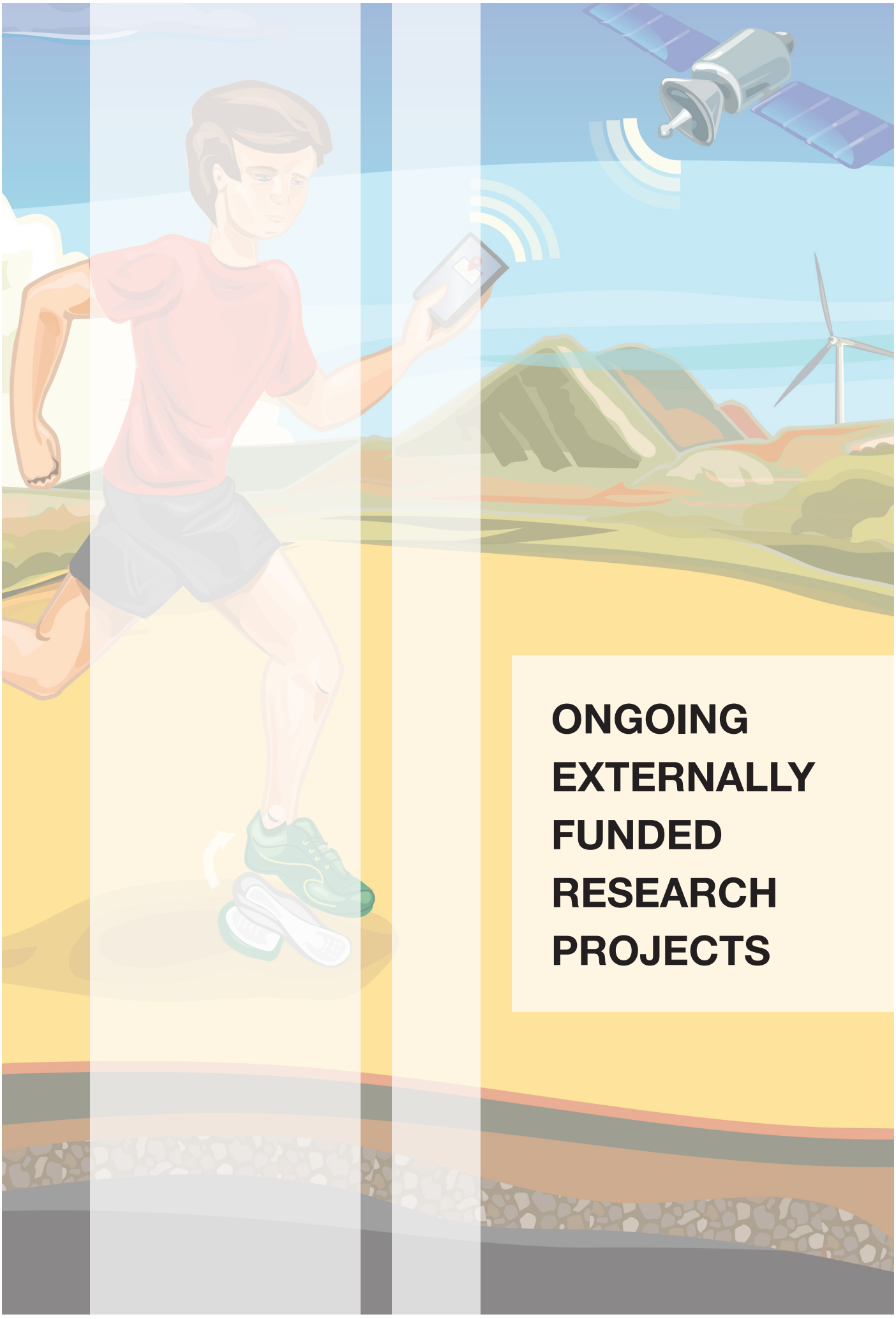
Undergraduate projects include;

- Energy Projects focusing on solar power, wind power and waste to energy.
- Urban Projects such as thermal comfort in churches, infrastructure for urban mobility.
- Medical Projects for example, prosthetics, finger movement, innovative implants, lumber spine behaviour, biodegradable implants and defect/damage tolerance for coatings of medical implants.

Ongoing External Funded Research Projects that are contributing to the UNESCO UNTWIN include bone replacement research, hip joint prosthetics, biomaterials, eye control for the disabled, smart micro combined heat and power systems, hydro energy storage and devices to support children with language impairment.

We are delighted to welcome Dr Lizzie Miles the Network Coordinator of the UNESCO UNITWIN from Coventry University UK to our Faculty of Engineering Exhibition representing both the UNESO UNITWIN and our partner Coventry University.

> *It is a privilege and deeply humbling to read so many summaries of undergraduate and postgraduate work in the exciting field of Humanitarian Engineering and IT. I am over the moon to meet all the students who have such a strong social conscious at such a young age. Engineering is everywhere and contributes to everything. I wish you all the best with your ground breaking exhibition.*
>
> Dr Lizzie Miles



ONGOING EXTERNALLY FUNDED RESEARCH PROJECTS

Engineering an Antigen Sensitive, Rapid Osteoregenerative, Bioresorbable Scaffold

The development of successful scaffolds for bone replacement requires a concurrent engineering, chemistry and anatomy approach that combines the different research fields. Metallic biomedical implants are normally made from Ti- and Co-alloys. These materials have excellent corrosion resistance which makes them permanent. In the last five years, a paradigm shift with relation to permanent implants is happening and biodegradable metallic implants are now receiving ample attention. The idea is to have an implant which is removed slowly by the body and therefore as opposed to a permanent implant there is no need for a revision surgery to remove it. Iron-manganese alloys are a potential candidate material to be used in the production of biodegradable implant components. These materials are non-magnetic, have excellent mechanical properties and can be tailored to have good biodegradability rates. Over and above this alloy is also surface engineered in order to have an osteoconductive hydroxyapatite (HA) coating which is loaded with different antibacterial and chelating molecules. This will avoid infection, allow healthy bone growth and also release a drug that will chelate iron which is toxic in high quantities.

Funding Bodies: **Reach High Funds (ESF)**

Project Fund: **€ 200,000**

UoM Share value: **€ 60,000**

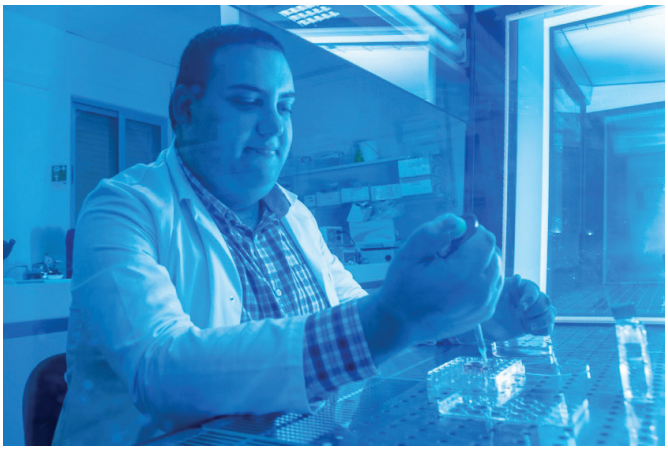
Principal Investigator: **Dr Malcolm Caligari Conti**

Co-Investigators: **Dr Ing. Joseph Buhagiar, Prof. Pierre Schembri Wismayer MD, Dr Daniel Vella and Prof. Emmanuel Sinagra.**

Consortium: **Department of Metallurgy and Materials Engineering, Faculty of Engineering, UoM; Department of Anatomy, Faculty of Medicine and Surgery, UoM; Department of Chemistry, Faculty of Science, UoM.**

Project Start Date: **March 2016**

Project Duration: **3 Years**



Dr Malcolm Caligari Conti: Post-doctorate researcher working on cytotoxicity testing

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

The proposal is to develop a novel hip joint prosthesis to improve upon existing options including metal-on-metal, metal-on-polymer, ceramic-on-polymer and ceramic-on-ceramic options. Using our knowledge of anatomy, biomaterials and the surface treatments to increase wear-resistance, we aim to design a metal hip prosthesis with a markedly improved lifespan. This will be achieved through design modifications as well as the development of new materials. Such a prosthesis can be prototyped and tested in the Department of Metallurgy and Materials Engineering inside a hip joint simulator that is designed for this project. Later on, the developed prosthesis will be field tested in the Department of Anatomy through surgical implantation inside a cadaver with the involvement of orthopaedic surgeons. This will permit the replication of the natural joint movement and hence providing insight on the wear performance of the prosthesis.

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

Project Fund: **€ 194,593.69**

UoM Workshare Value: **€ 145,674.19**

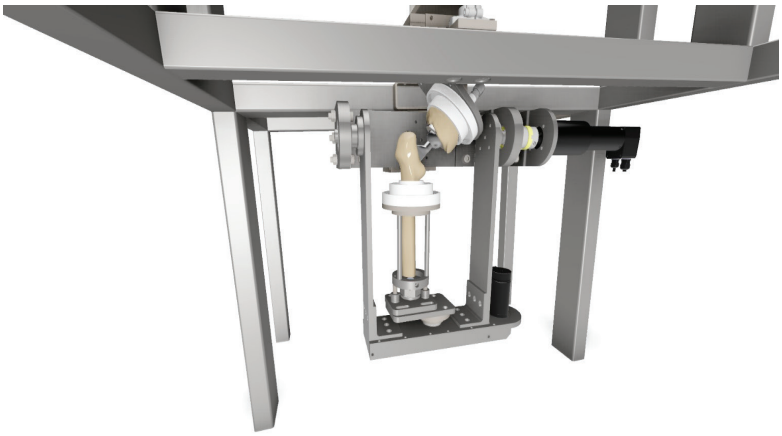
Principal Investigator: **Prof. Pierre Schembri Wismayer MD**

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

Consortium/Partners: **Department of Metallurgy and Materials Engineering, Faculty of Engineering, UoM; Department of Anatomy, Faculty of Medicine and Surgery, UoM; Department of Mechanical Engineering, Faculty of Engineering, UoM; MCL Components Ltd.**

Project Start Date: **September 2016**

Project Duration: **3 Years**



Hip joint simulator designed to replicate the natural hip movements

Reciprocating Sliding Tribocorrosion Testing of Surface Modified Biomaterials

The project involved the design and building of a custom made reciprocating sliding tribocorrosion tester. This new facility in conjunction with physical vapour deposition and state-of-the-art materials characterisation facilities were used to develop novel surface treatments for the tribocorrosion protection of biomedical grade 316LVM stainless steel. This research led towards the better understanding of tribocorrosion mechanisms exhibited by surface engineered materials through a combination of physical vapour deposition and diffusion treatment processes. Work is being currently undertaken to minimise tribocorrosion damage at the interface(s) between the treated layer(s) and original substrate surface.

Funding Bodies: **Internal Research Grant; Master it! Scholarship and Endeavour Scholarship (Bench Fees)**

Project Fund: **€ 49,000**

UoM Share value: € 19,000

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

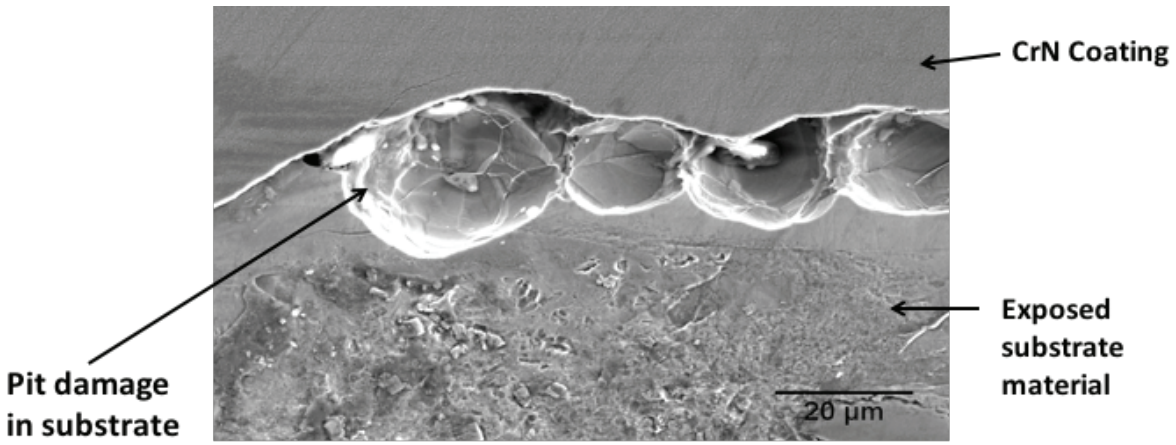
Co-Investigators: **Prof. Peter A. Dearnley, Dr Ing. Joseph Buhagiar, Dr Y. Sun, Dr Karl Andreas, Dr Ing. Glenn Cassar, Ms Raisa Chetcuti, Mr Antonino Mazzonello, Ms Sarah Farrugia, Mr Nicholas Brincat; Ms Josianne Farrugia; Mr Shaun Maniscalco; Ms Brenda Farrugia, Mr Imer Cardona, Ms Miryea Borg, Mr Christian Micallef, Ms Christine Borg, Ms Julia Sammut, Mr Karl Laspina, Mr Mark Bonello, Ms Jeanelle Arpa, Mr Kurt Zerafa and Mr Aaron Farrugia**

Surface treatments in Kind: **Boride Services Ltd. (UK), Bodycote Hardiff GmbH (DE), Wallwork Heat Treatment Ltd. (UK), Hauzer Techno Coating BV, (NL)**

Consortium: **Department of Metallurgy and Materials Engineering, Faculty of Engineering, UoM; Boride Services Limited, UK; National Centre for Advanced Tribology (nCats), University of Southampton, UK; School of Engineering and Sustainable Development, De Montfort University, UK; and Bodycote Hardiff, DE.**

Project Start Date: **January 2010**

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

MEMENTO: Multi camEra high fraMe ratE syNchronisaTiOn

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.

Funding Body: **MCST R&I Fusion 2015 (R&I-2015-024-T)**
Project Fund: **€ 195,000**
UoM Workshare Value: **€ 150,000**
Principal Investigator: **Dr Ing. Marc Anthony Azzopardi**
Co-Investigators: **Mr Andre Micallef**
Consortium Lead: **Department 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

Thermal Imaging for Peripheral Vascular Disease Monitoring in Diabetics (TIPMID)

In this project the use of thermography as a monitoring tool for patients with diabetes is being investigated. Specific temperature patterns in individuals suffering from diabetes may serve as early indicators of peripheral vascular disease. These indicators could in turn lead to earlier preventive action or treatment, reducing the risk of complications.

Funding Body: **Malta Council for Science and Technology through the National Research and Innovation Programme 2013**

Project Fund: **€ 165,252**

UoM Workshare Value: **€ 121,602**

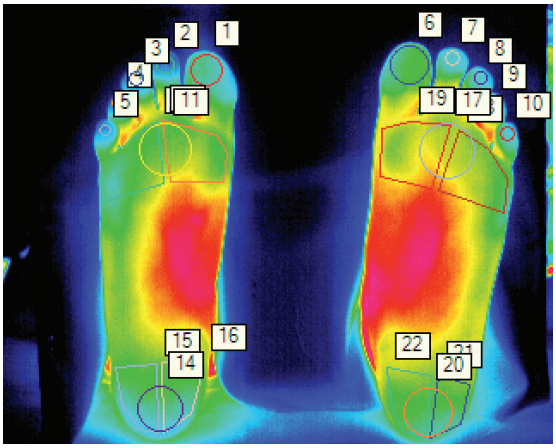
Principal Investigator: **Dr Owen Falzon**

Co-Investigators: **Mr Jean Gauci, Prof. Kenneth P. Camilleri, Dr Cynthia Formosa, Dr Alfred Gatt, Mr Stephen Mizzi, Ms Anabelle Mizzi, Mr Christian Ellul, Prof. Nachi Chockalingham, Prof. Kevin Cassar, Ms Cassandra Sturgeon**

Consortium/Partners: **Centre for Biomedical Cybernetics (UoM), Department of Systems and Control Engineering, Faculty of Engineering (UoM), Department of Podiatry, Faculty of Health Sciences (UoM), Department of Surgery, Mater Dei Hospital**

Project Start Date: **1st March 2015**

Project Duration: **32 months**



Foot temperature monitoring using thermography

EyeControl

This project focusses on the use of eye movements to control applications within an intelligent environment. Rather than using standard video based eye gaze trackers that are susceptible to lighting conditions and subject's head movements, this project proposes an alternative solution using electrooculography (EOG), which refers to the electrical signals generated during eye movements. The project makes use of a recent Japanese EOG glasses that can be found on the market, called the MEME glasses, comprising of three electrodes at the nose bridge and nose pads to record the electrical signals in real time, thus offering a sleek and cost effective solution to the standard gel based, wired, six-electrode conventional EOG setup.

The work carried out in this project involves the development of signal processing tools that can reliably distinguish between different eye movements, such as saccades and blinks, and their translation to continuous eye movements on a computer screen.

This project was also presented for the Malta Innovations Award 2016 and took the first prize for the Scientific Innovations Award and received the WIPO IP Enterprise trophy from the World Intellectual Property Organization.

Funding Body: **JINS Company Ltd**

Project Fund: **€ 9,858**

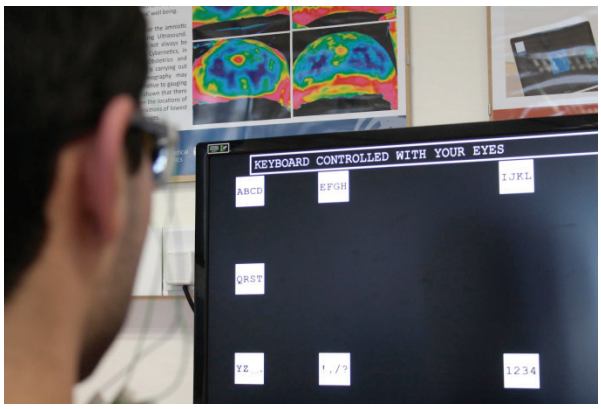
Principal Investigator: **Dr Tracey Camilleri**

Co-Investigators: **Prof. Kenneth P. Camilleri, Mr Nathaniel Barbara**

Consortium/Partners: **Department of Systems and Control Engineering at the University of Malta**

Project Start Date: **October 2016**

Project Duration: **1 year**



Controlling a speller application using the MEME glasses

SHAPEC: Space Hardened Platform for Electronic Communications

SHAPEC aims to investigate the challenge of providing a cost-competitive alternative to dedicated Space-grade electronic communications components, as required in the rapidly expanding next-generation ("Space 2.0") commercial Space applications. It is unclear whether certain types of terrestrial hardware can be re-certified for suitability under the Space 2.0 operating regime, whereby satellites are considered disposable, and a certain degree of failure is acceptable if it can be managed within the context of a given mission.

For this study, a particular computational platform is currently begin investigated in terms of meeting the computational a reliability requirements of a software radio application. The plan is to eventually fly the hardware in space for an extended period, to collect operating data and perform other telemetry to assess its performance in the actual space environment.

Funding Body: **Malta Enterprise R&D Feasibility Study 2017**

Project Fund: **€ 20,000**

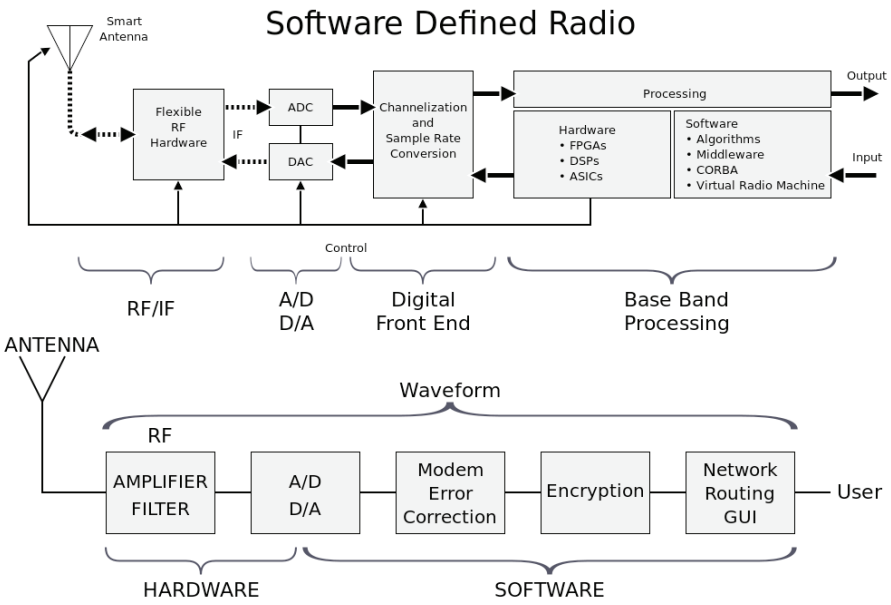
UoM Workshare Value: **€ 10,000**

Principal Investigators: **Prof. Ing. Victor Buttigieg, Dr Ing. Marc Anthony Azzopardi**

Consortium Partners: **Blu5 Labs Ltd., Dept. of Communications & Computer Engineering, Faculty of ICT, Dept. of Electronic Systems Engineering, Faculty of Engineering**

Project Start Date: **March 2017**

Project Duration: **6+ Months**



Validating off-the-shelf Software Radio hardware for Space Applications

A Smart Micro Combined Heat and Power 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.

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

Project Fund: **€ 194,956**

UoM Workshare Value: **€ 146,207**

Principal Investigator: **Prof. Joseph Cilia**

Co-Investigators: **Ing. Matthew Schembri**

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

Electrical Energy System Optimisation for 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.

Funding Body: **University of Malta 2017**

Project Fund: **€ 60,000**

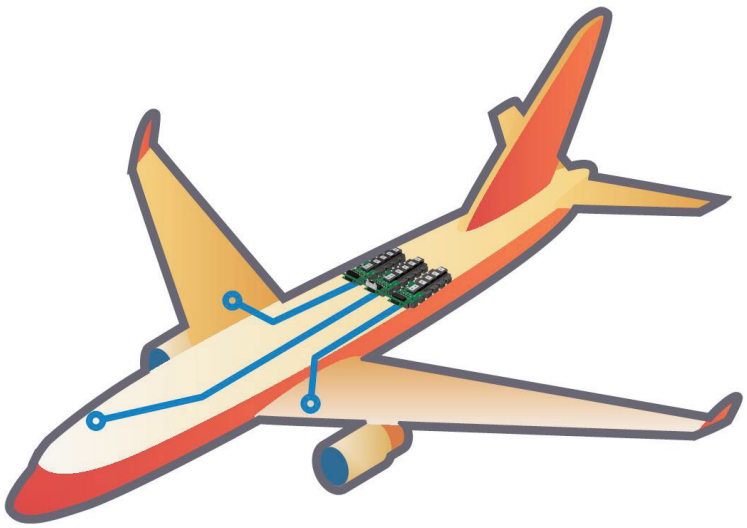
Principal Investigator: **Prof. Ing. Cyril Spiteri Staines**

Co-Investigators: **Dr 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

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

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 of MEMS have been instrumental in the development of new devices and applications, as well as in the creation of new fields of research and development. A typical example includes the MEMS gyroscope devices for smartphones to enable screen tilting. MEMS devices can be categorised as micro-sensors and micro-actuators. Research on micro-actuators is a relatively new field for Malta. This research project will deliver an advanced thermo-mechanical study of micro-actuators as micro-grippers, which will be the basis to develop novel applications such as handling of living cells on the micro-scale level, and micro-assembly, micromanipulation and micro-manufacturing of micromechanical parts.

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

Project Fund: **approx. € 200,000**

UoM Workshare Value: **approx. € 60,000**

Principal Investigator: **Dr Marija Cauchi**

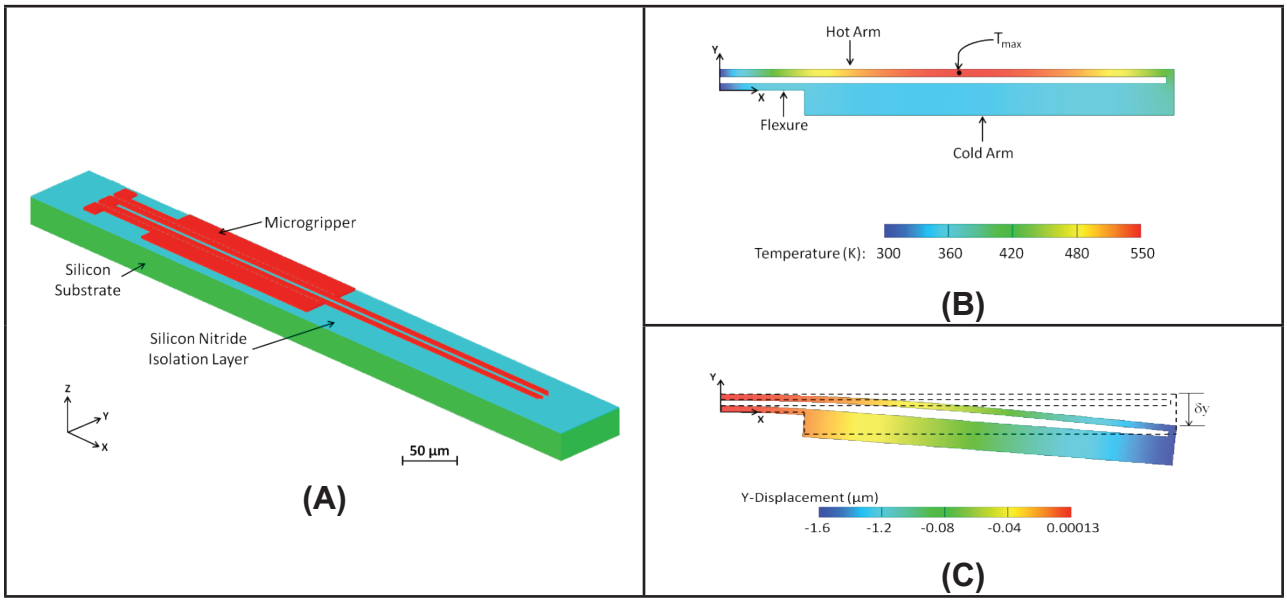
Main Academic mentor: **Dr Ing. Pierluigi Mollicone**

Co-Investigators: **Dr Ing. Nicholas Sammut , Prof. Ivan Grech, Dr 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) An oblique view of the 3D 'hot and cold arm' microgripper in CoventorWare®. (B),(C) Simulated steady-state temperature and displacement plots of the polysilicon thermal actuator at an applied potential

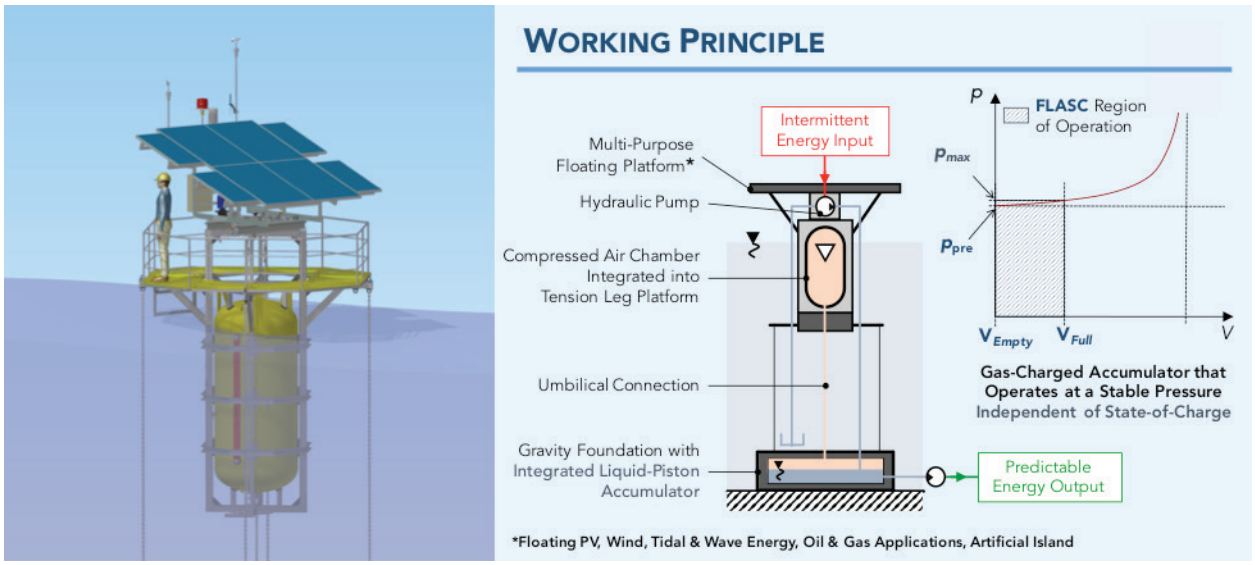
Project FLASC: Development of a Hydro-Energy Storage System for Offshore Multi-Purpose Floating Platforms

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 fixed operating pressure, independent of the state-of-charge.

FLASC is patent pending: PCT/IL2016/050100

Funding Body: **Malta Council for Science and Technology through the National Research and Innovation Programme 2015 (Project Reference R&I 2015-044-T)**
Project Fund: **€ 198,206**
UoM 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 and Institute for Sustainable Energy at the University of Malta, in collaboration with MedServ plc.**
Project Start Date: **July 2016**
Project Duration: **3 Years**



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

WALNUT Brain-controlled Music Player

We are developing a brain-controlled music player application for a mobile device. This application is not controlled through conventional push buttons, instead the user wears the WALNUT headband and simply focuses at the icon of interest on the music player app to select and control music. The music player icon elicit particular brain patterns that are detected and translated into commands by the system. A prototype of this brain-computer interface had been developed and tested on numerous subjects using a laptop and clinical research grade brain signal acquisition system. The goal of this project is to translate this prototype to a portable system on a mobile device and using a low cost wireless brain signal acquisition headband.

Funding Body: **The Centre for Entrepreneurship and Business Incubation (CEBI) at the University of Malta and the Ministry for the Economy, Industry and Small Business (MEIB) through the TAKEOFF Proof of Concept Fund 2014.**

Project Fund: **€ 7,500**

Principal Investigator: **Dr Owen Falzon**

Co-Investigators: **Ms Rosanne Zerafa, Dr Tracey Camilleri, Prof. Kenneth P. Camilleri**

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

Project Start Date: **June 2014**

Project Duration: **Ongoing**

Developing a portable system of the WALNUT Brain-controlled Music Player

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

This project aims to provide an alternative communication channel for persons with physical disabilities via the eye movements alone using a hardware setup that comprises a notebook computer with an integrated webcam. In this regard, the project seeks to address various challenges associated with eyegaze tracking under uncontrolled daily life conditions, including handling of head and non-rigid face movement, and reduction or elimination of user calibration for more natural user interaction. At this stage of the award, the project is concerned with the first three stages of the Voucher Programme, namely, the IP Check, Market Research and Product Development Costing, and the Economic Impact and Risk Profile.

Funding Body: **FUSION Programme 2016, MCST**

Project Fund: **€ NA (Voucher Programme)**

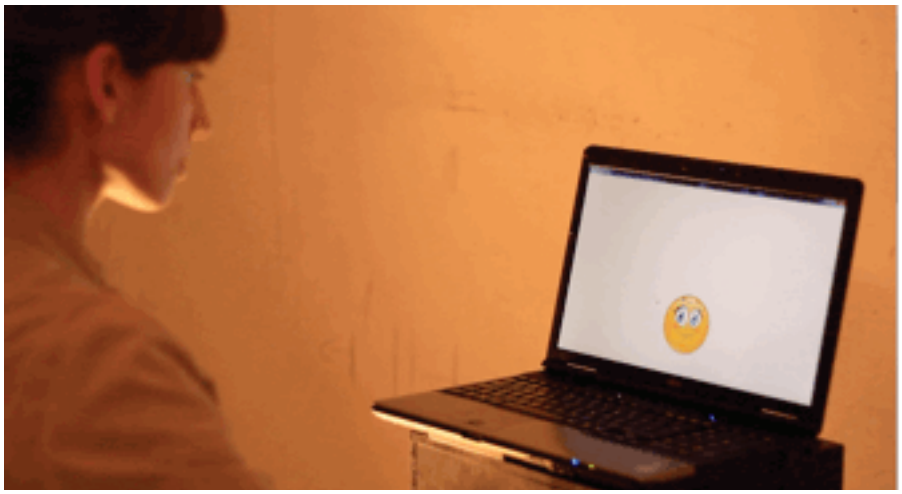
Principal Investigator: **Prof. Kenneth P. Camilleri**

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

Consortium/Partners: **Department of Systems and Control Engineering at the University of Malta**

Project Start Date: **March 2016**

Project Duration: **9 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

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

Language impairment (LI) in children is often attributed to various factors including intellectual disability, autism and hearing loss. However, it is reported that approximately 7% of the global childhood population experience LI in the absence of evident causative factors. Children with LI are often faced with social communication, behavioural, educational and vocational difficulties. Although bilingualism does not cause LI, such disorders can be complicated when children have bilingual or multilingual exposure, which is a common occurrence worldwide. This has particular relevance to the language-learning context of Maltese children. LI in children can often be addressed by a customised intervention programme drawn up by a professional speech-language pathologist (SLP) on the basis of assessment and regular review of the child's speech and language skills. However, children often lose engagement when subjected to repetitive therapy activities and lengthy assessment procedures. This impinges on the effectiveness of intervention. Moreover, speech-language sessions offered in the public health clinics often take place during school hours, disrupting children's routine. Furthermore, with guardian(s) often being engaged in full-time work, it becomes an issue to accompany children during the sessions.

Within this context, the project's goal is to develop a novel, multi-modal device, nicknamed SPEECHIE, to facilitate language therapy for children with LI both within and beyond the clinical setting. SPEECHIE will be developed as a smart educational toy that entices children to engage with the designated exercises by creating a more rewarding and motivating environment.

Funding Body: **Malta Council for Science and Technology through the 2015 FUSION Technology Development Funds**

Project Fund: **€ 194,960**

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

Amplifying Research in Digital Factories for Innovative Product Development (DiFIP)

The DiFIP project is intended to amplify the international activities of the Concurrent Engineering Research Unit (CERU) of the University of Malta in the field of Digital Factories for Innovative Product Development. The activities planned in this project will thus directly contribute to the High Value-Added Manufacturing (HVAM) smart specialisation as identified in the National R&I Strategy 2020. Moreover amplifying CERU's international presence in this area is also relevant to the EU's H2020 programme Factories of the Future (FOF).

Funding Body: **Malta Council for Science and Technology through the Internationalisation Partnership Award Grant No. IPAS-2016-017**

Project Fund: **€ 5,000**

Investigators: **Prof. Ing. Jonathan Borg, Dr Ing. Emmanuel Francalanza**

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

Robert Zammit	Development and Fabrication of Patient-Specific Knee Implant Using Additive Manufacturing Techniques
Nathan Gatt	Sustainable Management of Industrial Processes at a Waste Treatment Facility: a simulation based approach
James Mamo	A Computer-based Support System for Designing Sportsbikes

M.Sc. IPD

Greta Attard	Development of an Ankle Dorsiflexion Measurement Device
Christina Vella	A Feasibility Study to Produce an Optogenetics Optical Fibre Cannula
Carl Borg	Developing and Testing a Lean Maturity Assessment Tool to Assess and Benchmark Manufacturing Companies
Raisa Galea	An IPD approach for Sustainable Manufacturing of Bottled Water

Ph.D.

Emanuel Balzan	User-Centred Design Methodology for Assistive and Persuasive Products for Children in a Pervasive Healthcare Context
Lawrence Farrugia	Emotional 'Design for X' : A 'Human and Life-Phase Systems Meetings' Consequence Knowledge Approach

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

M.Sc. by Research

Clayton Farrugia	Degradation of Diesel Engines in an Industrial Environment. RTDI funded project
Michael Fiott	Carbon based coatings for the protection of Magnesium alloys
Claire Bezzina Cornish	Investigation of stress and fatigue response of shot peened austempered ductile iron.
Roberto Migneco	Empirical relationship between microconstituents, heat treatment parameters and mechanical properties of austempered ductile iron

Mark Anthony Bonello	Tailoring the Degradation Rate of Fe-Mn-C Bioresorbable Implants
Christina Cardona	Optimization of the Calcium Tartrate Consolidation Treatment for Globigerina Limestone
Raisa Chetcuti	Duplex PVD Treated Biomedical Implant Alloys for Increased Durability in Tribocorrosion Environments
Antonino Mazonello	Tribocorrosion Enhancement of Biomedical Stainless Steel using Dual Byer PVD Coatings and Low Temperature Carburising
Gianella Xerri	Towards Bioresorbable Fe-Based Implants: Optimisation of a Fluorapatite Coating

Ph.D.

Anthea Agius Anastasi	Molecular Simulation and Atomic Probe Studies of Graphene
Donald Dalli	Development of a Low Wearing novel Hip Joint Prosthesis with a Longer Lifespan
Diana Kusova Cini	Protective coatings for heritage Metals
Mary Grace Micallef	Development of Photocatalytic coatings for solar water treatment applications

Post-Doctorate

Malcolm Caligari Conti	Engineering an antigen sensitive, rapid osteoregenerative, bioresorbable scaffold

Projects supervised by members of the Department of Electronic Systems Engineering

M.Sc. by Research

Darren Cachia	Design on a Nano-Satellite Platform
Darren Debattista	Design of an Attitude Determination and Control System for the UoMSat1 Pico-satellite
Johann Cassar	Optimization of a 3 Axis Teslametre for the Calibration of the Next Generation of Undulators

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

M.Sc. by Research

Noel Darmanin	Investigation of the Effects of Integrating Large Scale Photovoltaic Systems on the Maltese Power Network
Joseph Azzopardi	Analysis of Malta Freeport Terminals Power Network
Diane Cassar	An Electric Catamaran designed with a Smart Charging System
Andrea Brincat	Design and Development of Electronic Control Systems for Hybrid PV+CHP Residential Grid Connected Set-ups with Battery back-up.
Jonathan Palombi	Design of an Electric Power Train for Malta's FSAE Team

M.Phil.

Daniel Zammit	Control of Microgrids for Distributed Generation including Energy Storage

Ph.D.

Kris Scicluna	Sensorless Control in Steer-by-Wire Application

Projects supervised by members of the Department of Mechanical Engineering

M.Sc. by Research

Marco Abela	Modelling Offshore Floating Structures for Combined Wind And Solar Energy in Maltese Deep Waters
Luke Aquilina	Performance and Efficient Analysis of a Model Underwater Compressed Air Energy Storage System
David Bartolo	An Investigation of Different Welding Manufacturing Procedures to Minimize Distortion
Paul Joseph Borg	Design, Development and Building of Mobile Load Cells for Use in Laboratory Experiments
Adrian Camilleri	Simulation and Feasibility Study for Two Cycle Engines with Scavenging Through Poppet Valves.
Carl Caruana	Incylinder Pressure Measurements of a Diesel Engine and Heat Release Analysis
Jean Paul Farrugia	Design and Manufacture of Camshafts for a Four-Cylinder Engine
Owen Parnis	Investigating the Influence of Mooring Design on Floating Wind Turbine Aerodynamics
Marcus Portelli	Preliminart Thermo-Mechanical Design of a High Power Absorber for HL=LHC Cyrstal Collimation

M.Phil.

Almehat Mahmoud Ayad	Development of Benefits Accruing from Implementation of Environmental Management Systems in Wasteserv Malta Ltd

Ph.D.

El Gammi Moutaz	Modelling the Self-Induced Cycle-to-Cycle Variations in the Aerodynamic Blade Loads of a Yawned Wind Turbines
Omar Salem Osta	A Solar Powered Absorption Air Conditioning System

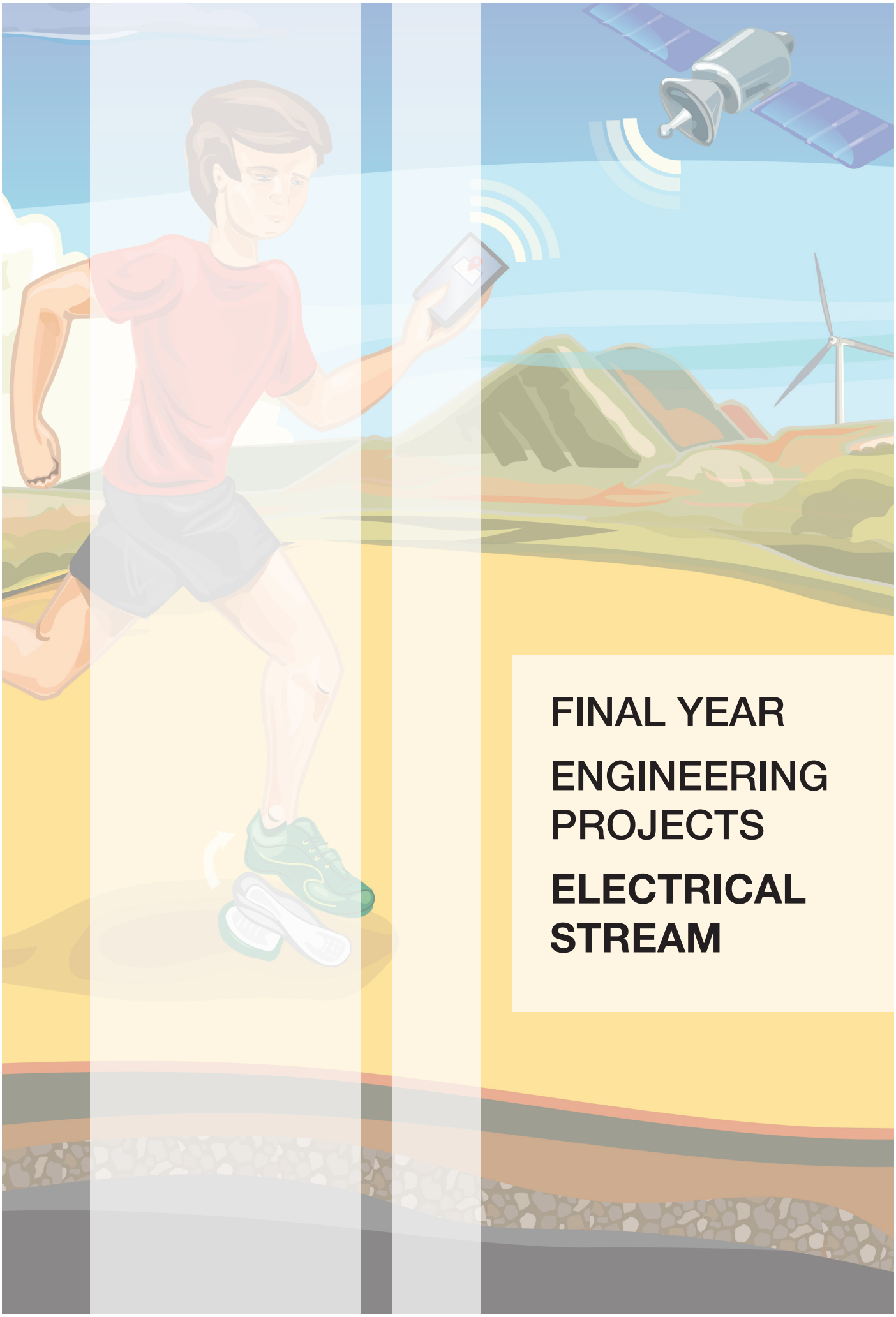
Projects supervised by members of the Department of Systems and Control Engineering

M.Sc. by Research

Jean Luc Farrugia	Swarm Robotics for Object Transportation
James Attard	A Speech Recognition and Analysis System for SPEECHIE: A Device Supporting
Clare Saliba	Development of a Training Simulator for Teleoperated Robots Deployed in Hazardous Environments at CERN
Jean Gauci	Automated Analysis of Thermal Images for Peripheral Vascular Disease Monitoring
Nathaniel Barbara	Continuous Eye Gaze Tracking using EOG Signals
Charlotte Camilleri	Localisation and detection of barcodes using aerial robots
Lucianne Cutajar	Combined Visual and Thermal Imaging for Non-Contact Physiological Signal Measurement
Darren Debattista	Design of an Attitude Control and Determination System for the UoMBSat1 Pico-Satellite

Ph.D.

Rachael N. Darmanin	Coordination and Control of Multi-Robot Systems
Nikiforos Okkalidis	An Enhanced Wearable System for Kinematic and Kinetic Gait Analysis
Luana Chetcuti Zammit	Autonomic Control for Road Network Management
Idris Garba	CT Radiation Doses in Nigeria: Establishment of Diagnostic Reference Levels and Radiation Dose Optimisation
Mark Borg	Automatic Video-based Sign Language Recognition
Marc Tanti	Visual Object Recognition based on Textual Descriptions
Carl Azzopardi	Quantifying Atherosclerosis Using Freehand 3D Ultrasound Imaging



FINAL YEAR ENGINEERING PROJECTS

ELECTRICAL STREAM

High Frame Rate Image Sensor Pixel Design

Student: Alessandro Catania / Supervisor: Prof. Ivan Grech / Co-Supervisor: Dr Ing. Marc Anthony Azzopardi

Introduction

High Frame Rate Image Sensors are used extensively in scientific research and commercial applications. These range from machine vision, topographic imaging, and optical molecular vision. Furthermore the recent advancements in Active Pixel Sensor (APS) image sensors have fuelled the need for research into ultra-high speed image sensors.

Project Objectives

The main aims for this dissertation were to design and characterize pixel circuits used inside image sensors along with their associated readout circuitry. The designed pixels are required to operate at a high frame rate and exhibit low noise operation whilst being size efficient.

Project Methodologies

The methodology used for this project consisted of the following steps:

- ➔ A detailed literature review on the type of image sensor technologies, pixels and readout circuits was performed.
- ➔ The 0.35µm Opto-CMOS process (C35O) was chosen to implement these pixels in a microelectronic circuit.
- ➔ Three viable pixels were chosen [1], [2]. These were designed and simulated in CADENCE.
- ➔ The pixel circuit features such as signal to noise ratio (SNR), dynamic range, fill factor and operational modes were then extracted.
- ➔ Various readout circuits were designed in order to interface a 5X5 array of each pixel type.
- ➔ The layout of the individual components was performed and a parasitic extraction was done. This was used for a layout versus schematic simulation.
- ➔ All components were combined together and the layout of the image sensor was done.

Results and Achievements

The simulations done yielded promising results. One type of pixel (9 transistor pixel) excelled in terms of noise performance, achieving an input referred noise of $2e^-$ rms. The readout for a 5X5 pixel array can easily reach 1Mfps with the maximum (theoretical) being 3.4Mfps. The bottleneck for such circuits was also highlighted to be the readout circuits and not the individual pixels. Therefore future implementations should aim towards an analogue to digital converter (ADC) for each pixel to achieve ultra-high speeds.

References

[1] S. Lauxtermann, A. Lee, J. Stevens and A. Joshi "Comparison of Global Shutter Pixels for CMOS Image Sensors", Teledyne Imaging Sensors, 2007.
[2] J. Bogaerts, P. De Moor, K. De Munck, D. Sabuncuoglu Tezcan and C. Van Hoof, "Development of CMOS Active Pixel Sensors for Earth Observation", Proceedings 5th EARSeL Workshop on Imaging Spectroscopy, 2007.

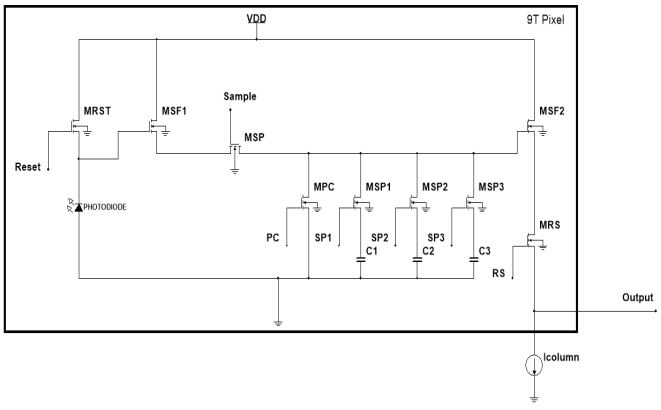


Figure 1: 9 Transistor Pixel Circuit Diagram

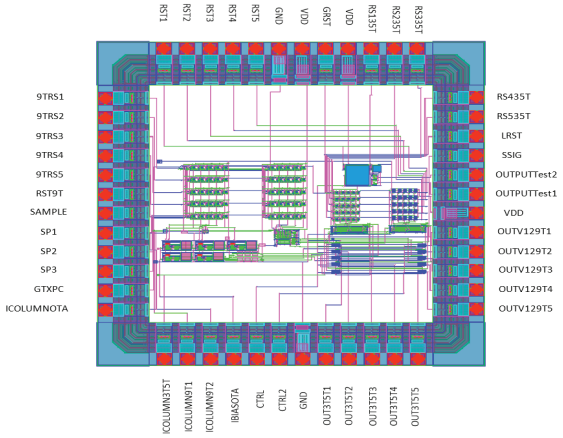


Figure 2: Layout of Image Sensor Integrated Circuit

Design of a Communications Link for an ROV

Student: Rachel Cauchi / Supervisor: Dr Ing. Brian Zammit / Co-Supervisor: Dr Ing. Marc A. Azzopardi

Introduction

It is a known fact that the land-to-water ratio on Earth is that of 29% to 71% which means that sea occupies more than twice the area occupied by land. It is therefore natural for human beings to desire being able to navigate with ease underwater, be it for exploration or to carry out underwater works. A popular means of achieving such capabilities is by deploying Remotely Operated Underwater Vehicles (ROVs) which take commands from an operator (pilot) situated safely in a remote location. This also reduces the risks associated with physically conducting underwater diving activities, especially for missions carried out in previously unexplored environments [1][2][3].

Project Objectives

This project focused on various aspects of the ROV design process, such as mathematical modelling to predict the trajectory of the vehicle in the underwater environment. In addition, electronic hardware was designed to enable a robust communications link between the pilot and the ROV in order to transfer pilot commands to the underwater processors. Another objective was to characterise the behaviour of the selected underwater propulsion system in terms of generated thrust versus motor speeds.

Project Methodologies

Fibre optic tether cable was chosen as the communications link medium which provides for the required high transmission bandwidths whilst reducing some of the problems associated with copper cables such as their high physical weight. The system has been developed such that commands sent to the ROV are packaged into a robust protocol which is then interpreted underwater before actuating the associated thrusters corresponding to the pilot's command. The same physical link is also used to transfer data from the various underwater sensors back to the pilot ground-station. Such data includes vehicle related information such as attitude, speed and orientation. Finally, all the transferred data is visually represented on a graphical user interface (GUI).

Results and Achievements

In order to test the robustness of the communications link, data errors obtained at various baud rates were recorded and it was concluded that the data was error-free up to a serial baud rate of 115200. Meanwhile, the correct operation of the complete system under normal conditions could only be carried out visually, by monitoring the motors' behaviour to operator input. The remote control was given inputs and the motors' outputs were monitored. The GUI was monitored, making sure its display changed with any command changes.

The simulation model was tested using a number of scenarios and the resulting trajectory was successfully compared to the expected vehicle behaviour.

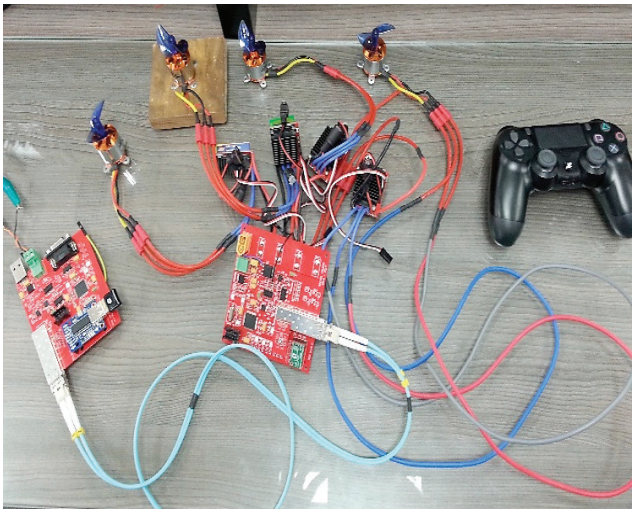


Figure 1: The developed system

References

[1] M. Kokegei, F. He and K. Sammut, "Fully Coupled 6 Degree-of-Freedom Control of an Over-Actuated Autonomous Underwater Vehicle," in *Autonomous Underwater Vehicles*, Rijeka, InTech, 2011, pp. 147 - 170.

[2] S. Cornfield and C. Hillenbrand, "Defence Applications For Unmanned Underwater Vehicles," in *Technology and Applications of Autonomous Underwater Vehicles*, London, Taylor & Francis, 2003, pp. 161 - 178.

[3] R. D. Christ and R. L. Wernli Sr., The ROV Manual - A User Guide for Remotely Operated Vehicles, Waltham: Butterworth - Heinemann, 2014.

Electric Propulsion for Picosatellites

Student: Daniel Cumbo / Supervisor: Dr Ing. M. A. Azzopardi / Co-Supervisor: Dr Ing. M. Fenech

Introduction

Some technologies are largely absent in the picosatellite class of spacecraft, which range between 100g – 1000g. Propulsion is one such technology. Without propulsion, satellites are confined to their orbits set at launch with no means of altering their trajectory. This limits their range of applications.

Project Objectives

The objective of this project is to investigate a suitable electric propulsion engine that fits into the weight, size and volume budget of a 1p PocketQube Picosatellite. Furthermore, it also aims to establish the required groundwork for future research in the area.

Project Methodologies

The project is divided into a number of sections. Firstly, a comprehensive literature review is conducted where a number of various electric propulsion technologies are pitted together to determine which one is the most suitable for this application. The Pulsed Plasma Thruster (PPT) is found to be the most feasible, incorporating the propellant, the feeding mechanism and the thruster itself in one compact unit. The PPT is then investigated further to gain an understanding of its mechanics.

Secondly, a scaled down version of the PPT is developed, which consists of two coaxial electrodes separated by a layer of Teflon (PTFE) propellant.

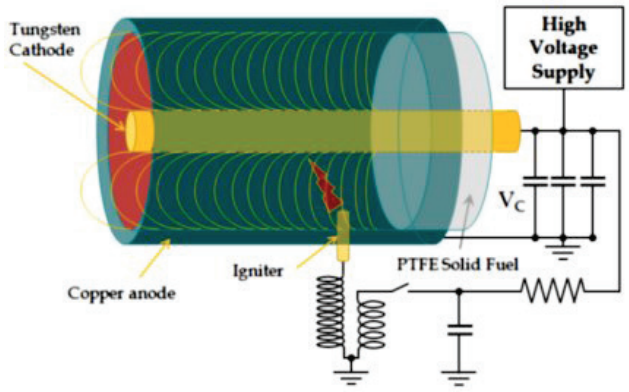


Figure 1: Coaxial Pulsed Plasma Thruster Concept

A third electrode, which is simply a wire, is placed close to the central electrode such that a high-voltage spike can initiate the PPT.

Thirdly, in order to power the PPT a high-voltage power supply is required, which must also fit within the picosatellite. A circuit including an oscillator, a transformer and a charge-pump is designed which steps up the voltage from a few volts to a few kilo-volts. This is done whilst remaining piecewise and as compact as possible.

Finally, the PPT and circuitry are incorporated into a single PCB such that they can be tested in a vacuum environment. Here, the plasma generated in the PPT, together with other characteristic behaviours of the PPT, is examined to determine if the behaviour conforms to literature.

Results and Achievements

The low-voltage to high-voltage converter successfully stepped up a 4.2 V supply to approximately 2 kV. A modified three-electrode PPT was built with a mass of 4 g, a height of and with the dimensions of 15 mm × 9.5 mm × 9.5 mm (L×W×H). These were incorporated onto a test PCB with the following dimensions: 10 cm × 5cm.

Based on the observations made in the experiments with respect to the size of the PCB, electric propulsion for picosatellites was deemed feasible. Furthermore, mechanisms and areas that require further research were listed, paving the way for future work.

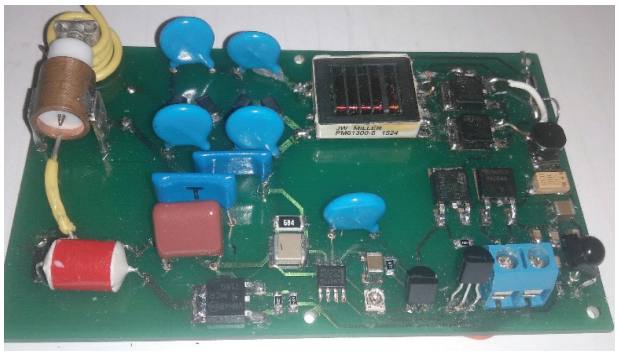


Figure 2: Prototype PCB with PPT and power supply

A Study of Control Laws for a Quadrotor Drone

Student: Liam Farr / Supervisor: Prof. Ing. David Zammit Mangion

Introduction

The quadrotor is an example of a UAV which is being used in a variety of applications due to its simplicity of construction and maintenance, its small size and its ability to hover and also take-off and land vertically [1]. Having six degrees of freedom (DOF) and four independent inputs makes quadrotor control a fundamentally difficult and interesting problem.

Project Objectives

The objectives of this project included creating an accurate simulation of the quadrotor system, designing four controllers to control the attitude and height of the quadrotor, comparing different control discretization techniques and implementing these control systems on a quadrotor.

Project Methodologies

First, the mathematical model for the quadrotor system was derived using Newton-Euler formalism. This system was then linearised by introducing certain assumptions into the system.

The system parameters necessary for the quadrotor simulation were calculated so that a faithful simulation would be obtained. This involved obtaining values experimentally and/or mathematically for the mass moment of inertia matrix, the thrust coefficient and drag coefficient. The quadrotor model was then simulated and compared to its linearised version.

Four PID controllers were then designed in continuous time using Root Locus techniques to control the attitude and height of the quadrotor. After simulating the controllers, these were converted to discrete time using the Bilinear Transform as well as First Order Finite Differences. The results obtained were compared and finally, the angle controllers were implemented on the actual quadrotor system.

Testing the angle controllers on the quadrotor required different setups that would allow for safe and reliable testing as shown in Figure 1.

Results and Achievements

The controllers derived using the Bilinear Transform and that derived using First Order Finite Differences gave similar responses in the simulation. However, the Bilinear Transform gave an unusual response in the output of the controller. Therefore, it was concluded that the First Order Finite Differences was more appropriate for this application.

When implementing the controllers, the one derived using Bilinear Transform resulted in an oscillating unstable response. On the other hand, using First Order Finite Differences resulted in a stable control system for the roll, pitch and yaw. However, the height controller was not tested.

Figure 1: Methods of Testing

References

[1] A. Bousbaine, M. H. Wu and G.T. Poyi, “Modelling and Simulation of a Quad-Rotor Helicopter”, *6th IET International Conference*, March 2013.

Determination of Dielectric Properties of Rocks for Ground Penetrating Radar (GPR) Images

Student: Geraldine Mifsud / Supervisor: Ing. Evan Dimech / Co-Supervisor: Dr Lourdes Farrugia

Introduction

Ground Penetrating Radar (GPR) is a non-invasive method for analysing the sub-surface structure. It is currently being utilised to provide accurate verification and localisation of possible buried hazards, identify archaeological sites and investigate environmental conditions. The GPR technique utilises electromagnetic radiation which results in various reflections. It requires an initial guess of the dielectric properties of the target material/s for post-processing of the GPR images.

Project Objectives

The aim of this dissertation is to obtain the electromagnetic dielectric properties (permittivity, permeability and conductivity) of the Lower Globigerina Limestone through a scientific laboratory waveguide measurement technique. The Lower Globigerina Limestone was chosen because of its importance in many aspects of Maltese heritage.

Project Methodologies

A literature review was carried out to choose a suitable microwave measurement technique to determine the dielectric properties, including the permittivity and permeability of one of the Maltese rocks. This being the Lower Globigerina Limestone. This study was conducted through the use of a waveguide along with a Vector Network Analyzer (VNA) using a frequency range between 1.7 GHz and 2.6 GHz. Through such equipment, the scattering parameters were measured. After comparing the different measurement techniques, the Transmission/ Reflection Line (TRL) measurement was found to be the most suitable.

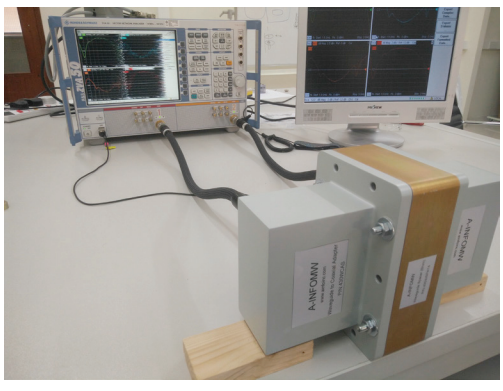


Figure 1: Experimental Set-up

Before every measurement session, the VNA was calibrated by following the Through-Reflect-Line (TRLc) calibration procedure. For validation of the calibration, that is the validation of the measurement session, a standard material with known dielectric properties such as PTFE was used.

The samples were extracted from a borehole in circular shape and then cut to a specific rectangular shape to fit tightly the rectangular sample-holder. Sample preparation followed which lead to performing the saturation procedure and obtaining measurements. The drying procedure then followed. Finally, the NIST and NRW conversion method were utilized to express the scattering parameters in the respective dielectric properties.

Results and Achievements

The average real relative permittivity of all the samples, when in the saturated state as illustrated in Figure 2 (green curve), increased with frequency due to the presence of water. In the dry state, the real relative permittivity remained rather constant as it varied with frequency (orange curve). Also, it was concluded that the samples act similar to a transparent material when exposed to magnetic fields, when in saturated and dry state. The analysis of the results has shown a trend within the dielectric properties. At the frequency of 2 GHz, the average permittivity and the average permeability of Lower Globigerina Limestone in the dry state resulted to be 5.025 ± 0.065 and 0.552 ± 0.27, respectively. The average permittivity and the average permeability of Lower Globigerina Limestone in the saturated state at 2 GHz, resulted to be 8.396 ± 0.072 and 0.269 ± 0.31, respectively.

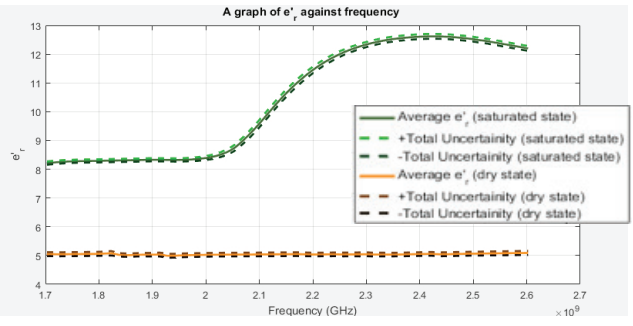


Figure 2: Average value of permittivity of all the samples including the total combined uncertainty in saturated and dry state

Characterisation of Ultrasonic Sensors for Vehicle Occupancy Detection

Student: Abigail Psaila / Supervisor: Dr Ing. Andrew Sammut

Introduction

Automotive companies are constantly evolving and adapting new technologies to offer better services and solutions. In such an industry, a company like Methode Electronics must offer innovative products to keep up with the competition. This project serves as a proof of concept for such an innovative system.

Project Objectives

The proposed system is a seat belt reminder that that can also function as a vehicle intrusion detector. This system is to be implemented in an overhead panel. The aim of this project is to implement an algorithm using readings from sensors to correctly detect the occupant of the passenger seat, be it a person or an object, and implement an algorithm that would monitor the passenger seat area for any intrusions.

Project Methodologies

Several different proximity sensors were compared to identify the best sensor for the application. The choice was ultimately between active ultrasonic sensors and passive infrared sensors. Ultrasonic sensors were chosen due to better target detection capabilities [1]. Several ultrasonic sensors on the market were considered and the HRLV-Maxsonar-EZ2 was chosen [2]. This sensor was tested to evaluate its detection zone for targets of different sizes, to analyse the error in the reported readings and to verify the sensor's performance as the temperature varies.

Two algorithms were implemented, one for vehicle intrusion detection and one for occupancy detection. The objective of the occupancy detection function is for the system to recognize the occupant by means of distance measurements from the ultrasonic sensors. Two sensors were used, one to monitor the area of the head rest and the other to monitor the area in front of the seat.

For vehicle intrusion detection, the hardware and sensor configuration is the same as that used for occupancy detection. The system monitors the sensors' readings constantly, to check for any changes which suggest intrusion. Both algorithms were tested for different scenarios and under different conditions, to test their ability to correctly detect an occupant or intrusion.

Results and Achievements

From the tests done on the sensor, it reports very accurate readings with errors of only a few millimeters. The errors are mostly due to human error, since all the setup and placing was done manually. For temperature testing, the readings are constant until the temperature is high. The only downfall of this sensor is that its operating temperature range is lower than that required by automotive standards.

Overall, both algorithms' performance was satisfactory. However, the system could always improve and be optimized further. Adding another sensor to the system would provide an extra set of readings to correctly distinguish the occupant of the seat and increase the area that the system is monitoring for intrusion detection purposes.

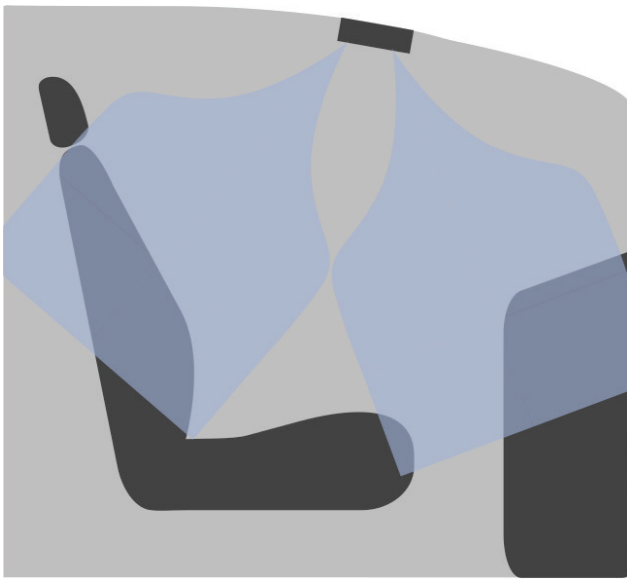


Figure 1: Side view of the passenger seat with the sensors' beam patterns

References

[1]"Performance comparison of Infrared and Ultrasonic sensors for obstacles of different materials in vehicle/ robot navigation applications", IOP, 2016.

[2]HRLV-MaxSonar® - EZ™ Series, MaxBotix.

Attitude Control Platform for Pico Satellites

Student: Ramses Rotin / Supervisor: Dr Ing. Marc A. Azzopardi / Co-Supervisor: Prof. Ing. Simon Fabri

Introduction

PocketQubes (PQs) are the next leap in satellite miniaturisation. Through compact 5x5x5cm standard dimensions they allow for accessibility to space at a low price-points. However, their multiple restrictions limit their possible applicability. The University of Malta aims to overcome these barriers through UoMBSat1, a PQ pico-satellite which aspires to implement, amongst others, an attitude determination and control platform.

Project Objectives

This project was required to implement a fully-active, tri-axial attitude determination and control sub-system (ADCS) using a system of reaction wheels, within a restricting 42x42mm footprint with suitable provisions for high reliability. Redundant electronics design was to be investigated as a way of overcoming component failures due to the adverse space environment [1].

Project Methodologies

To determine the pico-satellite's attitude, sensory data is required from attitude-finding vectors such as the sun vector or the Earth's magnetic field. This data, in addition to further information from inertial measurement units, such as gyroscope, is processed through data-fusing and attitude-determining algorithms [2] to produce the require actuation for small coreless motors coupled to reaction wheels. This project implements the necessary hardware for attitude determination and control in a spatially deprived footprint. The scarce resources are further stretched through the need for a redundant design which avoids single points of failure and failure propagation. Thus, a fault-tolerant, and fault-mitigating architecture is necessary, especially when commercially available off-the-shelf (COTS) devices are used in applications beyond their rated capabilities.

Figure 1: Coreless, permanent magnet micro-motors

Results and Achievements

The design identifies and implements the necessary instrumentation for an ADCS, such as magnetometers, accelerometers and gyroscopes. Despite the several limitations, a triple-redundant design was implemented for the benefit of democratic data scrutiny. The failure intolerant parts of the architecture were constructed out of discrete components to reduce the likelihood of failure. The design also targets the mechanical wear in the micro-motors' brushes by providing compensation circuitry to limit arching. Several health-checking mechanisms are also provided. These allow the system to assess its own health and recover. The final architecture was implemented in the allocated space, which resulted in a densely populated 6-layer printed circuit board (PCB). Finally, the design was subjected to a failure mode analysis (FMEA) to identify potential failures.

References

[1] L. D. Edmonds, C. E. Barnes, L. Z Scheick, "An Introduction to Space Radiation Effects on Microelectronics", Jet Population Laboratory, JPL Publication 00-06, May 2000.

[2] K. Krogh, E. Schreder, "Attitude Determination for AAU CubeSat", Ph.D. dissertation, Aalborg University, Denmark, 2002.

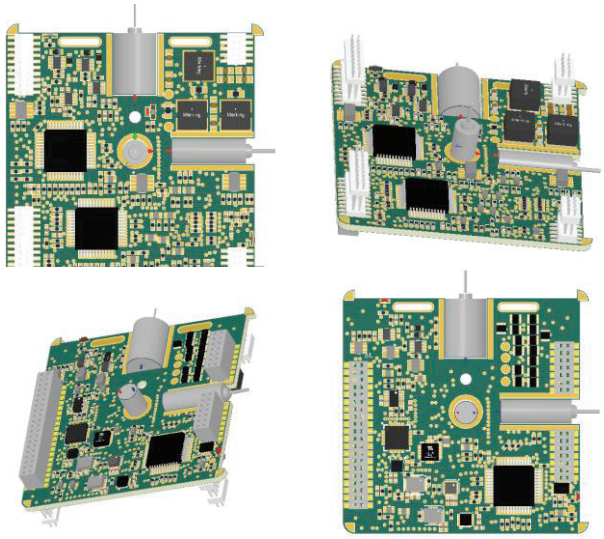


Figure 2: 3D renders of the attitude control platform.

Indoor Localisation Using UWB Technology

Student: Eryl Vella / Supervisor: Dr Ing. Brian Zammit / Co-Supervisor: Dr Ing. Marc Anthony Azzopardi

Introduction

The rise in use of automated technology, such as autonomous robots or automated systems in a home or industrial environment, bring about a technical need to accurately locate or track the movement of such autonomous robots or humans. One of the most common techniques for localisation involve time-of-flight techniques which measure signal flight time between two nodes. Ultra-wideband technology improves on current technologies by adopting extremely short pulses that result in a high bandwidth signal with desirable characteristics such as signal penetration through obstacles, increased localisation accuracy and lower interference with other radio frequencies.

Project Objectives

This work was intended to provide an insight into the advantages of UWB signals for object localisation. In this respect, a distance measuring system was developed using readily available system-on-chip hardware which can synthesize and receive the UWB pulses. The selected integrated chip was interfaced with a microcontroller and the final design used to carry out a preliminary evaluation of the resulting distance-measuring accuracy.

Project Methodologies

Various measuring techniques were investigated and after evaluating several possible candidate integrated chips, one was selected which provided the user with the possibility to perform distance measurements based on a radar technique. This was done by sending a UWB pulse and then receiving any reflections off the surroundings by sampling RF signals at rate of approximately 39GS/s. The chip being used was investigated further to better understand its operation, especially the techniques being used for such high frequency sampling.

The system designed comprised of sending several identical UWB pulses and initiate the sampling process. The received signals would then be analysed for any reflections of the pulse. This procedure is repeated several times in order to extract the position of any moving object in the radar path

Suitable hardware was then designed to host the radar chip and its interfacing circuitry. Software code was then implemented to initialise and communicate with the radar chip.

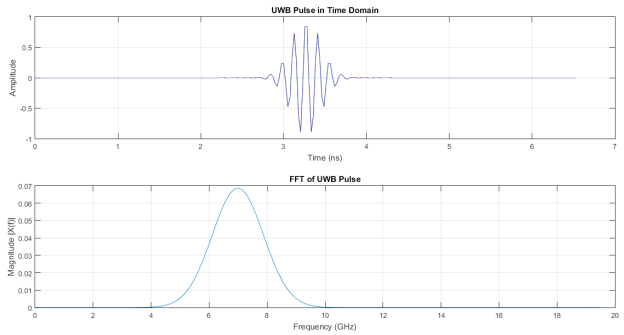


Figure 1: Example of UWB pulse

Results and Achievements

The preliminary results showed that the radar chip is being configured as required and the UWB pulses are being transmitted at the correct rate. Further work is however required to test the correct operation of the high frequency interface design before distance measurements can be carried out.

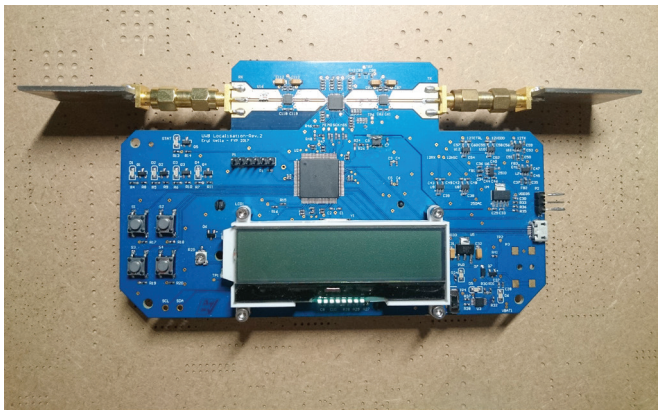


Figure 2: Designed hardware

A Cooling Fan Speed Controller for Energy Efficient Temperature Control of a Race Car Engine

Student: Jeanluc Mangion / Supervisor: Dr Ing. Reiko Raute

Introduction

The project entails the design and implementation of a variable radiator fan speed controller. This is an alternative to a hysterisis or bang-bang controller which switches abruptly between the off and on state. Adopting a variable speed controller, minimises the current required from a battery, allowing the use of a lighter battery.

Project Objectives

The objectives were to design a temperature acquisition system to monitor and feed the temperature to a controller. The controller will determine the speed required and generate PWM signals to rotate the radiator fan accordingly.

Project Methodologies

As the project entails both hardware and software design, the hardware was designed first. The synchronous buck converter which is responsible for driving the radiator fan was first built. Subsequently the temperature acquisition system was built in order to obtain the temperature of the coolant flowing out of the radiator. A temperature controller was designed to obtain the coolant temperature, execute the temperature algorithm and determine the required fan speed in order to cool down the temperature to the defined setpoint. A current controller was also implemented to limit the current accordingly, elongating battery life.

Results and Achievements

Both the motor driver circuit and the temperature acquisition system worked according to the design requirements.

For testing purposes, the radiator was connected to a water supply providing water at a temperature of 42˚C. With a sampling time of 5 seconds, the fluid was cooled down to a temperature setpoint of 35˚C within approximately 90 seconds.

Efficiency tests were taken and showed that the motor driver circuit is at least 97% efficient when the fan is operating at 70% of its rated speed.

References

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[2] N.Mohan, W.P.Robbins., and T.M.Undeland, ‘Power Electronics – Converters, Applications and Design 3rd Edition’, Wiley, USA, 2003

[3] K.Ogata, ‘Modern Control Engineering’, Pearson, USA, 2010.

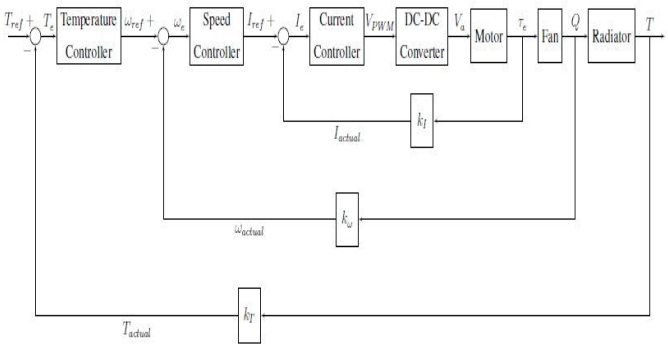

Figure 1: Block Diagram of the Whole Control System

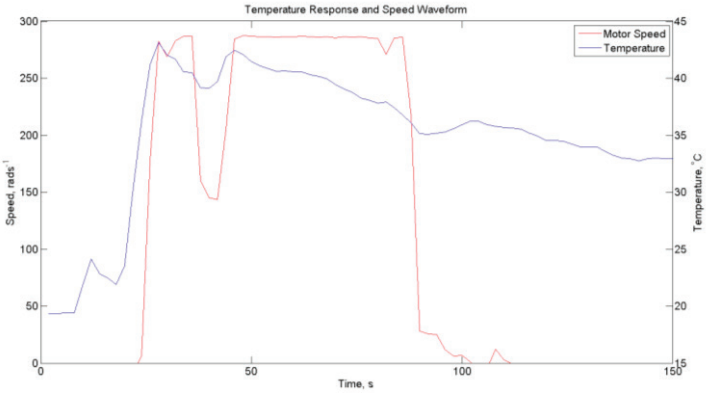

Figure 2: Temperature Controller Response

Design of a Modular Half-Bridge DC/DC Converter

Student: Luke Sestito / Supervisor: Dr Alexander Micallef

Introduction

In the past years there has been an advancement in the technology behind the development of circuits and components that are used to implement DC/DC converters. This led to the improvement in the thermal performance, while decreasing the weight, size and cost of the converter.

DC/DC converters are important components in consumer, communications, novel power distribution systems and industrial applications. Most of the DC/DC converters topologies are designed to function only in single-quadrant mode, that is, power can only flow from the source to the load [1]. However, in some applications such as regenerative braking for electric vehicles [2], a bi-directional converter is required.

Project Objectives

This project presents the design of a modular switch-mode DC/DC converter. The converter topology used is similar to the half-bridge converter, but instead of connecting the output to a passive load it is connected to another voltage source. Thus, the converter is able of being operated in first and second quadrants, supporting current flow in both directions.

Project Methodologies

In order to select the optimal semiconductor switch, the losses of five power electronic switching devices were estimated and compared at the different switching frequencies. From the design specifications of the convertor, the values of passive components were also calculated. The ideal switching frequency for the converter was then chosen upon the availability of the passive components and the losses in the switching device.

Before implementing the system in practice, a simulation model was created by using Simulink® in conjunction with PLECS® blockset. Various open loop and closed loop control simulations were performed and analyzed to verify that the converter was working as expected.

After validating the simulation results, the necessary circuitry of the modular DC/DC converter was designed and implemented on ten PCBs. These consisted of the gate driver, over-voltage and over-current protection and signal conditioning circuitry of the voltage and current feedback sensors. Isolation between the low voltage and the high voltage circuitry was also implemented.

Results and Achievements

The functionality of each PCB was then individually tested and verified, so that the holistic system could operate correctly. The characterization of the voltage and current feedback sensors were then obtained, for the microcontroller to compute the actual sensed. The gate driver board was tested to check that the designed dead-time was achieved. The DC/DC converter experimental setup was then tested and compared with the simulation results.

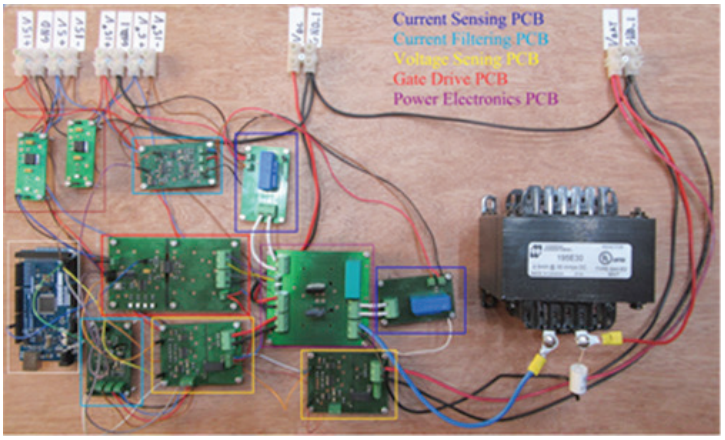

Figure 1: Experimental setup of the DC/DC converter

References

1] H. Ruedi, Two and four-quadrant DC/DC converters with SCALE drivers. [Online] CT-Concept Technology Ltd.,http://www.5scomponents.com/pdf/AN9902E_2_and_4_quadrant_dc2dc_converters.pdf

[2] M. Al Sakka, J. Van Mierlo and H. Gualou, DC/DC Converters for Electric Vehicles, in: Electric Vehicles - Modelling and Simulations, 2011, pp.309-332.

Design and Implementation of a Solar 12V Battery Controller for Off–grid Operation

Student: Nicholas Spiteri / Supervisor: Dr Ing. Reiko Raute

Introduction

The advancements in PV technology and power electronics lead to the ever increasing of solar energy as a source of energy production. It is a clean and renewable source of energy and the depletion of fossil fuels is forcing us to find an alternative and solar energy is proving to be a good alternative.

Project Objectives

The aim of this dissertation is to design and implement a Maximum power point tracking battery charger for off grid operation. This includes the design of a DC-DC converter to regulate the PV panel voltage to the battery voltage and also having a way to manipulate the PV operating point via the converter PWM duty cycle.

Project Methodologies

A MPPT algorithm was implemented using the perturb and observation concept. This required two data acquisition circuits, PV panel voltage and current. According to these variables the algorithm varies the DC-DC converter duty cycle to operate the PV panel at its desired maximum power point. This power is being used to charge a Lead acid battery. A Lead acid charging profile was implemented in conjunction to the MPPT algorithm to charge the battery safely and monitor the state of charge to charge it safely.

Results and Achievements

The implemented MPPT charge controller was tested at different levels of irradiance and its performance was analysed. Results showed that the charge controller exhibits good converging speed to the MPP and was able to alter the PV operating point according to changeable conditions.

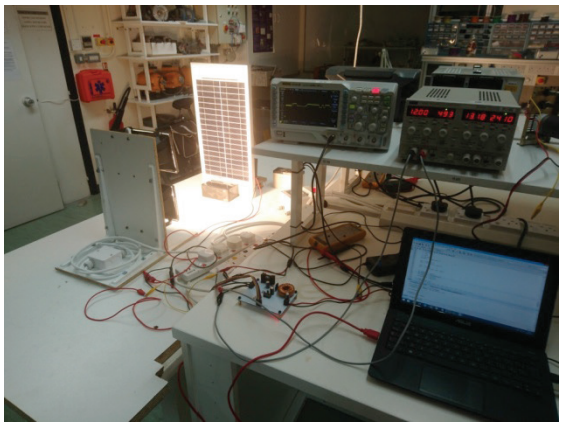

Figure 1 - MPPT charge controller test rig

Attitude Control of a Pico-Satellite with Reaction Wheels

Student: Denise Baldacchino / Supervisor: Prof. Ing. Simon G. Fabri / Co-Supervisor: Dr Ing. Marvin K. Bugeja

Introduction

Attitude control is a vital part of all satellite systems, providing the necessary control over the orientation (attitude) of the spacecraft. This dissertation provides a complete design of the attitude controller of the UoMBSat-1; a 5x5x5cm satellite, weighing 250g, currently being designed by the astrionics research team, ASTREA, at the University of Malta.

Project Objectives

The aim of this dissertation is to design an optimal controller for a laboratory set up of the UoMB-Sat1 in order to provide a proof of concept of the controller for said system. This includes designing the necessary models of the respective system. Reaction wheels mounted on motors are used as control actuators. When rotated, the torque developed by the wheels induces an equal and opposite torque on the satellite body, causing it to

Project Methodologies

Initially, a model of the satellite in Earth orbit was designed. This included the modelling of various reference frames, any external disturbance torques, and of various predicative models to determine the position and velocity of the satellite, as well as to calculate the value of the Earth's magnetic field at the satellite's respective position.

Following this, the lab test set-up was modelled, and the desired controllers were then designed based on this model. For the attitude controller, a Linear Quadratic Regulator with integral action was used. A PI motor torque controller was also designed. Cascade control was used, whilst designing at the necessary sampling frequencies to ensure the necessary torque control for the outer loop attitude controller. Two controllers are designed for two modelled rotations of the satellite prototype on Earth. One caters for rotation in a horizontal place, whilst the other models the rotation in the vertical plane.

The system was also aimed to be implemented on a physical test set up. Design of the necessary hardware and software algorithms was also performed on a microcontroller in order to provide for a fully embedded and stand-alone system. The physical set up is shown in Figure 1.

Results and Achievements

The advantage of using optimal control is that a compromise between accuracy obtained in the desired angle and reduction in power consumption can be attained. Figure 2 shows the simulation results of the cascade controller for the Case 1 (rotation in the horizontal plane) where a desired angle of 5 degrees is obtained in approximately 12 seconds, whilst maintaining power consumption to a minimum. In this case, the necessary anti-wind up control was implemented to avoid excessive wind up of the integral action. In addition, anti-aliasing filters were implemented in the feedback loops of the inner and outer loop controllers.

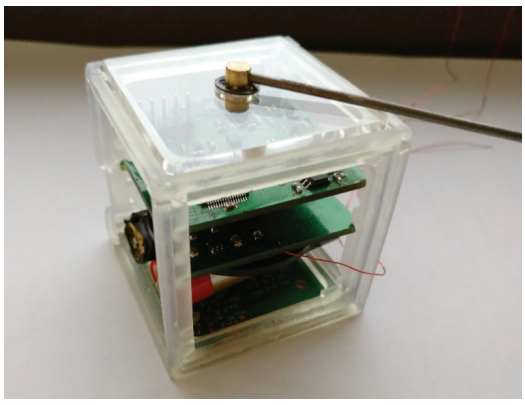

Figure 1: Physical arrangement of lab test set up

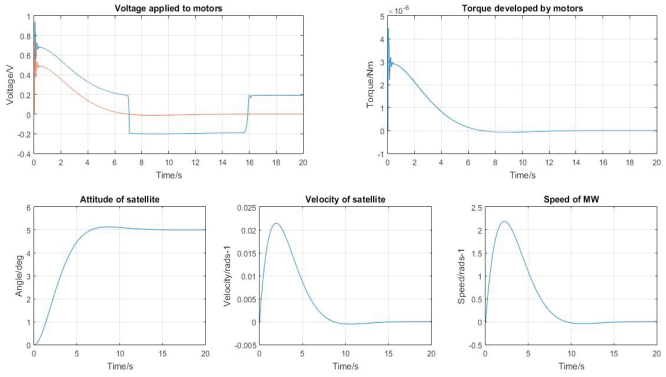

Figure 2: Response of cascaded optimal attitude controller

Registration of Thermographic Video for Dynamic Temperature Analysis in Humans

Student: Christina Bonett / Supervisor: Dr Owen Falzon / Co-Supervisor: Dr Kenneth Scerri

Introduction

The use of thermography in the biomedical field has increased in popularity due to the decrease in the cost of thermal imaging cameras and a significant improvement in their specifications. Common uses of thermography include breast cancer detection and the diagnosis of physiological impairments such as diabetes mellitus [1] . Using dynamic thermography, reliable information regarding any underlying physiological processes may be extracted.

Project Objectives

The project objectives included the implementation of a thermographic video registration procedure for the compensation of unwanted target movements. Following registration, temperature variations from the regions of interest were to be extracted and analysed in the context of any potential underlying physiological activity.

Project Methodologies

Two methods for thermographic video registration were developed to cater for involuntary target movement and the dynamic temperature changes undergone by the region of interest, since the latter causes the features associated with each salient point to change continuously. Their performance was assessed qualitatively and quantitatively, followed by a two-sample t-test to determine whether the difference between the two methods was significant. Dynamic temperature analysis was then carried out on the extracted temperature data in both the time and frequency domains for an in-depth analysis.

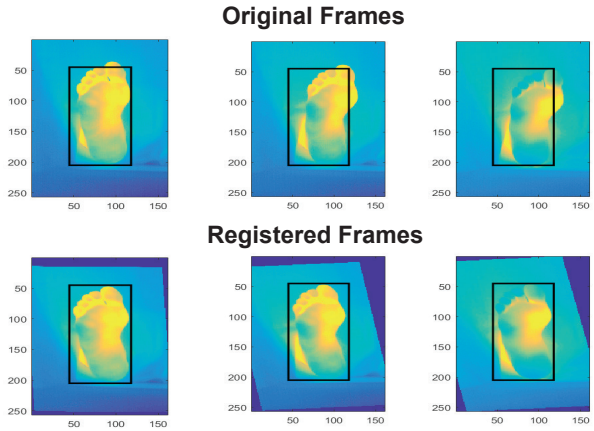

Figure 1: Comparative example of three original frames and their corresponding registered frames

Results and Achievements

Most of the anticipated target movement was catered for via the developed registration procedures. This is exemplified in Figure 1, which depicts three original frames and the corresponding registered frames from a particular thermographic video. As shown in Figure 2, each temperature signal extracted could be decomposed into different components, which could in turn be associated with acclimatisation, underlying physiological processes and noise. Following filtering and spectral analysis, it was deduced that cyclic patterns of distinct frequencies were exhibited by each individual area considered within the plantar surface of the foot of healthy subjects. Further analysis is to be carried out to determine the biological significance associated with these patterns, since such behaviour has not been documented in literature.

The registration process thereby allowed for an in-depth analysis of the temperature data associated with any desired region of interest through the automated tracking of these regions. The developed registration and temperature analysis approach can be adopted for a wide range of applications where thermography has been utilised but has been limited to manual or static analysis of the thermographic data.

References

[1] Lahiri B., Bagavathiappan S., Jayakumar T., and Philip J., 'Medical Applications of Infrared Thermography: A Review', Infrared Physics & Technology, 2012, Vol. 55, pp.221-235

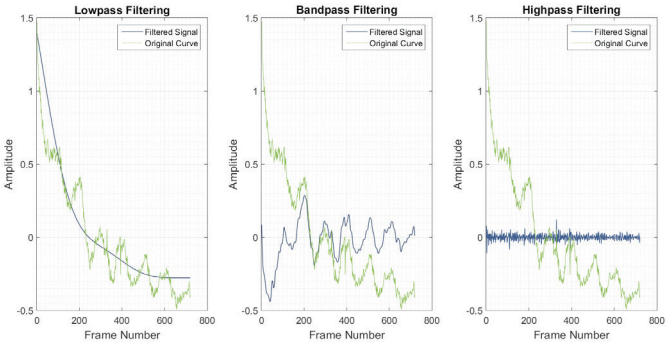

Figure 2: Temperature signal decomposed into three distinct components through the use of filtering

EMG Based Finger Movement Estimation

Student: Gabriel Calleja / Supervisor: Prof. Kenneth Camilleri / Co-Supervisor: Prof. Michael Saliba

Introduction

The advancements in electronics these past years enabled the scientific community to read the smaller voltages created by the muscles called Electromyography Signals (EMG). These signals can be used to actuate artificial limbs to help amputated patients rehabilitate.

Project Objectives

The aim of this dissertation was to capture EMG signals from the forearm and investigate their relationship with the finger joint angles of the index and middle finger Metacarpophalangeal Joint (MCP).

Project Methodologies

The EMG data was acquired using Zero-Wire Wireless Mini Wave electrodes. The kinematic angles of the joints were measured using a goniometer which was synched with the EMG signals (Figure 1). Once the raw EMG signals were captured, the signals were divided to ensure the steady state parts are considered. Four major features were chosen to be extracted from the EMG signal, these are the Mean of the Absolute Value, Waveform Length, Willison Amplitude and Variance. The method used to estimate the joint angles was a Multi-Layer Perceptron. Once the joint angles were estimated they were used as inputs to actuate a robotic hand through an Arduino Due (Figure 2).

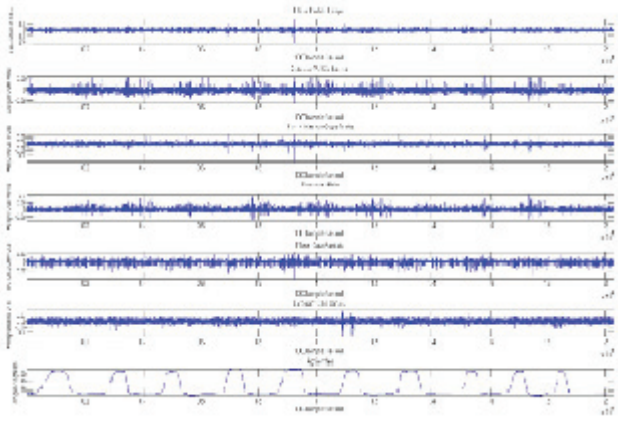

Figure 1: EMG and Goniometer Signals

Results and Achievements

This dissertation also achieved a solid data acquisition protocol that was rigorous so as to get the specific data needed from the EMG. The estimation of the angles at a steady state EMG input was found to be quite accurate for the MCP of the index and middle finger individually comparable to the literature. This accuracy within the result diminished as the fingers were added or operated together. This was to be expected since the neural networks have more to learn and cross-talk between muscles may create overlaps in the data. The angles estimated could successfully operate a robotic hand through MATLAB in a non-continuous decoding application.

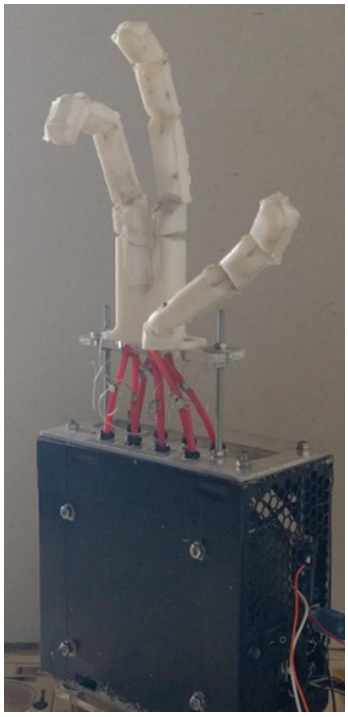

Figure 2: The Robotic Hand

Swarm Robotics

Student: Luke Camilleri / Supervisor: Prof. Ing. Simon G. Fabri

Introduction

The field of swarm robotics has been growing fast over the last few years. Apart from performance gains on tasks that allow for parallel execution, simple robots can also be smaller, enabling then to reach areas that cannot be accessed by a larger, more complex robot. Their ability to cooperate means they can execute complex tasks while offering self-organised adaptation to changing environments and robustness due to redundancy.

Project Objectives

Development, simulation and physical implementation of robust formation control and obstacle avoidance algorithms on a team of four Khepera III mobile robots [1], that would enable the robots to cooperate and execute tasks such as pushing large objects in unison.

Project Methodologies

The first step in this project was to do a critical appraisal of literature on types of swarming and obstacle avoidance algorithms. The background theory relevant to this study was then described. It started by giving a comprehensive understanding of the relevant theory pertaining to differential drive wheeled mobile robots. The algorithms used in this dissertation were also listed. Important building blocks such as threads and web sockets were also described.

The algorithms were designed and tested. Furthermore, simulations were designed in order to test the proposed algorithms sufficiently. V-Rep, an animated robotic simulator was also used to reproduce and test realistic scenarios. The communications infrastructure, which was vital for the sound operation of the swarm, was implemented. Finally, all the algorithms were implemented on the physical robots and testing was done through the use of a VICON motion tracking system.

Results and Achievements

This dissertation has not only studied, developed and implemented pre-existing swarming algorithms, but has also developed a novel set of algorithms which have been shown to work successfully, not only in simulation, but also on the physical robots. It was also proven that the approach taken in this project works with different initial conditions, hence proving that not only is it simple and computationally inexpensive, but also robust. These are all important attributes in a swarm robotics system, where the concept of swarm robotics is usually exercised on small and simple robots. The success of the algorithms was severely hampered by odometry errors. This was also proven with data from a motion tracking system. Figures 1 and 2 show the robots in a line and V-shaped formation after they had originally started from arbitrary positions.

References

[1] Khepera III User Manual, v3.5, K-Team S.A, Switzerland, 2013.

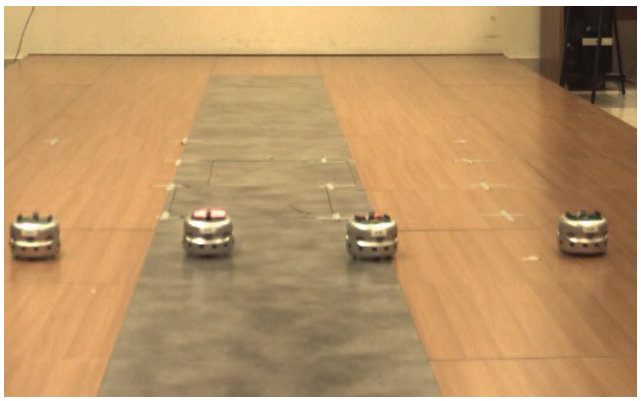

Figure 1: The swarm in a line formation

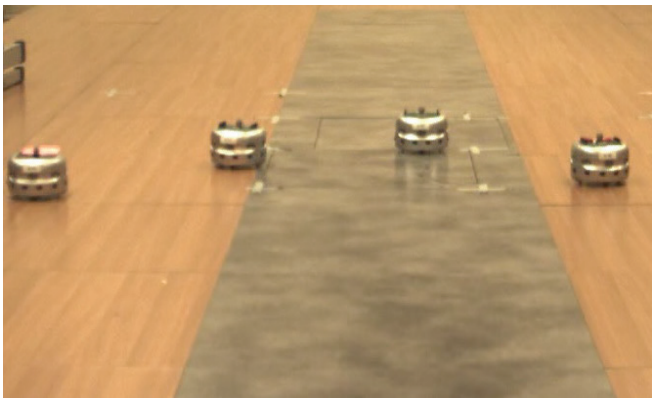

Figure 2: The swarm in a V-shaped formation

Autonomous Control of a Quadcopter

Student: Julian Magri / Supervisor: Dr Ing. Marvin Bugeja

Introduction

The quadrotor belongs to the field of Unmanned Aerial Vehicles (UAVs), a recent field of research focusing on aerial robots and their autonomous control. For complete autonomous control of a quadrotor, full control of both its attitude and its position is required. This enables the quadrotor to move about, vertically and horizontally, in space through pitch, roll and yaw movements.

Project Objectives

The main aim of this project was to study, design and implement an autonomous control system for a quadcopter. This control scheme allows the quadcopter to be used in several different applications, such as for search and rescue, parcel delivery and autonomous surveillance.

Project Methodologies

The first step towards reaching the project's objective was to choose a quadcopter platform. This included familiarization with the field of quadcopter UAVs in general, and observing the most popular platforms being used for control applications.

The quadcopter chosen for this project was a custom build, primarily comprising of a QAV400 quadcopter frame and a Pixhawk Mini Flight Controller. The sensor feedback in this project was obtained using an Inertial Measurement Unit (IMU) built-in in the flight controller itself, consisting of a gyroscope, accelerometer and magnetometer.

Quadcopter selection was followed by deriving a mathematical model which represents the nonlinear and multivariable dynamic behavior of the real quadrotor.

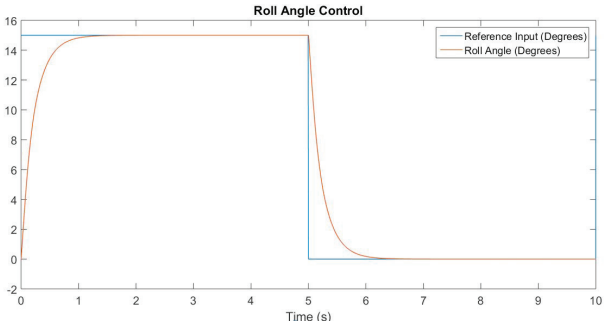

Figure 1: Roll Angle Control

By going through various control techniques previously proposed for quadrotors, PID cascade control techniques were chosen for quadrotor control. The control strategies adopted for the control of quadrotors are based on typical flight modes found on most quadrotor systems.

The pilot typically communicates with the quadcopter using a radio remote controller. The inputs provided by the pilot are then perceived according to the flight mode chosen, and closed-loop controllers were designed for all the considered flight modes, ranging from manual flight to fully autonomous flight.

The full control system was then simulated using Matlab/Simulink. The simulation was interfaced with a real joystick to emulate a 3D remote-controlled real time scenario for enhanced realism and ease of performance validation.

Results and Achievements

The PID control strategies designed and implemented in this project proved to be successful for the autonomous control of a quadcopter in simulation. Figure 1 shows the stabilization of the roll angle according to a reference input.

The quadcopter was loaded with the Pixhawk Software Framework and flown manually in the simplest flight modes. In future work, this software framework can be modified and the controllers designed in this project can be implemented on the real quadrotor platform for experimental validation. The quadcopter custom built for this project is shown in Figure 2.

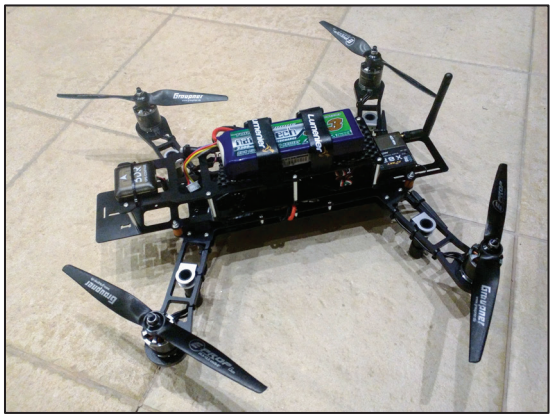

Figure 2: QAV400 Quadcopter Custom Build

Computational Modelling of Expressive Music Performance

Student: Maria Mifsud / Supervisor: Dr Alexandra Bonnici

Introduction

There exists a difference between the output of a computer system that has the ability to generate perfect performances which conform to all the symbolic information of the notes and the performance of a human. Computer Systems for Expressive Music Performance (CSEMP) try to bridge this difference through simulation of elements of human expressive performance.

Project Objectives

The target of this project is to computationally enhance a MIDI file rendition of a piano sheet music with expressive quantities. Such expressive quantities constitute the dynamics and articulation indicated on the music sheet.

Project Methodologies

The design of the implemented CSEMP is based on the Analysis-by-Synthesis method as used by [1] and follows the generic model for CSEMPs illustrated in Figure 1. It centers around the performance knowledge which analyses the music sheet to identify the expression notation and where this notation is to be applied to the music. The performance knowledge makes use of the performance examples through which recordings of performance of renowned pianists are analysed and different expressions are modelled from these performances. This helps to formulate performance principles with which the expressive qualities may be applied to a MIDI recording to create an expressive performance of the recording.

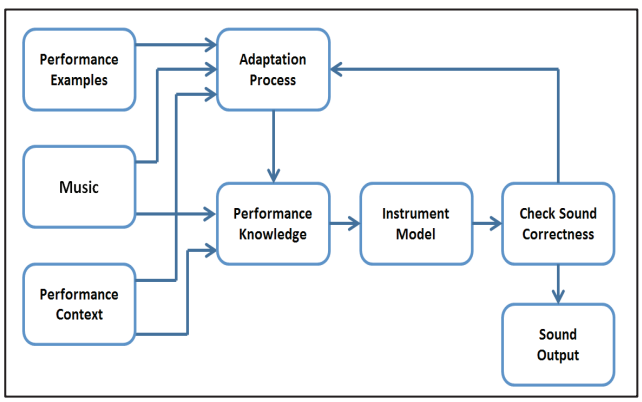

Figure 1: CSEMP Generic Model [2]

Results and Achievements

The precision and recall of the expression notation recognition algorithms for the dynamics are 97% ± 4.4% and 95% ± 6.4% respectively, whilst those for the articulation result 96.3% ± 5.9% and 87% ± 9.8% respectfully. From the 228 correctly detected expression notations, 216 (94.7%) were assigned to their respective beat. Of these 196 (90.7%) were assigned to the correct note. The proposed system produces music whose expressive qualities follow a model obtained from recorded performances but are different to the expressions contained in any individual performance on which they are modelled, just as any other two human performances. As expected from a good CSEMP, its differences fall within some tolerable difference for all expressions. As can be witnessed from a listening test survey conducted, the performance modelled by this system is endowed with exceptional expressive qualities which make it very similar to what one would expect a human performance to sound like. The resulting performance of Beethoven's Piano Sonata Op.2 No.1 can be heard by scanning the QR code in Figure 2.

References

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Figure 2: CSEMP Expressive Performance of Beethoven's Piano Sonata Op. 2 No. 1

Modelling of Stage 2 Sleep EEG Data

Student: Natasha Padfield / Supervisor: Dr Tracey Camilleri

Introduction

Humans spend a third of their lives asleep and monitoring of brain activity during sleep through an electroencephalogram (EEG) has significant clinical relevance. Sleep spindles for example, a transient event that occurs during one of the stages of sleep, referred to as Stage 2, is known to be linked to various disorders and diseases such as dementia [1]. Typically, sleep EEG data is manually scored by a human expert but this is tedious, time consuming and subjective. Hence alternative automatic detectors are currently being investigated.

Project Objectives

The main objective of this project was to implement and compare two automatic detectors for sleep spindles, particularly a standard detector used for comparison by different studies and a more complex detector previously proposed by the Department of Systems and Control Engineering [3].

Project Methodologies

In the first part of this project, a standard spindle detector, known as a root–mean-square (RMS) amplitude detector was implemented and tested on two different sleep EEG datasets, one of which is open source. This detector locates spindles by calculating a threshold from the amplitude of filtered EEG data and assumes regions of the data which exceed this threshold to be a possible spindle event.

The RMS detector was then compared to an autoregressive switching multiple modelling (AR-SMM) detector [2], which is based on mathematical modelling of the spindles and background EEG data. These models are trained using pre-labelled data by a human expert.

Various standard statistical methods were used to evaluate the performance of the two detectors on the same datasets and changes in performance with variations in the length of training data were also investigated.

Results and Achievements

Overall, the RMS amplitude detector performed better than the AR-SMM detector with an average accuracy of 96% compared to 67% when testing on the open source database. However, the AR-SMM detector was consistently more sensitive, possibly highlighting the need for this detector to be trained with high quality rather than high quantity data. The performance of both detectors improved when the length of the training data was increased, however this trend was more evident in the case of the AR-SMM detector. This project successfully reached its objectives and future work will investigate how further tuning of the AR-SMM detector can help improve its detection performance.

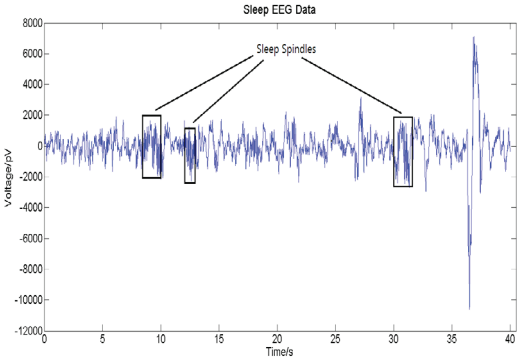

Figure 1: Comparing the Performance of the two Detectors

References

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Robotic Mapping, Localization and Navigation in ROS

Student: Matthew Pulis / Supervisor: Dr Ing. Marvin Bugeja

Introduction

Autonomous navigation of a robot in a dynamic environment is a widely researched topic in robotics. This is usually comprised of three procedures : (1) Mapping, (2) Localization and (3) Navigation. Mapping is the process of obtaining a map of the robot's environment and storing it in a usable format. With a map available, the robot must be able to localize itself within its environment, i.e determine its position in the map as it moves around. The last step is navigation, where the robot must be able to traverse the map to reach a specified goal location while avoiding dynamic and static obstacles along the way. To be able to do this the robot must have some means of perceiving its surroundings, done through the use of sensors. In this project the PowerBot developed by Adept MobileRobots was used. The Robot Operating System (ROS) was installed on the robot. This is an open-source robotics development framework designed to help in the development of robotics projects.

Project Objectives

The main objectives of this work were to test the effectiveness of the mapping and localization procedures implemented using ROS. A method of how to improve these results was researched. The improvement of autonomous navigation through the installation of an Inertial Measurement Unit (IMU) was proposed.

Project Methodologies

First a selection of algorithms which are used in the mapping, localization and navigation procedures were researched.

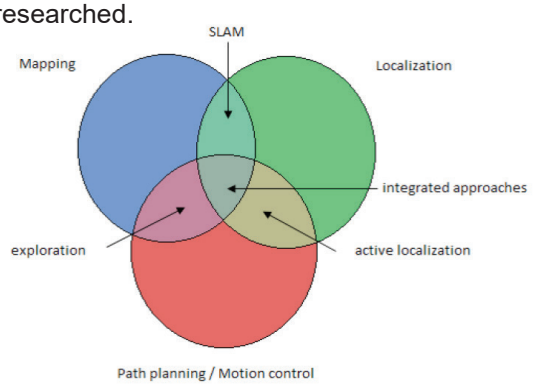

Figure 1: The Facets of Autonomous Navigation [1]

For the mapping procedure two SLAM algorithms that could be implemented using ROS were chosen for testing.

These were GMapping and Hector SLAM. Both use laser measurements but GMapping fuses this with data from wheel encoders attached to the robot's wheels. The localization algorithm used in this project is AMCL which is a type of particle filter.

The algorithms were tested in two different environments, one which had many recognizable landmarks and another which was an empty room.

An IMU was bought and installed on the PowerBot to improve the orientation estimate. An ROS package was written which obtained data from the IMU and published it to the network, where an EKF was used to fuse the orientation data with that from the wheel encoders.

Results and Achievements

From the tests, the following results were obtained:

1. It was found that mapping environments which have few unique landmarks leads to a degradation of the produced maps.
2. AMCL is a great improvement over position estimation using only dead reckoning techniques (odometry).
3. Similarly to the SLAM algorithms, AMCL suffers from degradation when used in an environment with few unique features.

The results from the integration of the IMU were poor but this is due to the need of more tuning being done to the data sent to the EKF.

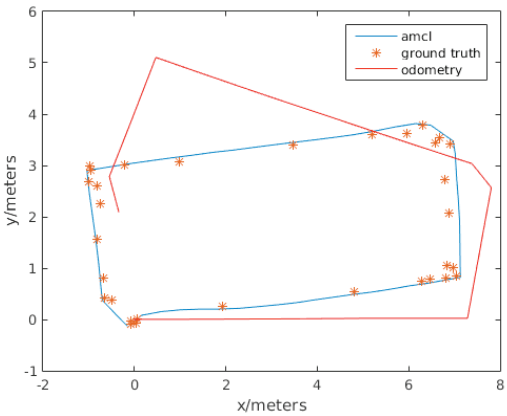

Figure 2: Comparison of AMCL position estimation with ground truth and odometry

References

[1] C. Stachniss, "Robotic Mapping and Exploration" in *Springer Tracts in Advanced Robotics,* 2009, vol.55, ch.1, pp.3-6

Connected Vehicles and Road Infrastructure for Urban Mobility

Student: Nirvana Sciberras / Supervisor: Dr Kenneth Scerri

Introduction

The advancement in transportation led to an increase in vehicle ownership [1], thereby increasing traffic congestion. This caused several unforeseen problems, such as the increase in pollution, fuel consumption, delays and driver's frustration. Evidently, the solution to traffic congestion is quite a challenge, with one possible remedy being the introduction of an Intelligent Transport System to optimize traffic flow.

Project Objectives

The main aim of this project is to address the problem of traffic congestion by collecting data from vehicles passing through a junction in Mosta, predicting the number of vehicles passing through the junction in the next few seconds and adapting the traffic light timings in real time to reduce the total travel time through the junction.

Project Methodologies

This project investigates the use of Vehicle-to-Infrastructure (V2I) Communication to collect information such as speed, destination and origin from vehicles approaching the junction.

To implement this, a micromodel of the Mosta-Lija-Attard junction in Valletta road Mosta, was developed using an industrial traffic simulator known as VISSIM [2]. The communication between the infrastructure and the vehicles was established using MATLAB, which is a scripting language widely used by engineers and scientists. Hence, based on the number of vehicles detected by the infrastructure, a linear regression model is generated, for all the origin-destination pairs, for example, for vehicles originating from Mosta, whose destination is Lija. Then, an optimisation algorithm, known as the simplex method [3], was used to optimise the traffic light timings based on these mathematical models. This is repeated for every traffic light cycle, which in most cases is 90 seconds, with the aim to reduce the total travel time for the vehicles passing through the junction.

This methodology is tested using different scenarios, mainly when the vehicles communicated both their origin and destination and when the vehicles communicated their origin only.

The rate of vehicles that are equipped with V2I communication is continuously reduced to analyse the performance of the junction.

Results and Achievements

For both these configurations, the number of vehicles that are able to communicate with the infrastructure, is continuously reduced to 75 per cent, 50 per cent, 25 per cent and 10 per cent of the total Maltese private vehicle fleet, and the junction is analysed in each case.

Results show that even with a rate of V2I communication equipped vehicles as low as 10 per cent of the total private vehicle fleet, the infrastructure manages to optimise the traffic light timings while minimising the total travel time through the junction.

Figure 1: Mosta-Lija-Attard junction developed in VISSIM

References

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[2] Fellendorf M. and Vortisch P., "Microscopic Traffic Flow Simulator VISSIM," in Fundamentals of Traffic Simulation, New York, Springer Science+Business Media, 2010, pp. 63-92.

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An IoT Solution for Traffic Light Control

Student: Marija Vella / Supervisor: Dr Kenneth Scerri

Introduction

Traffic is the plague of our time. The relentless increase in the number of vehicles on the road in a small country such as Malta inevitably results in clogged roads; particularly in urban areas. Developments in sensor technology, advanced hardware and the advent of the Internet led to the Internet of Things (IoT) and consequently the possibility of IoT-based intelligent transportation systems. Implementing such a solution helps to minimise traffic congestion problems.

Project Objectives

The aim of this dissertation is to implement a real-time IoT-based solution which adjusts traffic light timings controlling an urban signalised junction. The ultimate aim is to minimise queue lengths. The Rue D'Argens and Sliema Road junction was the focus point for this project.

Project Methodologies

To reach this objective, a model of the actual junction was designed on the Vissim traffic simulator package. In the simulator, traffic lights as well as vehicle flow detectors were placed to measure the number of incoming vehicles, outgoing vehicles and the queue lengths. The junction visualized by Vissim is shown in Figure 1. A queue based macro model [1] to estimate the queue lengths as given by the simulator was developed for testing the proposed changes in the road infrastructure.

To transfer the sensor data between the traffic simulator and the cloud platform a communications link was set up between the two. The sensor data is processed and with the implementation of an optimisation algorithm known as the simplex method [2], efficient traffic light timings are obtained and sent back to the traffic simulator.

Results and Achievements

The implementation of the complete IoT solution shown in Figure 2 led to the possibility of real-time simulations to obtain optimal traffic light timings. Testing of the complete system to observe the traffic patterns and queue build-up during different traffic scenarios proved that significant reductions in the queue lengths can be achieved when adaptive traffic light timings are used rather than fixed traffic light timings. Great processing speeds were also obtained from the cloud architecture.

References

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[2] E. Chong and S. Żak, *An Introduction to Optimization* New York, John Wiley & Sons, 2001, pp. 287 – 310

Figure 1: Simulation of the junction on Vissim

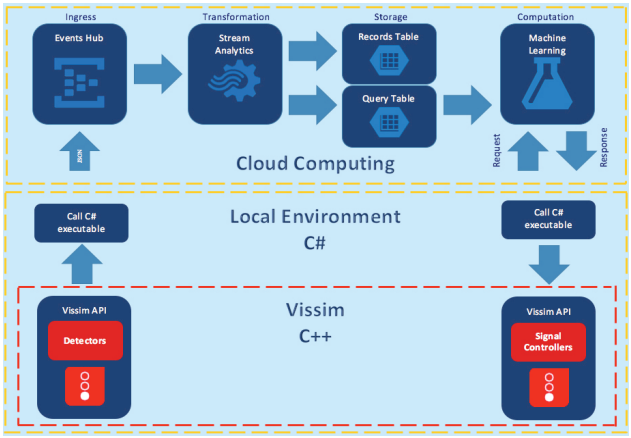


Figure 2: Complete IoT Solution

Web Browsing using Brain Signals

Student: Rebecca Vella / Supervisor: Dr Tracey Camilleri / Co-Supervisor: Dr Chris Porter

Introduction

Controlling computer applications through standard devices such as mice and keyboards is not always possible, especially for those suffering from neurological diseases, such as amyotrophic lateral sclerosis (ALS). An alternative communication channel can be achieved using brain signals, leading to what is commonly known as a brain-computer interface (BCI). Stages involved in realising a BCI and some typical BCI applications are depicted in Figure 1. One of the most researched BCI is that using steady state visually evoked potentials (SSVEPs), due to its high bit rate and accuracy. However, spontaneous background brain activity presents a major challenge to the detection of SSVEPs, which can be circumvented by employing

Project Objectives

This project aims to investigate different techniques used for SSVEP detection, focusing primarily on two feature extraction techniques which have different training requirements, and evaluate the potential of a calibration-free SSVEP-based BCI. The project also includes the development of a web browser controlled through thought.

Project Methodologies

An existing dataset, collected by R.Zerafa in [1] was used to perform feature extraction of SSVEP responses with a traditional technique called power spectral density analysis (PSDA), which requires training for selection of subject-specific best bipolar channels (BBCs) and collection of background EEG for each subject. In this project, the technique required the computation of the power spectral density (PSD) of visual stimulation trials and background EEG trials from each subject's BBC, such that the signal to noise ratio (SNR) of each SSVEP trial could be calculated to extract reliable features, and account for spontaneous background EEG activity. Additionally, a multivariate spatial filtering algorithm called canonical correlation analysis (CCA) was used as a feature extraction modality independent of calibration to subject-specific parameters. The algorithm finds two sets of weights ($\boldsymbol{W_X}, \boldsymbol{W_Y}$) to transform two original variable sets ($\boldsymbol{X}, \boldsymbol{Y}$) onto a new orthogonal space in which variables across sets are maximally correlated.

In this case, CCA was used to measure potential underlying correlations between multi-channel SSVEP data and reference signal sets (composed of sinusoidal oscillations) corresponding to each stimulus frequency.

Results and Achievements

When using both supervised and unsupervised classifiers, CCA achieved performances comparable to PSDA, with no statistical significance in the differences observed. Such results indicate that feature extraction by CCA is a step forward towards developing plug and play BCIs for commercial and clinical environments.

A web page containing links to several websites was hosted on a local server, and BCI commands were sent as http requests to the said server, realising a subject's SSVEP response into navigation commands of "up", "down", "go-to" and "go-back" in the browser window.

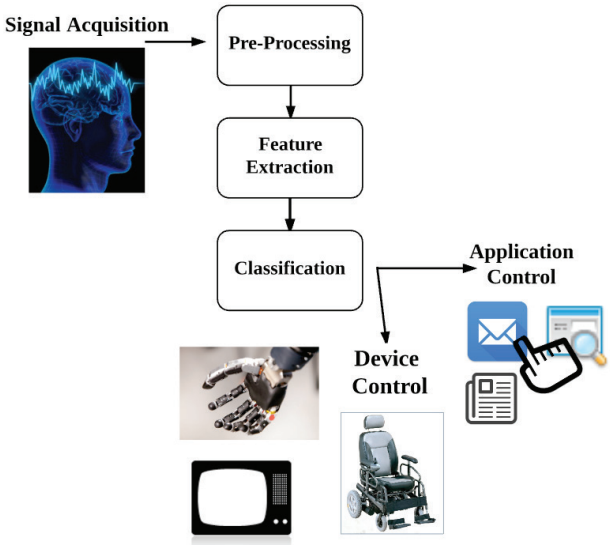
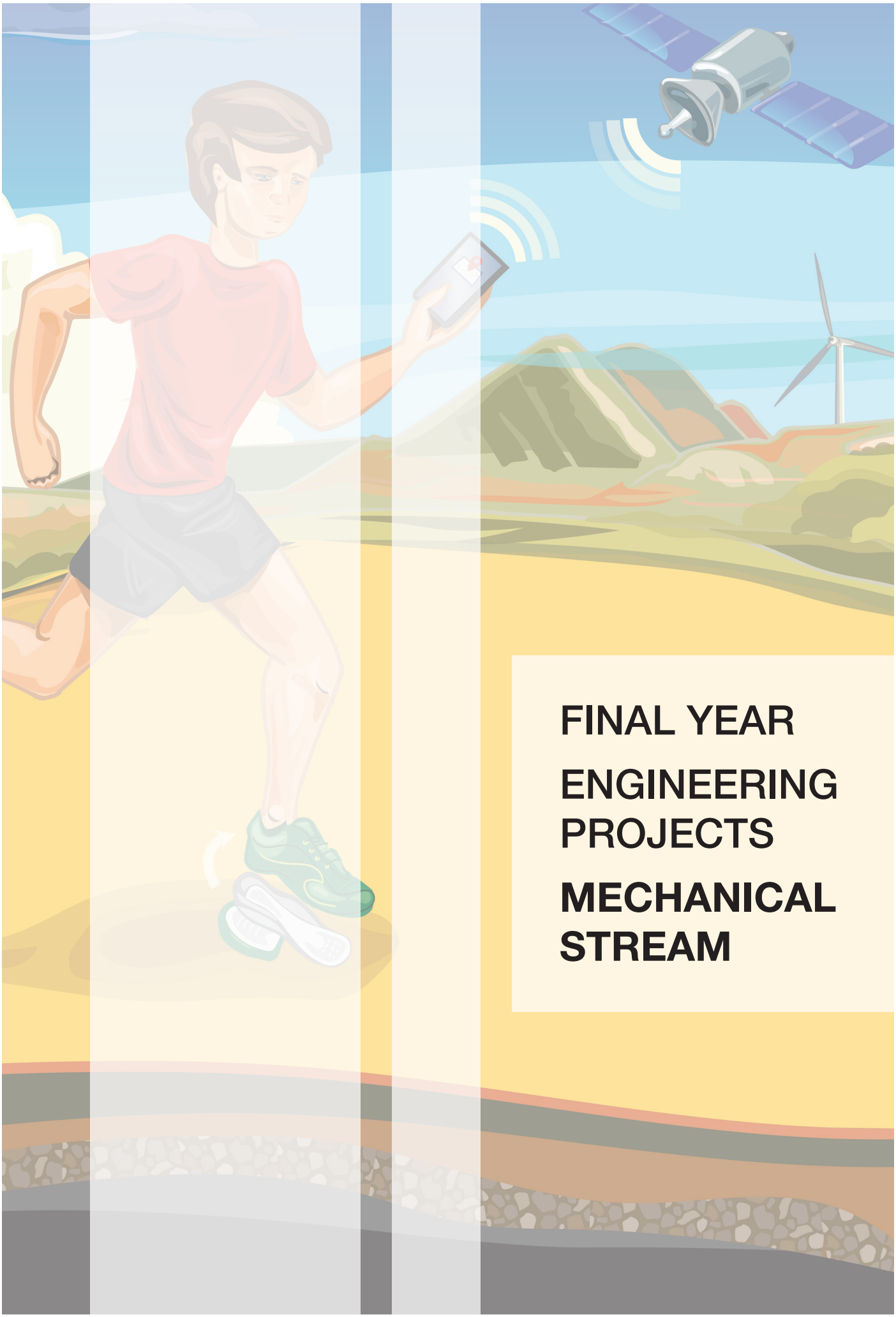


Figure 1: Stages of a typical Brain Computer Interface (BCI)

References

[1] Zerafa R., "SSVEP-based Brain-Computer Interface (BCI) System for a Real-Time Application", B.Eng.Dissertation, University of Malta, Malta, 2013.



FINAL YEAR ENGINEERING PROJECTS

MECHANICAL STREAM

Sustainability Analysis of Plastic Injection Moulding

Student: Isaac Aquilina / Supervisor: Dr Ing. Paul Refalo / Co-Supervisor: Dr Arif Rochman

Introduction

The industry of plastic injection moulding forms a substantial part of the manufacturing industry, which is a large consumer of energy worldwide. Advances in the injection moulding process and machines may therefore improve the sustainability of the industry.

Project Objectives

The aim of this project was to carry out a sustainability analysis of different injection moulding machines by distinguishing them according to their drive systems and years of operation, determining the amount of energy they consumed, as well as analysing the other factors that were involved in operating and maintaining these machines. The results allowed for recommendations to be made to Toly Products Ltd., the industrial partner of the study, regarding which generation of machines should be phased out and which type of machines should replace them. It was also possible to suggest the type of machine that would manufacture a specific type of part in the most efficient and sustainable manner.

Project Methodologies

The injection moulding machines that were tested were three hydraulic generations of machines and one hybrid generation. These were the Battenfeld 1500 tonne of 2001, the Battenfeld 2000 tonne of 2003, the Battenfeld 2700 tonne of 2003 and the Engel 2200 tonne of 2016, respectively. These machines were tested while producing three different parts.

The main test that was carried out was to find how each machine consumes energy while manufacturing each of the parts considered. This was done by using the Kyoritsu KEW 6305 Power Logger which generated graphs of power consumption against time. An example of these graphs can be seen in Figure 1. These graphs were divided into the different sections of the injection moulding cycle and analysed to see how this affects the cost of electrical energy and the emissions of CO_2. These factors were converted to their environmental, economic and social impacts that the injection moulding machine and process has.

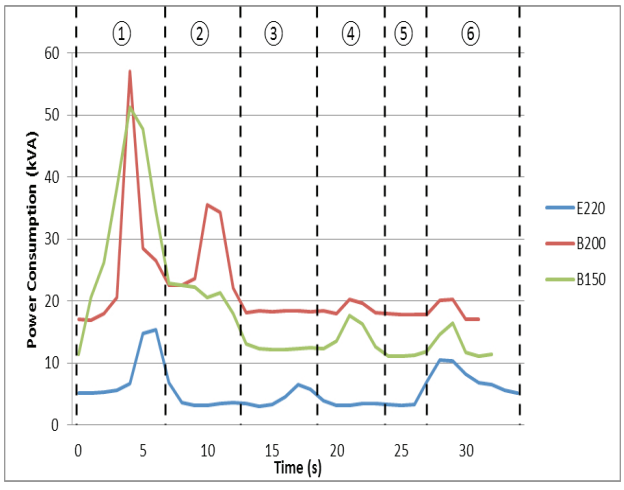


Figure 1: Graphs generated to illustrated the Power Consumption vs Time for the machines producing Part B

Results and Achievements

The results concluded that the new hybrid machine consumed a lower percentage of energy, when compared to the hydraulic machines as can be seen in Figure 2. The hybrid machine also proved to manufacture the parts considered most efficiently in each test. They also consumed similar amounts of energy across all parts with an average value of 6.7 VAh per part. In order to improve the overall sustainability of the plastic injection moulding industry, it was therefore suggested that new hybrid and all-electric machines ought to be invested in, and replace the older generations of hydraulic machines.

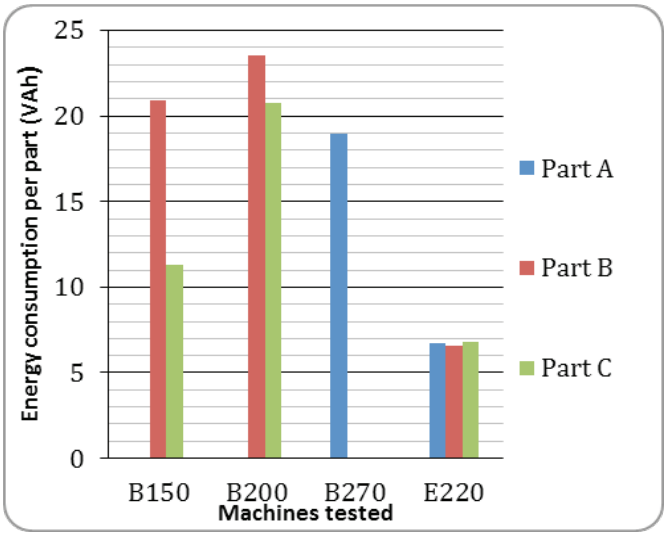


Figure 2: Comparison of energy consumption per part of the same machine when producing different parts

Re-design of a 'Toy-set' Industrial Packaging System

Student: René Camilleri / Supervisor: Prof. Ing. Jonathan C. Borg

Introduction

Profitability in a business organisation is a measure of success, derived from strong sales at competitive operational costs. Part of these costs is directed towards the non-value adding activity of transportation involved when supplying products to worldwide distribution chains [1]. This project relates to a study on reducing the distribution network costs for a promotional toy-set produced at Playmobil Malta Ltd. and providing a re-design solution to the current bagging process

Project Objectives

The main objective was to reduce the packaging volume occupied by a promotional toy-set, intended to accompany children's meals sold in popular fast food chains. Due to strict food hygiene requirements, it is not permissible that the plastic bagging material be perforated, currently resulting in excessive air entrapment during the promotional toy bagging process. Thus, the overall aim of the project was to minimize the "packaging/transportation of air" by improving the current plastic bag sealing process.

Project Methodologies

The DMAIC re-design methodology was used to define the objectives of the project with respect to the business and customer needs and the Basic Design Cycle was followed to generate a number of alternative solution concepts to address the problem. The current bagging process was analysed through detailed process modelling of how the "as-is" bagging sealing process is being achieved. It was identified that air was getting entrapped at the sealing point, and hence, the solution concepts generated targeted this specific step within the process.

The working principles were analysed, simulated and tested, where the strong and weak points of each solution were outlined, always within the constraints of the process itself. In this way, the subjectivity when evaluating the solutions was kept to a minimum and the best possible solution could be chosen. The prevailing solution involved the use of air nozzles directing a stream of readily-available air that presses on the promotional toy-set plastic package; thus potentially expelling entrapped air before complete sealing is performed.

Results and Achievements

The results obtained when the solution was implemented and tested gave an improvement of (at least) ***17 per cent in the volumetric space*** occupied by the case study product in the standard transportation carton boxes. This led to the better utilisation of transportation space inside the containers that are normally used to transport such products from Playmobil Malta Ltd. to the customer; effectively resulting in 2 container units less needed to transport a standard order of circa 1.9 million toy-sets. A total savings of circa €4000 per such order resulted, from the reduction in the required number of containers and also from the reduction in the raw material required for manufacturing the transportation carton boxes (8 per cent reduction in carton material costs).

The use and combination of systematic methods, such as the DMAIC and the Basic Design Cycle to a manufacturing process, proved to be effective in addressing particular practical problems generally encountered in such processes. Ultimately, this project demonstrates how through a well-researched and targeted minimal intervention substantial, yet sustainable improvement of an industrial process can ultimately be achieved.

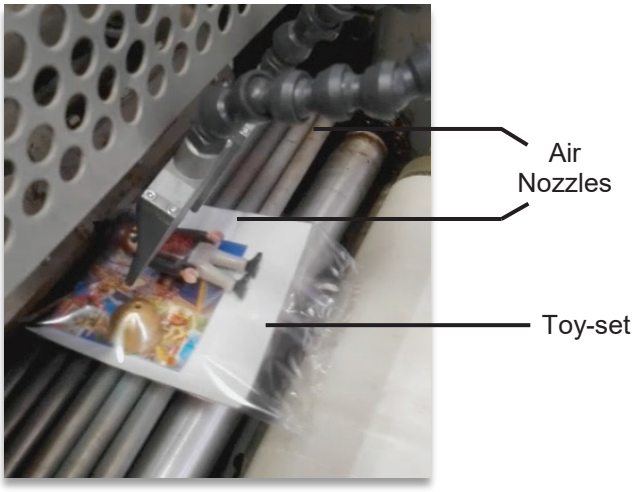


Figure 1: Re-design solution consisting of a stream of air pressing on a promotional toy-set during the final stages of the bagging process

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Sustainability Analysis of a Compressed Air System

Student: Luca Caruana / Supervisor: Dr Ing. Paul Refalo

Introduction

Compressed air is a widely used form of energy in the manufacturing industry. It is also one of the most expensive utilities due to the large consumption of energy associated with its generation, treatment, distribution and use. In fact, this accounts for about 10 per cent of the total energy produced for industry within the European Union [1]. Hence, enhancements to the sustainability of compressed air systems can have a considerable influence on the sustainable development of man.

Project Objectives

The aim of this project was to conduct a feasibility study on how to improve the sustainability of compressed air systems in industry, specifically the system at Toly Products Malta Ltd. This was achieved through the evaluation of the financial losses, environmental impacts, and societal effects in the working environment of the system and to society as a whole.

Project Methodologies

The feasibility study began with a review of the different approaches in obtaining a sustainable compressed air system in industry. This allowed the methodology for the project to be selected. This was then applied to analysing the compressed air system at Toly Products Malta Ltd. Firstly, a baseline for the specific system was established through the power logging of the air compressors. The next step involved loss quantification exercises on the major consumers of compressed air present at the facility.

A linear and rotary automated assembly line and a section of a mixed UV varnishing line were investigated. Loss quantification exercises on these major consumers of compressed air present at the facility were carried out. Once completed, an ultrasonic leak detector was used to identify and quantify leaks in order for them to be repaired. The savings produced from these leak remediation exercises were analysed. Health hazards to the employees related to compressed air were also explored.

Results and Achievements

The data obtained from the power logging of the compressors illustrated that when there was little demand for compressed air from production, the compressors still had to perform a considerable amount of work. This indicated that losses were present in the system. By taking into consideration only the equipment which was analysed, the total yearly environmental impact was projected to be 10.12 tonnes of CO2. This data was expanded onto the total number of automated assembly lines and the complete mixed UV varnishing line. The resulting yearly compressed air losses are illustrated in Figure 1. The percentage reduction in financial losses and environmental impact is also presented. The units in this figure are arbitrary units and have been normalized to All Linear Automated Assembly Lines Prior to leak remediation exercises = 100 units. The average percentage reduction in compressed air losses due to the leak remediation exercises carried out is of 27 per cent.

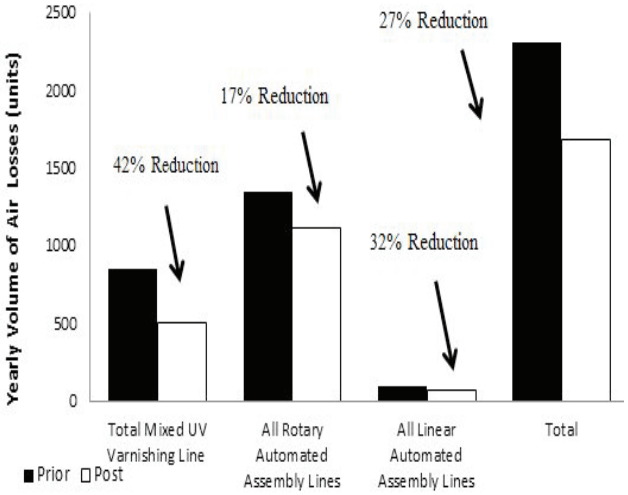

Figure 1: Yearly volume of compressed air loss and percentage reduction applied to all the major consumers of compressed air

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Design and Rapid Prototyping of a Highly Flexible Material Handling System

Student: Paul Cutajar / Supervisor: Dr Ing. Emmanuel Francalanza

Introduction

With the advancement of rapid prototyping technologies, there is a need for producing faster and cheaper prototypes within the industrial sector. In parallel, demands for flexibility of material handling systems has also increased.

Current research shows that the highest flexibility in material handling systems can be found in robotic manipulators. For this reason, a six degree of freedom (DOF) articulated robotic manipulator was chosen as the material handling system for the design. Although the system is flexible, its functions and applications were intended for industry.

Project Objectives

The aim of the design was to amalgamate the demand for fast and cheap prototypes with the need for increased flexibility. This involved conceptually designing and producing a rapid prototype of a highly flexible material handling system. Furthermore, the control of the robotic manipulator was designed to function as part of an industrial network adherent to Industry 4.0 requirements.

Project Methodologies

Using the Roozenburg and Eekels design cycle as a guide, the system's specifications were defined, and systematic methods were used to model the material handling system.

The concept generation of both hardware and software was created using structured methods. The concept generation for the hardware was referred to as the physical material flow, while the concept generation for the software was referred to as the information flow.

Physical material flow design included calculating the torque required to revolve each joint and support the manipulator as well as any load attached to it within the specified limitations.

Information flow design included robot kinematics calculations, system programming, electronic configuration and network planning.

Thus, a robotic manipulator was designed while taking into consideration the requirements of the rapid prototyping process.

Results and Achievements

A prototype of a single robotic joint was manufactured to prove that the concept design works. Once assembled, the prototype was tested to analyse the functionality of the joint, and hence the design. Possible improvements to this prototype were noted so that they could be rectified.

Another prototype was also created, this time of the full robotic manipulator. This implemented all the improvements noted from the single robotic joint. This design included six joints and two links, as shown in Figure 1. A networking system was also set up, establishing communication between a microcontroller and a personal computer.

Possible improvements to the full robotic manipulator were also noted from the prototype, and recommended as future work on the material handling system.

Figure 1: CAD Model of the Robotic Manipulator

Analysis of a Packaging Process

Student: Dylan Debono / Supervisor: Dr Ing. Pierre Vella / Co-Supervisor: Dr Ing. Paul Refalo

Introduction

The Manufacturing Industry is confronting tough challenges regarding Sustainability within its production and company management. In order to increase the market share and the competitiveness in the industry, continuous improvements must be done in the manufacturing processes. Each manufacturer would have its main focuses and goals. The packaging industry is aiming at achieving high quality packaging for products without compromising the overall costs and the manufacturing times.

Project Objectives

The main aim of this project is to improve the packaging process of toy sets by reducing the total downtime whilst reducing the total number of defects produced by the system.

Project Methodologies

This project used one of the methodologies offered by Lean Six Sigma which is DMAIC. Various tools were used during each stage in order to analyse a particular packaging process. Sustainability was also considered in order to propose any new possible ideas or solutions to the current process.

The DMAIC methodology is specifically divided into five sub-sections; Define, Measure, Analyse, Improve and Control as shown hereunder in Figure 1.

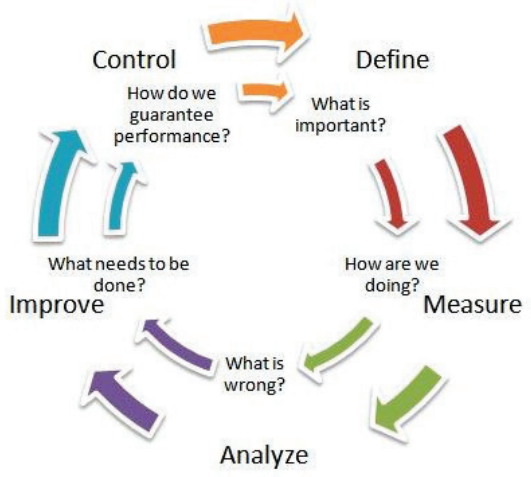

Figure 1: DMAIC Approach Cycle [1]

Results and Achievements

By using the DMAIC cycle, it was found out that the packaging process had several minor stoppages, all of which were understated. The accumulation of the minor stoppage times resulted in a negative effect on the Overall Equipment Effectiveness of the system. Minor stoppages also effecting the cost of energy consumption. The reduction of minor stoppages will reduce the energy consumption and hence improve the related environmental, financial and social pillars of Sustainability.

Moreover, the dimensions of the toy sets affect the overall product quality. The smaller the package, the more defects are generated. The bigger package has more room to cater for the possibility of placing the components wrongly without effecting the final quality and defects generation.

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Figure 2: Toy set Example Produced by this Packaging Process [2]

Design of User-customisable Cosmetic Makeup Applicators

Student: Maresca Demanuele / Supervisor: Prof. Ing. Jonathan C. Borg / Co-Supervisor: Mr Olaf Zahra

Introduction

Due to the unique nature of facial features, makeup applicators are required to be appropriate for every user. Conventional applicators do not provide for the differences between faces, rendering makeup application time-consuming and difficult. This project involves the design of a user-customisable applicator, to allow makeup application to be tailored to every required contour through simple adjustment.

Project Objectives

The aim of this project was the design of an innovative user-customisable makeup applicator, which provides a superior fit over conventional applicators and the creation of a prototype to aid analytical evaluation.

Project Methodologies

To ensure systematic development of a valuable design solution, the basic design cycle was followed. [1] Problem analysis included a detailed assessment of current issues with conventional makeup application through interviews and research. Solution concepts were developed and refined using tools such as Synectics and SCAMPER, from which the most promising, an adjustable curvature foundation applicator, was systematically selected based on criteria established in the PDS, and prioritized with the aid of a QFD. A solution was developed and a CAD model and prototype of an improved design created. Evaluations conducted included a DFMEA and user-evaluation.

Figure 1: The various curvatures on the face orange depicting concave and purple, convex. Source: L'Officiel [2013]

Results and Achievements

One of the most prominent issues observed is that of achieving even and symmetrical application of makeup to the face, due to the large number of applicators and level of skill required to achieve a smooth result. This is due to the large variations between the size and contour shape of different features.

The design solution created is the PAMelA, a professional adjustable makeup applicator. It makes use of a simple turning mechanism to adjust the sponge end-effector from flat to curved, providing easy application of foundation to problematic areas such as the sides of the nose, and also to large, flat areas like the forehead.

The adjustment mechanism is based on that used in a lipstick, using a helical thread, providing good control with low torque, and a pleasing motion. [2] The curve is created using a mechanism similar to that of an umbrella, in which spokes pull the edges of the sponge inwards, creating a flower-like shape. The outer case includes a TPU upper, allowing for improved control of the PAMelA when used in the curved state.

References

[1] N. F. M. Roozenburg and J. Eekels, Product Design: Fundamentals and Methods, Chichester, United Kingdom: Wiley, 1995.

[2] M. Anusas, Workshop: Design Emotion and Experience, Glasgow: University of Strathclyde, 2016.

Figure 2: Rendered images of the PAMelA in the curved and flat states

Design of a Reconfigurable Material Handling System

Student: Alec Fenech / Supervisor: Dr Ing. Emmanuel Francalazna

Introduction

The dynamic changes within manufacturing environments are compelling manufacturing organisations to remain competitive through their ability to react to change rapidly and cost effectively. One such approach of doing so is through reconfigurability, where the changes may occur on the system level or machine level [1].

Project Objectives

The project objectives included: understanding the typical problems when designing pallet based material handling systems and building a functional prototype of a reconfigurable pallet based material handling system (see Figure 1).

Project Methodologies

In the development of this project, a single design cycle according to the V-model was undertaken. This approach was chosen for developing both within the soft and hard domains of reconfigurability. There are limitations to using this approach, particularly, it is a generic approach and not specific for changeable systems, however each process of the design cycle has been adapted with reconfigurability in mind. This is done by practicing the Design for X principle, where X is substituted for Koren's key enablers of reconfigurability which are: modularity, integrability, customisation, convertibility, scalability and diagnosibility [2].

Results and Achievements

Mechanical interfacing (see Figure 2) between different material handling modules proved to be effective and quick, this is a significant innovation when compared to the current generation material handling systems.

Open-source architecture has been proven to drastically reduce implementation time and allow for specific system customisation.

The control architecture is on an EtherCAT network which proved to be suitable for the requirements of this project. The solution implemented proved to cost-effective without compromising in performance.

References

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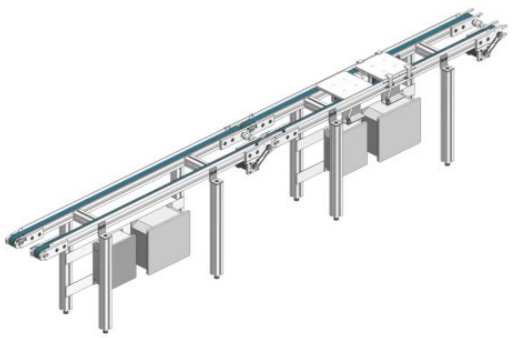

Figure 1: Illustration of the system prototype built

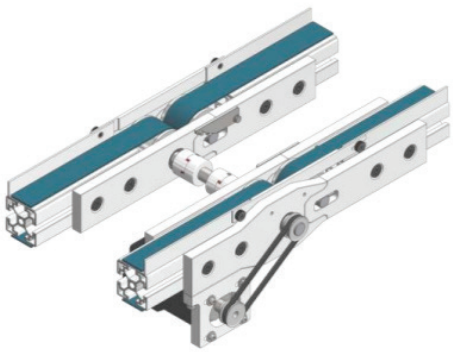

Figure 2: Designed mechanical interface

Improvement of Toy Figure Arm Feeding Systems

Student: Ryan Magro / Supervisor: Dr Ing. Philip Farrugia

Introduction

In an industry where time is money, stoppages and machine down time must be reduced to a minimum. This project was carried out with *Playmobil Malta Ltd.* where the overall production of the printing machines was to be increased. *Playmobil Malta Ltd.* produces toy figures, and during the process of production, arms might be needed to be printed on.

Project Objectives

The objective of this project was to analyse and identify the likely causes of machine stoppages and generate guidelines of such that the overall production of the printing machines was increased. The guidelines were to be evaluated.

Project Methodologies

The methodology used for this project was very similar to the DMAIC process. First, the problem was defined, and relevant literature regarding plastic injection moulding [1], amongst other tools were reviewed. Then case studies were analysed to get quantitative knowledge about the frequency and reason of stoppages. Figure 1 and Figure 2 show examples of stoppages that were noted during these case studies. Another case study regarding the mean down time of the process was analysed.
With this information, the most problematic stoppages were identified using PFMEA and the Pareto analysis. The root causes of the latter stoppages were determined, and guidelines / designs were provided to eliminate the cause of the most problematic stoppages, and reduce the mean down time value. The following is an excerpt from one of the guidelines.

G1. IF any printing machine stops due to a short shot arm
THEN avoid the formation of short shots by:

- *Modifying the injection moulding parameters, specifically:*
  - *Increasing the injection pressure*
  - *Increasing the back pressure*
  - *Increasing the nozzle pressure*
  - *Increasing the mold temperature*
  - *Increasing the injection hold time …*

Results and Achievements

The guidelines were evaluated by asking the workers working on the relevant machines what they think, based on their knowledge and experience, about the suggested guidelines. The majority of the guidelines were received positively, and agreed that will improve the production process. This means that the inefficiencies of the toy figure arm printing process at *Playmobil Malta Ltd.* can be reduced substantially. Hence leading to higher production values and can further lead to a more efficient and economical production process.

References

[1] Bryce D.M., 'Plastic Injection Molding ... material selection and product design fundamentals' Society of Manufacturing Engineers, Dearborn, Michigan, 1997

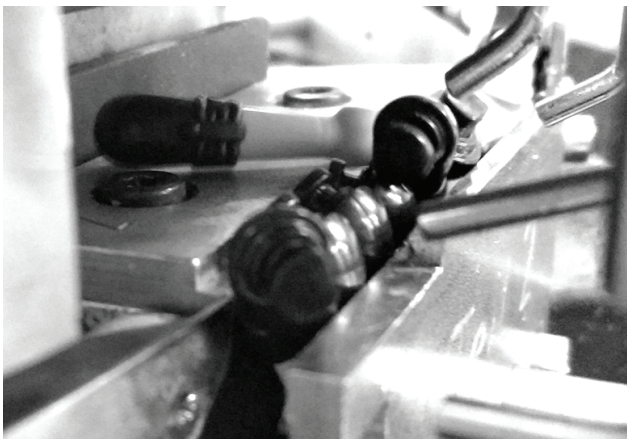

Figure 1: Example of Stoppage - Clogging (Stoppage Code: 80/86-BR-C)

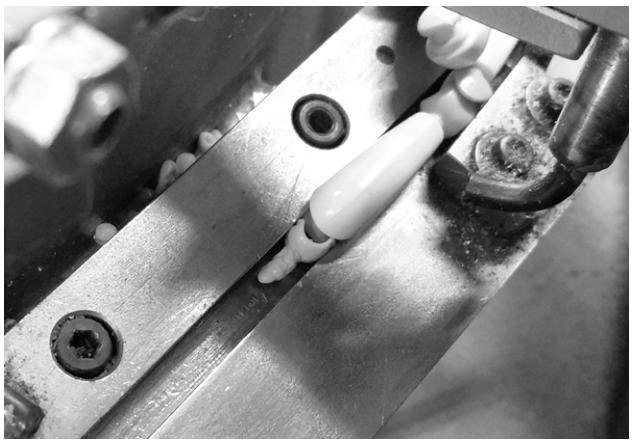

Figure 2: Example of Stoppage – Short Shot (Stoppage Code: IM-SS-A)

Design of an Innovative Implant for Rib Fracture Stabilisation

Student: Keith Mallia / Supervisor: Dr Ing. Philip Farrugia / Co-Supervisor: Mr Aaron Casha

Introduction

Rib fractures are the most common injury sustained in the chest area [1]. Their effect on the patients' lifestyle include abnormal respiration, constant pain, reliance on assisted ventilation and a disruption of the normal daily routine. Stabilising rib fractures would mitigate these effects and quicken the process of getting back to a normal, healthy lifestyle [2].

Project Objectives

The objective was to develop a practical implant to stabilise rib fractures. Surgeons and patients would benefit from a simple surgical procedure that makes the effort worthwhile by making use of an implant that has been designed to be effective and easy to install.

Project Methodologies

The methodology revolved around Roozenburg et al.'s basic design cycle [3]. An initial literature review regarding both the anatomical (Figure 1) and market perspectives was carried out. This was partnered with an analysis of the customer's requirements, with the customers being both surgeons and patients. These defined a Product Design Specification that was used throughout the product's development.

Design tools such as SCAMPER, synectics and morphological chart were used to develop concepts, until one would be chosen. The product would then be developed into a real-world implant and then evaluated thoroughly using practical methods.

Results and Achievements

The final product is a 3g, compact, Ti 6Al 4V implant. Results on the success of the implant were obtained using theoretical knowledge and practical procedures. The former refers to the mathematical modelling and finite element analysis method to analyze the implant's structural integrity throughout its life. The latter were two surgical procedures carried out by two different collaborating surgeons, on a plastic skeleton and a human cadaver respectively.

These were used to evaluate the ease with which the implant is installed, and the stability the implant produces on the fracture. From the feedback gathered, several key points were outlined. Firstly, the surgeons pointed out the ease with which it is dressed onto the ribs. Moreover, they referred to the fact that it can be sterilized without any problems due to the simplicity of the implant and the chosen material. Another important feature was the ability of the implant to stabilise the fracture site. Finally, the surgeons appreciated the way the implant was capable of contouring along the face of the ribs perfectly.

Figure 1: The Ribcage

References

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Analysis of Process Parameters Affecting Energy Consumption in Plastic Injection Moulding

Student: Isaac Meekers / Supervisor: Dr Ing. Paul Refalo / Co-Supervisor: Dr Arif Rochman

Introduction

Injection moulding is one of the most widely used processes for the production of plastic products and is a large consumer of energy. Energy efficiency has become a serious concern for manufacturing industries due to the rising energy costs and the associated impacts on the environment. The industrial sector is responsible for approximately 25% of the total energy consumption in Europe, and 28% of the total energy consumption on a world scale [1].

Project Objectives

The project entailed a sustainability analysis through the manipulation of parameter settings. The aim was to optimize the injection moulding process in order to reduce energy consumption whilst also ensuring satisfactory part quality.

Project Methodologies

Firstly, a bottle opener to be used as study part was designed and the mould was machined. The most important injection moulding process parameters for energy consumption and quality impact analysis were determined. The selected parameters were the nozzle temperature, screw rotational speed, mould temperature and cooling time. Following this, Design of Experiments was used to create the experimental procedure and the experiments were carried out. Data was recorded during experimentation by 3 power loggers connected to the chiller unit, injection moulding machine and temperature control unit respectively. Quality tests of mass, length and surface roughness were performed. The data recorded for both quality and energy tests were analysed through ANOVA analysis. The critical parameters were identified and the best combination of settings was determined.

Figure 1: Case Study Part for Energy Consumption Analysis

Results and Achievements

The results from this project conclude that optimization of the injection moulding process through the designed experiments is possible. The experiments showed that the single parameter having the greatest impact on energy consumption is the cooling time. The optimization of this parameter gives manufacturers the opportunity to not only decrease energy costs but also to increase production rates. The nozzle temperature also had a notable impact on the energy consumption, while the mould temperature and screw rotational speed had no significant impact. Concerning the quality of the injected part, the tests showed that the different selected process parameters had negligible effects.

The difference in energy consumption between setting all parameters at their minimum and maximum was approximately 23%, hence indicating an opportunity to save substantial amounts of energy by parameter optimization.

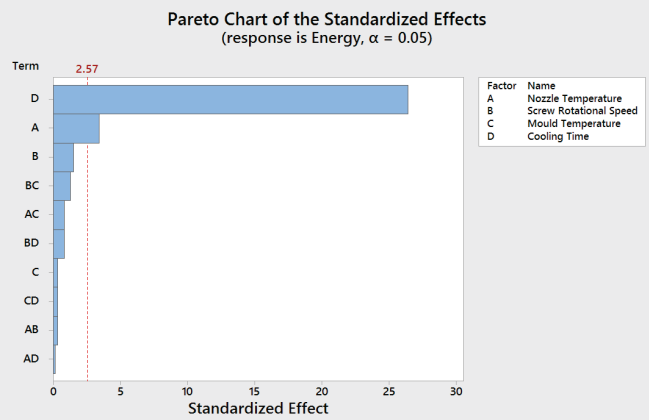

Figure 2: Pareto Chart Showing Critical Parameters

References

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Improvement of a Pick and Place Automation Manufacturing System

Student: Shaun Saliba / Supervisor: Dr Ing. Emmanuel Francalanza

Introduction

Automation in industry is the direct result of an ever-increasing market demand. This thesis aims to improve a pick-and-place manufacturing automation system, used in the toy manufacturing industry at Playmobil Ltd [1]. Such a system is faster and more reliable than a human since it does not suffer from any fatigue if it properly maintained.

Project Objectives

Understanding the existing process, analysing possible sources of variation and replicating the system accurately for further experimentation. Improvement of picking locations to decrease overall cycle time and increase machine profitability.

Project Methodologies

Research about the DMAIC methodology (Define, Measure, Analyse, Improve, Control) [2] and industrial automation components was carried out. The DMAIC methodology is used to limit process variation to within six standard deviations of the mean value.

In the define phase, information with regards to real-time process control and different components of the existing machine was gathered. The IDEF0 [3] modelling language was used as a tool.
In the measure phase, data describing process cycle time, overall equipment effectiveness, parts' height variation and parts' weight variation was gathered.
In the analyse phase, sources of possible variation were systematically listed using a cause-and-effect diagram. Data gathered during the measure phase was further analysed with statistical process control.
In the improve phase, the existing system was successfully replicated at the University of Malta, with the required accuracy and repeatability. Rotation was achieved as shown in figure 1. Experiments were conducted and values for improved picking locations obtained.
In the control phase, the results obtained throughout the dissertation were presented and discussed.

Results and Achievements

Having accurately replicated the existing system with a limited budget was already an important improvement and achievement in itself. Some of the components purchased for the aims of this system replication can be useful for future thesis.

Seven picking values were identified as providing an incredible rate of successful picking. Suction cups providing different material properties, such as marginally better durability, were also found to be useful when used in combination with particular picking values. Some minor improvements aiming to improve worker-machine interaction at Playmobil were also suggested.

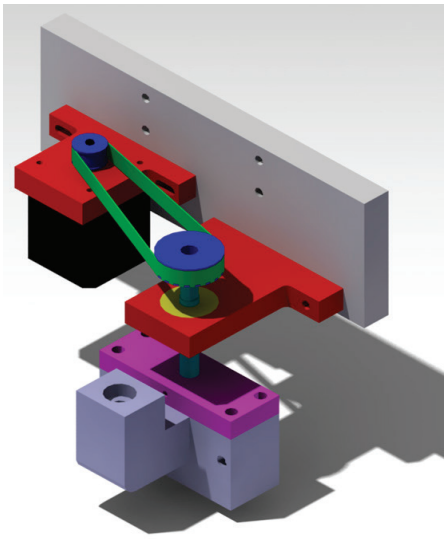

Figure 1: Orienting Mechanism of Replication System

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Exploring the Process Capabilities of the Sodick AP3L

Student: Andrew Saré / Supervisor: Dr Ing. Pierre Vella

Introduction

As a non-traditional material removal process, Electrical Discharge Machining (EDM) has long been employed in the manufacturing of dies and molds, amongst others, due to its unique properties of non-contact machining by thermal-mechanical effect regardless of the hardness of the material [1]. Mold cavities are machined as direct copies of their respective tool electrode and as the required mold shapes get more and more complex, tool manufacturing becomes more time-consuming. Additionally, when the shape changes or the tool is worn beyond a certain limit, these must be remade. EDM milling deals with this problem, with the use of simple shaped electrodes that follow a numerically controlled path to achieve the required cavity shape [2].

Project Objectives

The main objective of this project is to investigate the influence of different rotational speeds on the output parameters measured in EDM-milling a cavity in the macro-scale, with the use of 3 mm and 6 mm cylindrical electrodes, along a pre-defined tool path using the Sodick AP3L EDM.

Project Methodologies

The project was split into two main experiments. In the first experiment, the behavior of different rotational speeds, in milling a cavity with a single electrode, on the machining performance was investigated. Rotational speed was varied between 0 RPM and 2000 RPM. This machining performance was based on Material Removal Rate (MRR), Tool Wear Rate (TWR), Surface Roughness and Cavity Dimensional accuracy; being the output parameters.

In the second experiment, the machining performance, particularly with regards to the achieved cavity dimensional accuracy was investigated with the use of a multiple electrode strategy. This is done by first using a roughing electrode to obtain the rough shape of the cavity/feature required, followed by a finishing electrode to complete the machining process. Two-electrode and three-electrode strategies were investigated.

Results and Achievements

From the first experiment, it was concluded that material removal was increased with increase of rotational speed above 750 RPM. This is confirmed by literature, where the increase in rotational speed enhances flushing conditions within the sparking gap and hence provides better material removal [3].

In the use of a multiple electrode strategy, improvements were noticed in the dimensional accuracy of the acquired cavity. The corner diameter at the bottom of the cavity was reduced by 70 per cent with the use of a three-electrode strategy over a single-electrode strategy, as shown in Figure 1.

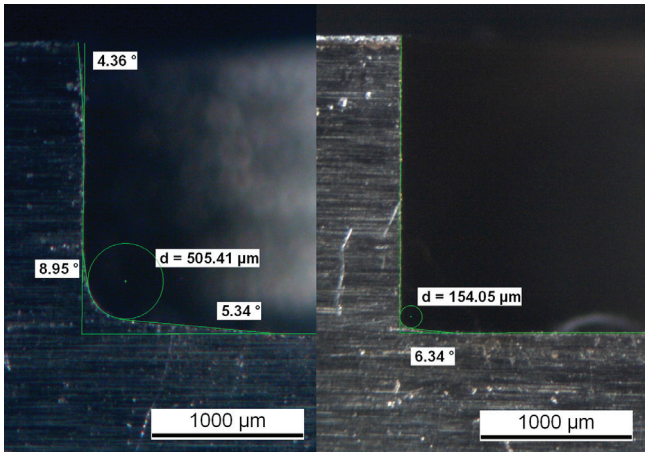

Figure 1: Difference in final corner diameter with a single electrode procedure against a three-electrode procedure

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[2] Han F., Wang Y. and Zhou M., 'High-Speed EDM milling with moving electric arcs' International Journal of Machine Tools & Manufacture, 2009, Vol. 49, pp. 20-24

[3] Dwivedi A. P. and Choudhury S. K., 'Comparative Assessment of MRR, TWR and Surface Integrity in Rotary and Stationary Tool EDM for Machining AISI D3 Tool Steel' Proceedings of the World Congress on Engineering, 2015, Vol. II

Design of a Cost Effective Hermetic Seal System

Student: James Spiteri / Supervisor: Prof. Jonathan C. Borg / Co-Supervisor: Mr Olaf Zahra

Introduction

The cosmetic makeup industry is constantly looking for novel products that exploit engineering principles in an aesthetically appealing and cost effective way. The need for airtightness in packages has grown due to new legislation and formulas in cosmetic makeup. The reduction in preservatives and use of silicones requires the package to protect the cosmetic formula from external environmental conditions, however, the package tends to be expensive to produce and bulky to handle.

Project Objectives

The objectives of this project is to design a hermetic compact that manages to seal better and come up with different seal types while making the package simpler without degrading performance.

Project Methodologies

In order to reach the objectives of this project, given it is a design problem, the 'Basic Design Cycle' [1] was followed. The design cycle involves a series of sequential steps to select the most promising design solution from a number of potential solutions.

Current hermetic compacts were first identified and analysed to highlight the problems and cost drivers that arise. A survey on cosmetic compacts was then conducted to gather customer feedback and criteria, from which the Product Design Specification (PDS) was developed to generate proposed solutions.

Prototypes were then designed and built to test the working principle and hermeticity of the compacts. A weight loss measurement test was later performed to evaluate the airtightness of a compact by measuring the weight lost from an aqueous composition after a period of heating. The prototypes were placed under a temperature of 50℃ for 21 days to test the sealing system and record the weight lost from the compact.

From the results obtained during the weight loss test, the prototypes that provided the best hermetic results were established as the solution for a cost effective hermetic seal system.

Results and Achievements

A cost effective hermetic seal system was achieved by eliminating conventional sealing systems such as O-rings and instead replacing them by a component-to-component sealing system. The close tolerances of the sealing grooves and sealing ribs of the sealing system provide the hermeticity towards the compact. The Computer Aided Design (CAD) models of the proposed design solutions are shown in Figure 1.

Elimination and simplification of the product system managed to reduce capital expenditure, allowing the hermetic compact to be easily mass produced.

The component-to-component sealing system does not manage to achieve the hermeticity attained from conventional sealing system hermetic compacts but strives in creating a cost effective hermetic compact.

Figure 1: Front Push Button and Side Push Button Compacts

References

[1] N. F. M. Roozenburg, J. Eekels, 'Product Design: Fundamentals and Methods', John Wilek & Sons, 1991.

Design of Airless Shut-Off Nozzles used in Cosmetic Packaging Products

Student: Matthew Vassallo / Supervisor: Dr Ing. Philip Farrugia

Introduction

This project was a collaboration between the University of Malta and Toly Products (Malta) Ltd. The company was interested in developing an airless nozzle which can be offered as an option to their customers. The motivation for designing such a nozzle derived from the cosmetic formulation typically used in creams and make-up products. These formulations involve volatile solvents which evaporate if the container is not airtight. This causes the formulation to solidify and harden potentially blocking the nozzle`s exit.

Project Objectives

The Aim of this project was to create a cost effective airless shut-off nozzle to be used in low pressure cosmetic applications. The designed nozzle also needed to incorporate the minimum amount of components and be compatible with Toly`s existing standard airtight containers.

Project Methodologies

For the purposes of this project, the design of an airless shut-off nozzle is viewed as a design problem. In order to solve any design problem the basic design cycle is used iteratively until a satisfactory result is achieved. Using this methodology ensured that the design problem is tackled in a logical, systematic manner

The first step was to conduct a literature review. This is where existing state-of-the-art airless nozzle designs were critically reviewed. By conducting a patent search the different strategies to achieve the required functions of a cosmetic airless nozzle were explored.

Insight gathered from the patent search aided the formation of the QFD. This led to the customer and functional requirements of the proposed airless nozzle to be defined. Finally, these requirements were expressed holistically in the product design specifications.

The requirements listed in the PDS served as guidelines in the conceptualisation of new designs. A brain-storming session was used to generate ideas and this resulted in several nozzle working principles. After a selection process involving a decision matrix, the provisional design was chosen.

The solution simulation was carried out as an iterative process. The provisional design was developed using CAD modelling and rapid prototyping resulting in the first iteration of the conceptual design. After two more iterations, the embodiment design was formed and after further refinement, the detailed nozzle design was achieved and evaluated. After a satisfactory design was achieved, a material selection exercise was performed to select the best material for each moulded component. Moldflow analysis was then used to ensure there were no issues with injection moulding the final design. Finally, detailed CAD drawings of the final design were created.

The finalised design was evaluated for its ability to satisfy two of its core design requirements. Its ability to create an airtight seal was tested using Toly`s standard TM-71 Vacuum Test seen in Figure 1. Then, a costing exercise was conducted to estimate the final design`s estimated cost. This value was then used to assess the design`s cost-effectiveness.

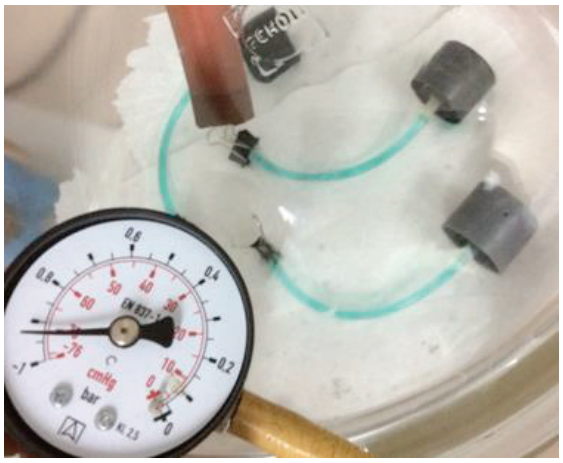

Figure 1: Toly`s standard TM-71 Vacuum Test

Results and Achievements

To conclude, the primary objective, that of designing an airless shut-off nozzle to be used in cosmetic applications, was accomplished through the successful implementation of the basic design cycle, which resulted in a functional, cost-effective solution. As seen in Figure 1, the designed nozzle was proven to be able to withstand a vacuum pressure of - 0.92bar which exceeded the required amount of - 0.7bar.

Micro Electron Discharge Machining of Micro Cavities for Injection Moulding

Student: Thomas Zammit Tabona / Supervisor: Dr Arif Rochman / Co-Supervisor: Dr Ing. Pierre Vella

Introduction

There is a continuous need for micro components, especially due to the improvement of technology in recent years. Micro electron discharge machining is used to create these micro parts, by creating the cavities used for micro injection moulding. Micro-EDM is a non-conventional machining process that has the advantage of machining hard workpieces, with the possibility to create complex shapes. However due to the small size of the cavities, the dimensional accuracy is dependent on the surface roughness. These factors influence the quality of micro parts. Traditional machining methods have been taken to their extreme; and new designs and processes have been introduced when moving to this micro scale.

Project Objectives

This project intends to identify, investigate and optimise the leading instructions and technique of the Sodick AP3L EDM machine. In order to achieve the best dimensional accuracy of micro cavities used for micro injection moulding. The dimensions of the cavity must also be retained while increasing the surface roughness. Other goals involve understanding the limitations of the machine.

Project Methodologies

The intention was to design a scenario, where it would be possible to observe the dimensional accuracy of the micro cavity produced, while also being able to measure the surface roughness inside the cavity. The tool steel, workpiece was machined into two separate pieces, which can be seen in Figure 1. Clamping of the two separate pieces would reenact their state prior to separation. By doing this, it would be possible to perform micro EDM machining and subsequent characterization at the interface.

An experimental regime was adopted to investigate the process and ultimately achieve more defined shapes, with regards to the micro cavities. These experiments extended to analyse the surface roughness and tool wear during this dissertation.

Results and Achievements

The results show that by incorporating multiple electrodes, orbiting and other instructions, one is able to achieve exceptional dimensional accuracy and desired surface roughness simultaneously. The results are supported by images, as shown in Figure 2, and other measurements taken throughout the experiments.

The following instructions are what should be entered into the machine in order to achieve the best dimensions. To obtain a Ra value of 0.2 µm, 3 electrodes must be used with a Core-Pin shape instruction, at a Performance value of 1 and a Loran function of Edge with a Square pattern.

The conclusion describes the strengths and limitations of the project while also explaining the benefit of the research done. It also aids anyone who wishes to commence further work using the Sodick AP3L EDM machine.

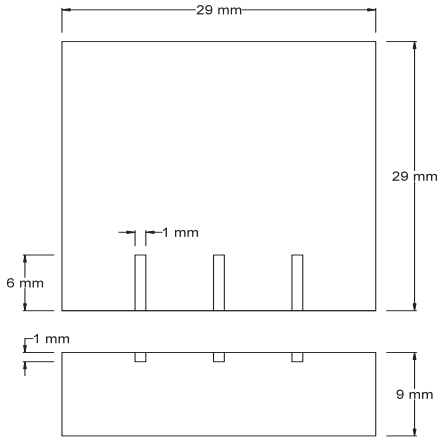

Figure 1: Top view of the workpiece design with 3 cavities to be machined using micro-EDM

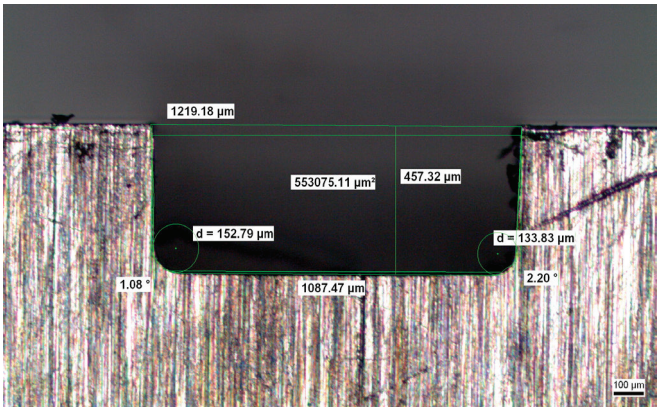

Figure 2: Dimensional accuracy measurement of micro cavity cross section

The Effect of the Intervertebral Disc on the Lumbar Spine Behaviour

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

Introduction

The intervertebral disc (IVD) is a complex structure within the human body. The soft tissues making up the disc provide the ability to withstand deformations and large loads. The effects of the nucleus pulposus and the annulus fibrosus, which form the structure of the IVD, must be understood in order to understand the mechanical behaviour of the lumbar spinal

Project Objectives

The aims of this study are to:

- Develop an FEA model of an intervertebral disc and analyze the model as part of the lumbar spinal segment.
- Obtain realistic stress-strain distributions through modelling the disc as a two phase material structure.
- Explore the structural response of the IVD in different positions and varying conditions.
- Examine the effects of flexion and imposed loads on the lumbar segment.
- Provide a better understanding of the behaviour of the IVD as part of the human lumbar spine, which may somehow improve the life and health of individual patients.

Project Methodologies

The study was accomplished through the use of finite element analysis software (ANSYS). The software provided a solid ground for geometric and material modelling of the IVD, along with computation of stresses and strains within the disc.

The disc was modelled as a two phase material system through consideration of the distinctive properties between the nucleus pulposus (core) and the annulus fibrosus (structure surrounding the nucleus) forming the disc. Three different models were simulated with respect to the lumbar spinal segment. The spine was studied under 0, 40 and 65 degrees flexion.

Furthermore, the effects of imposed loads was also studied. This refers to the case when an individual holds a 180N load in hands. The behaviour was studied through applying external forces on segment at 65 degrees flexion. A comparative analysis with a straight and unloaded segment was carried out.

Results and Achievements

Stress-strain distributions were obtained for the different models. The corresponding displacement results of the segment were also computed (Figure 1). The modelling of the disc as a two phase material system provided a better representation of stresses within the disc.

The results explored the roles of the annulus and nucleus and the relevant material properties, along with their role within the intervertebral disc. The study shows how the annulus fibrosus is the principal load-bearing module of the disc, without allowing the disc to rupture. The results confirmed the function of the nucleus in redirecting the applied pressure equally in all directions.

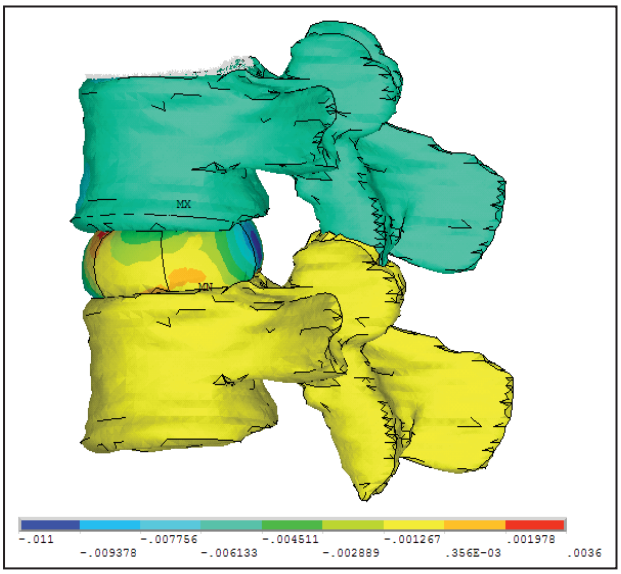

Figure 1: Z-displacement of the lumbar spinal segment at 0 degrees flexion

Design, Build and Test of a Torsion Experiment

Student: Paul Apap Bologna / Supervisor: Dr Ing. Pierluigi Mollicone

Introduction

In order for a design to simulate any mode of stress that could be able to be demonstrated in real life a series of steps must be followed. This would be done in order to be able to demonstrate and analyse the mode of failure that are a common finding in the failure of structures. In fact, the mode of failure that was followed up in this dissertation was Torsion.

Project Objectives

The main scope of this dissertation was to design and build a mechanics experiment by using the necessary design and manufacturing tools in order to provide a lab test bench for testing to improve the learning experience for students.

Project Methodologies

A market research on numerous types of mechanics experiments that were available globally was carried out. After this, an analysis was conducted to evaluate what type of mechanics experiment shall be designed. From this, it concluded that a Torsional experiment shall be designed. In order to design a Torsional experiment, a design cycle was following by using the literature gathered. Then, design tools such as material selection, calculations and using design software such as Autodesk Inventor Professional 2017 as well as using numerous machining processes such as Computer Numerical Control to assemble the apparatus in an efficient way. [1]

Results and Achievements

From this dissertation tests were carried out on mild steel bars of different cross-sectional shapes. The torsion was set not to exceed the elastic limit of the material. With such a test bench, numerous torsion tests can be conducted on a variety of cross sectional shaped shafts or bars - namely square, circular and tubular as can be seen in Figure 2.

From this test, as seen in Figure 1, experimental data was gathered to confirm that the relationship between torque and angle of twist is linear as well as it is easier to twist a tubular bar than both circular and square - in that order - by keeping the length, outer dimensions and increments of weights constant. These results were then correlated to theoretical data as well as Finite Element Analysis on ANSYS® [2].

Having a test bench that could produce the ideal results is both beneficial for the students to understand such a fundamental concept such as Torsion occurring right in from of them.

References

[1] ''Autodesk Inventor Professional 2017,'' Student Edition 2nd ed: Autodesk, 2017.

[2] ANSYS Academic Research,'' ed, Release 17.1

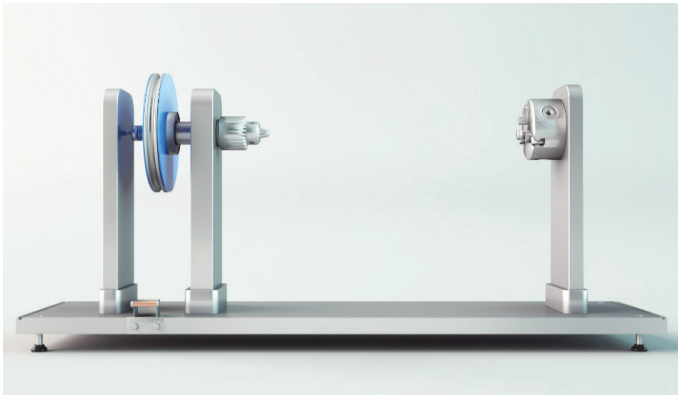

Figure 1: Assembly of Torsion apparatus

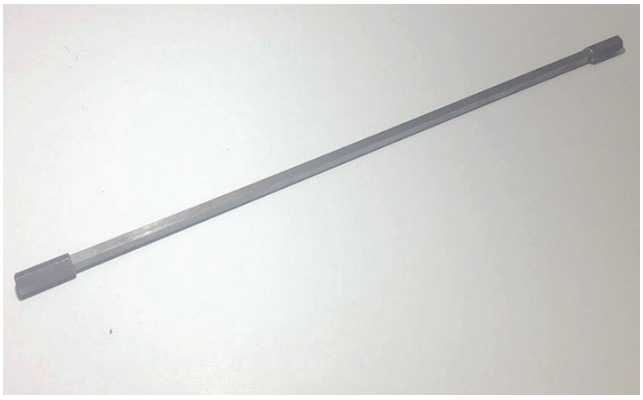

Figure 2: Cross-section bar for experiment

Application of a SCARA Robot to the Service Sector

Student: Yesenia Aquilina / Supervisor: Prof. Michael A. Saliba

Introduction

A robot is a man-made device, consisting of mechanical, electronic and electrical systems which are designed to automatically perform one or more tasks, with precision and speed. Robots are used extensively in industry to automate their processes. However, the use of robot is no longer limited to the manufacturing industry, but they are also being used in the service sector to perform useful tasks for humans or other equipment. [1]

Project Objectives

The scope of this dissertation was to identify and explore a potential application in the service sector, for the four degrees of freedom, Epson SCARA robot, available in the lab. The identified application was designed, developed and implemented. The solution also required the design and development of a custom-built end effector for the robot, as well as the use of external sensors and actuators to form part of the robotic system.

Project Methodologies

From the Literature review carried out, it was observed that the SCARA robot has been utilized in various service industries such as laboratories, rehabilitation, education and entertainment. However, it had never been used in a supermarket. Therefore with the help of surveys that were conducted, the chosen application was to automate the checkout process of a supermarket, in order to make the process more efficient and reduce the waiting time. From the surveys which were addressed to both supermarket owners and their customers, the most important requirements for such a system were speed, easy to use, safety, low maintenance and running cost.

The Design Cycle: Conceptual Design, Embodiment Design and Detailed Design, was utilized to develop the most efficient and effective robotic system that satisfies the requirements for the system. A versatile end effector that was able to handle various products of different shape, size weight and even packaging was also developed. Hence, design tools such as Function Means Tress was used to brainstorm different ideas and generate different solution for both the robotic system and the end effector. A schematic layout of the chosen robotic system is shown in Figure 1.

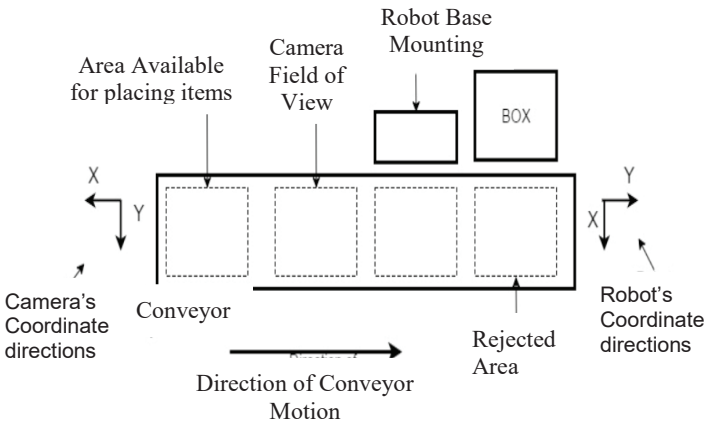

Figure 1: Schematic Layout of the Concept

Results and Achievements

The Epson SCARA robot was successfully used to demonstrate automation of the checkout process of a supermarket, Figure 2. It was able to identify a number of various products usually found in a supermarket and place them in a box, in a systematic way, which the customer could then take home. The system took on average 19.99s to pack a single product in the box, from the moment the button was pressed. However, this time does not take into consideration the fact that when multiple products are placed on the conveyor, the machine vision and the robot would be working simultaneously. In addition, the conveyor would not need to be indexed as often. Hence, the overall time to check out the items would be reduced.

References

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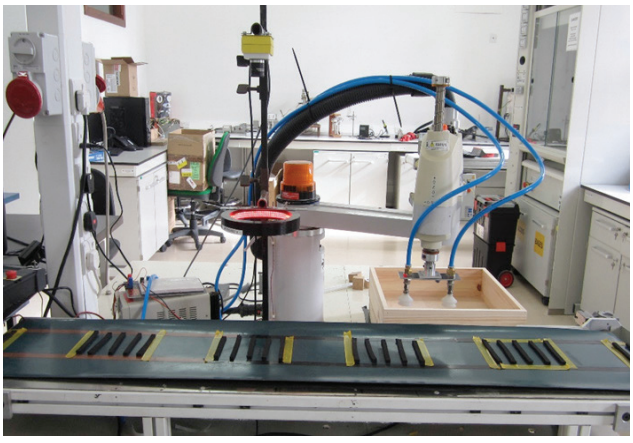

Figure 2: The designed automated checkout system

Improvements of the Turbocharger Hot Gas Test Stand

Student: Benjamin Attard / Supervisor: Dr Ing. Mario Farrugia

Introduction

The operating characteristics of the turbine and compressor making the turbocharger (see **Figure 1**), are illustrated on a performance map, For the past two years a turbocharger hot gas test stand was developed, which allows the measurement of a turbocharger's performance independent of any disturbances related to a vehicle engine.

Project Objectives

The focus of this project was to continue developing the setup and the automation process of the turbocharger hot gas test stand, in order to improve both its data logging capabilities and to facilitate system control.

Project Methodologies

A new exhaust system was designed and built to improve exhaust gas temperature measurement at the turbocharger's turbine outlet. Moreover, a small buffer tank was installed to improve the response from the buffer tank when throttling gas from the propane tank. Whilst the temperature inside the lubricating oil tank was monitored and controlled with the introduction of a solenoid valve, an oil to water heat exchanger and a 'Hysteresis' controller developed in LabVIEW.

The test stand temperature measurement capability was enhanced with the integration of a Keithley Model 2701 ethernet based, data acquisition / multimeter system which offered superior measurement integrity and remote measurement capabilities. Moreover, real time temperature data logging and control were achieved through the developed LabVIEW Virtual Instrument (VI).

A cascade control system was developed and tested through LabVIEW, to keep a tight control of the temperature at the turbocharger's turbine inlet. Moreover, a sequential tuning procedure was opted to determine the PID control parameters for both PID controllers, forming the cascade control system. Initially, the secondary controller was tuned using the Ziegler and Nichols tuning procedure [1], whilst the PID gains of the primary controller were obtained through a series of tests.

Results and Achievements

The turbine inlet temperature control system was improved with the implementation of a cascade control system. When compared to a single loop PID controller, the cascade structure made a much faster correction, which provided a much better control response. As illustrated in **Figure 2,** disturbances in the buffer tank pressure (secondary controller) were quickly corrected without affecting the turbine inlet temperature, also resulting in a better control of this multivariable system. Finally, the introduction of a more robust DAQ system such as the Keithley, the problem of noise in temperature measurement was heavily reduced.

References

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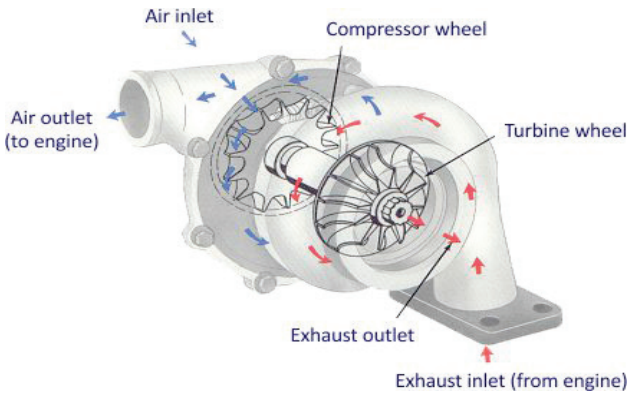

Figure 1: Turbocharger Assembly and Flow of Gases

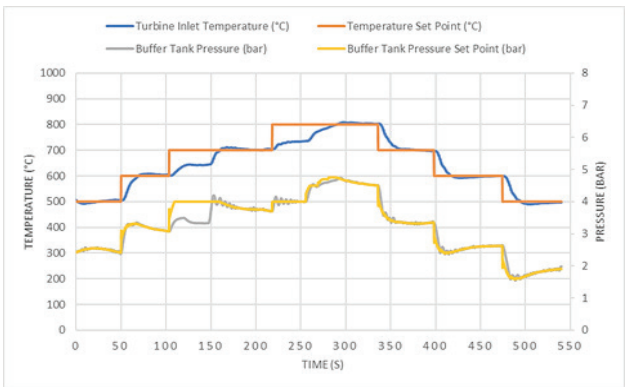

Figure 2: Cascade Control Response

Design, Build and Test of a Mechanics of Materials Experiment

Student: Samuel Bartolo / Supervisor: Dr Ing. Pierluigi Mollicone

Introduction

A buckling apparatus set up was required in the lab to better portray the phenomena to students due to its paramount importance in design. In the age where computational analysis is undergoing greater importance, the project provides a basis for comparison of theoretical, practical and computational simulations, for better engaging of the students' mindset preparation for design.

Project Objectives

The project aims to build a functional model for analysis of buckling. Applying tools of design along with utilisation of various instruments for acquiring data. The practical results were compared to the Euler theoretical and recommended solutions as well as Finite Element Analysis computational models.

Project Methodologies

A thorough market research was carried out in order to understand what is available in the market and used in other universities. Concepts for the buckling apparatus were initiated and looked into for implementation of the final design. An additional literature review was undergone to understand how buckling is tested and calculated in various end conditions and modelling techniques. The apparatus was built as required; to acquire the deflection via a digital dial gauge, and force by means of a planar beam compression load cell. Additional FEA models were generated, having different methodologies to obtain buckling in the studied column, for better comparison of all methodologies carried out.

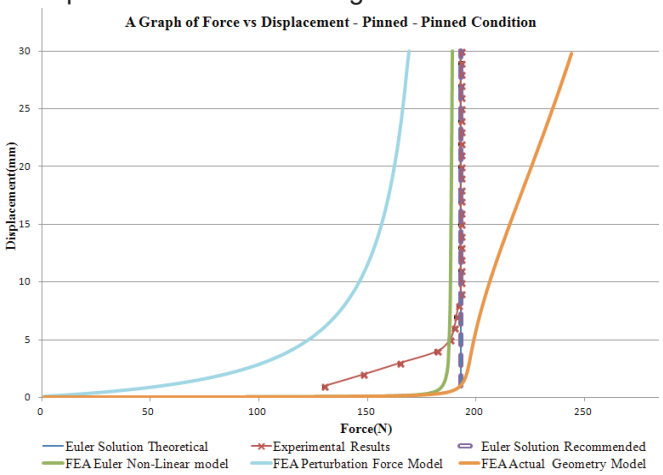

Figure 1: Results of Aluminium 6060 column for Pinned- Pinned ends

Results and Achievements

The results obtained are observed in Figure 1, showing the span of outcomes for different analysing techniques. The Euler theoretical solutions presented a far more conservative value than the practical results obtained in experimentation of the built apparatus. The Euler recommended solutions for design offered a more realistic approach. On the other hand the three different FEA models presented showed their degree of accuracy. Where, either, a horizontal force was present to initiate buckling (perturbation force), else, a pre-stress was applied to the column, (Euler analysis) or where the column's actual geometry was input for computational analysis, (actual geometry). The achievements of the project, in addition to the built apparatus, seen in Figure 2, were the visual representation of the present analysis techniques and the practical values of forces causing buckling [1], [2].

References

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[2] [Chajes A.], '[Principles of Structural Stability Theory]' [Prentice-Hall, Inc.], {Eaglewood Cliffs, N.J.}, 1974.

Figure 2: The Buckling Apparatus Set-up

Ship Hull Structures

Student: Bernard Bonello / Supervisor: Prof. Ing. Claire De Marco

Introduction

Bulk carriers play the key role of the most convenient mode of transport of cargo in bulk across sea borders. Due to the increasing importance, organisations such as the *International Association of Classification Societies* (IACS) have set regulations to monitor the safety standards of such vessels in different loading scenarios.

Project Objectives

The objective of this dissertation involved obtaining knowledge of rules and regulations regarding bulk carriers, designing a full 3D model, designing a 3D model of the central cargo hold and carrying out an investigation regarding stability, longitudinal strength and stresses experienced at localised members.

Project Methodologies

The objectives set were reached by first designing a full 3D model, using *Maxsurf Modeler* [1], of on an in-use vessel which was kindly provided by Ing. Darren Zahra. The resulting model, seen in Figure 1, was tested regarding stability and longitudinal strength in different loading and sea conditions.

Next, a more detailed model of the central cargo hold was designed to assess the stresses present on each component making part of the amidships cross-section while showing the deflections of the components and plates. The mentioned procedure was achieved by loading the central cargo hold with hydrostatic loads on outer plates, cargo loads on the inner bottom plates and bending moments and shear loads at the bulkheads.

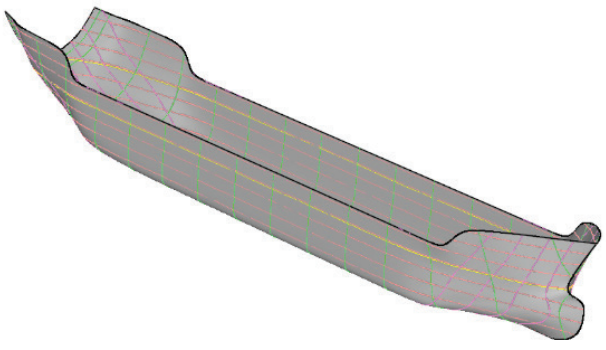

Figure 1: MV Bulk Carrier – Full Vessel Model [1]

Results and Achievements

From the stability analyses, the results have shown that MV Bulk Carrier satisfies all nine compulsory criteria set by *Resolution MSC 267.(85) [2]* for all loading conditions.

Regarding longitudinal strength, the minimum still water bending moment which the vessel must withstand was surpassed in some cases leading to further analyses at the region of biggest concern, amidships.

After conducting an analysis on the central cargo hold, an acceptable maximum deflection of 18.513 *mm,* shown in Figure 2, was noticed on the inner side plating, resulting from the unrestricted hydrostatic forces pushing the side plating inwards.

References

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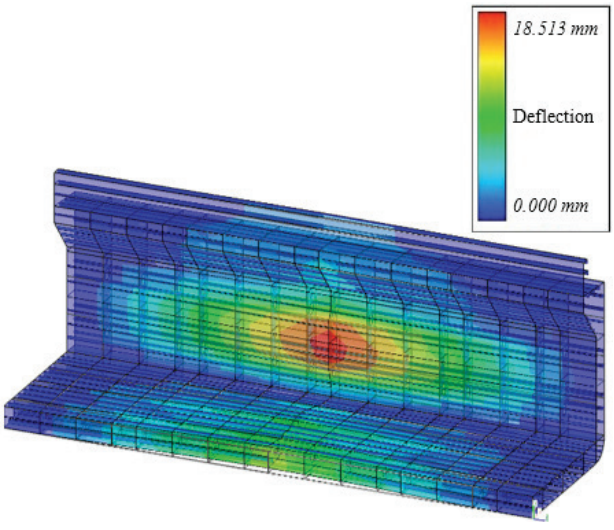

Figure 2: Central Cargo Hold Deflection Plot [3]

Analysis and Design for the ASTREA Project

Student: Mario Bonnici / Supervisor: Dr Ing. Pierluigi Mollicone / Co-Supervisor: Dr Ing. Maurizio Fenech / Advisor: Dr Ing. Marc Anthony Azzopardi

Introduction

The performance and reliability of the pico-satellite UoMBSat-1 depend on extensive modelling and testing of its on-orbit behaviour prior to launching. As the satellite moves alternately from sunlight to eclipse, it experiences temperature swings which must be studied well to assess suitability of components. Since miniature satellites rely on passive thermal systems, thermal control is more difficult to achieve.

Project Objectives

- To develop a computational thermal model to predict the on-orbit thermal response of UoMBSat-1 and to validate the model using a finite element model;
- To study the effects of external surface finishes on the temperature response;
- To evaluate the thermal response of UoMBSat-1 over a spectrum of possible orbits by conducting parametric analyses.

Project Methodologies

A literature review was conducted on spacecraft thermal analysis and orbital mechanics. The principal forms of environmental heating are direct solar irradiation, albedo and Earth-emitted infrared (IR). The heat loads on the external surfaces of the pico-satellite were calculated. The general inputs were orbital, orientation and environmental parameters. Thermal environment design points were selected based on NASA/MSFC STEM data obtained from ERBE observations. The pico-satellite's components were reduced to a set of nodes connected by a thermal network and a finite difference scheme was used to predict the thermal response.

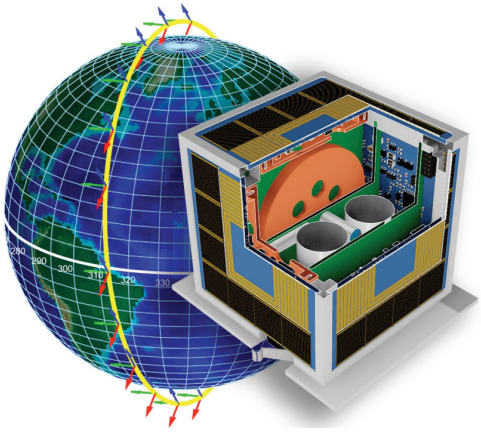

Figure 1: 3D CAD model of UoMBSat-1 (adapted from [1])

Results and Achievements

A number of case studies, with varying orbital, attitude, thermal environment and surface finish parameters were planned and the computational model was validated by comparing computational results (Figure 2) with numerical solutions. The two models agreed to within 2°C. Maximum and minimum temperatures occurred during late sunlight and eclipse periods respectively. Analyses showed that while the maximum temperature can be controlled easily using thermal-control finishes, it is much more difficult to passively control the minimum temperature since spacecraft-emitted radiation and Earth-emitted IR have approximately the same wavelength [2].

Parametric analyses were conducted to study the effects of beta angle (minimum angle between orbit plane and solar vector) on UoMBSat-1's thermal response. Maximum temperatures occurred at a beta angle of about 30° since direct solar irradiation was distributed better on the external surfaces. The minimum temperature was strongly influenced by the time the satellite spent in eclipse. Therefore, minimum temperatures occurred at a beta angle of 0° where eclipse times were longest. Increasing altitudes tended to increase the minimum temperature since the pico-satellite spent less time in Earth's shadow.

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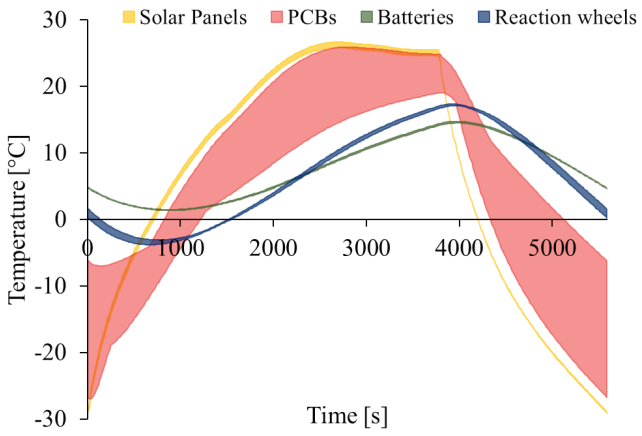

Figure 2: Temperature range plot for one orbit

Development of Diesel Particulate Filter Cleaning Furnace and LPG Injection Tests

Student: Delwyn Camilleri / Supervisor: Dr Ing. Mario Farrugia

Introduction

Soot accumulation will result in DPF blockage hence regeneration is required, either auto-regeneration when the car is driven at elevated speeds for longer than 20 minutes resulting in combustion of the accumulated soot, active regeneration by diesel injection in the exhaust stream to increase the temperature, or by heat procedures in a furnace.

Project Objectives

- Perform a Literature Review to obtain knowledge on combustion and autoignition of fuels
- Develop and improve a Diesel Particulate Filter Cleaning Furnace
- Carry out tests to find new methods for active regeneration, by performing LPG Injection Tests.

Project Methodologies

A DPF Heat Cleaning Furnace was fully developed from scratch. Keeping in mind the commercial availability of the parts being used and the fact that the time-consuming heating procedure, the Furnace was designed to be capable to heat clean two DPFs at once. The temperature of the furnace was controlled using the SYL- 2352P Ramp and Soak PID Temperature Controller. By use of the ramping, soaking and ON/OFF control functions the temperatures were controlled to keep a steady temperature and simulate auto regeneration.

A new method for active regeneration for the DPF was being researched, based on the autoignition theory of gases. LPG injection tests were being carried out to obtain an autoignition temperature value, in an exhaust simulation where, heated air was being used as the energy source for the LPG flow. Stoichiometric calculations were done based on air to fuel ratio by volume to see its effect on autoignition.

Results and Achievements

The DPF heating procedure is carried out by removing the DPF from the exhaust system of the car and put in the furnace. This was the reason for designing the furnace at a height of 1.05m, based on an available DPF. This will result in the DPF being unbolted as a whole from an exhaust system rather than being cut and welded again. Also, two DPFs could undergo this procedure at once due to the size of the Furnace

The LPG injection tests were carried out as an alternative method for active regeneration. This means that the procedure could be carried out without removing the DPF from the exhaust system, by injecting LPG through an existing hole in the exhaust upstream of the DPF. Three tests were carried out based on autoignition mechanisms, these being, one Heated Surface Ignition setup and two Hot Gas Ignition setups.

The heated surface ignition tests were carried out, only to achieve a better understanding of the concept of autoignition and testing the effect of stoichiometry on the process. This is due to the fact that in an exhaust system if no regeneration takes place means that there would not be red hot surfaces for ignition of the LPG to occur.

The Hot Gas Ignition setup showed a better representation of exhaust gas flow since the Activation Energy of the LPG will only be achieved from the hot air stream. Stoichiometry was also kept during this test and combustion was achieved but the test was deemed unrepeatable due to combustion

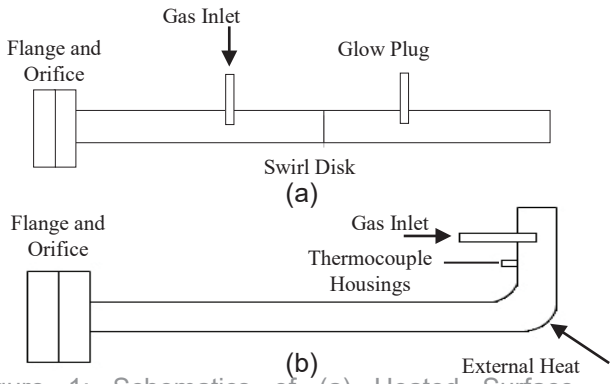

Figure 1: Schematics of (a) Heated Surface Ignition Setup, (b) Hot Gas Ignition Setup

Pneumatic Conveying of Granular Substances

Student: Jurgen Casha / Supervisor: Prof. Tonio Sant / Co-Supervisor: Dr Christopher Micallef

Introduction

Production companies dealing with granular materials such as sugar find that one of the best conveying methods of transport is pneumatic conveying. Unfortunately, degradation of the transported sugar is increased when pipeline bends are present. When it comes to pneumatic conveying, experimental data collection and analysis are still considered by the engineering community as a powerful tool. In fact, this experimentation with pneumatic conveying is what led to the inspiration behind the start of this final year project. The project was sponsored by Foster Clark Products Ltd.

Project Objectives

- Assemble a modular, fully functioning pneumatic conveying system.
- Use instruments to get a good understanding of the properties of air and sugar flow inside the pipeline.
- Compare two different bends having different geometries whilst attempting to characterize the flow of air and sugar within these bends and finding which bend offers the least amount of degradation.

Project Methodologies

In order to be able to obtain the empirical data, the conveying system was built and equipped with engineering instruments to gather important parameters. Sugar samples were when either passed 5 or 10 times through the assembled conveying system. The modular system was changed between having the *"no bend"*, *"short bend"* and *"long bend" setups*. The difference between the bends was that they had a different R/D ratio (curvature radius to diameter ratio).

Finally, after the experimental data was collected using a sieve stack, software was used to analyse the data and output the particle size distribution of the sugar samples in order to compare the conveyed sugar after passing through the three setups with the original *"supply sack sugar"*.

Results and Achievements

The two main modes of degradation in pneumatic conveying bends are due to the frictional forces experienced by the sliding of the particles with the bends and the forces experienced by the change in direction whilst passing through the bends. When sugar hits a *"short bend"*, the change in direction is extreme and thus the forces due to the change in direction are large. Consequently, the sugar particles do not experience a large number of collisions meaning that the frictional forces are low. The opposite is observed in the *"long bend"*.

At low velocities, breakage of the particles will not occur due to bend collisions. The phenomenon was occurring in the built system due to the low velocity reached. Applying this knowledge, the hypothesis formed was that at low speeds, the frictional forces (reflected by the number of collisions with the bend) create larger degradation effects when compared to the degradation effects due to the forces causing a change in direction (reflected by the collision angle).

Applying this hypothesis on the bends, the *"long bend"* produced a higher degradation due to the higher frictional forces experienced by the sugar whilst passing through it. The results are shown in Figure 1.

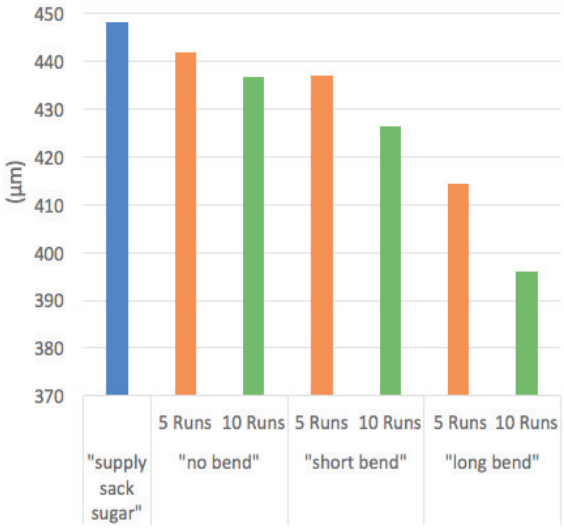

Figure 1: Mean particle size of sugar samples

Aerodynamic Characterisation of an FSAE Car

Student: Fabio Cauchi / Supervisor: Dr Simon Mizzi

Introduction

In motorsport engineering, aerodynamic packages play an important role in the overall performance of a race car. The fundamental purpose of these packages is to reduce the drag, which limits the power output, and to increase the downforce, which is translated into better tire performance.

Project Objectives

The aim of this project is to design an aerodynamic package which is to be implemented onto an FSAE car designed and built by the University of Malta Racing Team. This package must generate enough downforce to increase the normal loads on the tires and hence improve their performance. Furthermore, the best tools and methods to do so should be identified and implemented so they can serve as a foundation for future developments.

Project Methodologies

ANSYS-CFD software package is the main tool used to carry out Computational Fluid Dynamics (CFD) simulations with the aim of designing and optimising the aerodynamic package. Initially, two-dimensional simulations are carried out on single and multi-element airfoil setups. These involve comprehensive studies to validate the simulation methodologies and turbulent models used against published data. Moreover, CFD simulations are used to optimise the positioning of airfoil sections within multi-element wing setups for maximum performance.

Based on results from the two-dimensional studies, a three-dimensional model of the faired FSAE car equipped with the first iteration of the aerodynamic package was created using Autodesk Inventor. The package consists of a faired body, an undertray, a diffuser, a front wing setup and a rear wing setup. An efficient mesh generation procedure using ICEM-CFD was identified and implemented. The simulation of the 3D model is carried out using both simple and advanced turbulent models and the results are compared. An attempt to carry out an on-track test using a strain gauge system for data acquisition was also performed, with the aim to validate simulation data.

Results and Achievements

From the studies regarding the selection of turbulent models for simulations of race cars, it resulted that the Realizable $k-e$ turbulent model with enhanced wall treatment and curvature correction is the best one to use. This is due to its good balance between accuracy and computational requirement. Moreover, it was proven that inferior turbulent models can be used to obtain fairly reliable results in three-dimensional simulations of a race car. From these simulations, it resulted that the first iteration of the aerodynamic package designed, produced about 345.5N of downforce, which is far from the targeted 1600N. The cheap experimental setup tested during on-track testing resulted to be not fit for purpose since the data obtained was not satisfactory. Although more work needs to be done to achieve the desired performance, this project lays down the foundations for future improvements.

Figure 1: On-Track Testing at Hal Far Race-Way

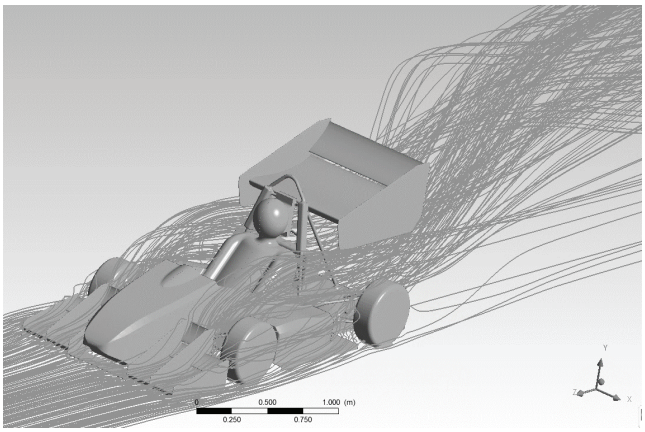

Figure 2: CFD Simulation - Flow Visualisation

Characterisation of Marine Hybrid Composite Laminates

Student: Jean Claude Chetcuti / Supervisor: Prof. Claire De Marco

Introduction

The focus of this dissertation was to characterise a light weight composite laminate designed for the specific use within high speed light craft monohulls. Following characterisation of an effective laminate that meets all set criteria, fabrication was carried out along with flexural and tensile testing with the aim of deriving the mechanical properties of the laminate.

Project Objectives

The key objectives were to characterise and fabricate hybrid laminates by adopting different manufacturing techniques and resins. Mechanical properties are to be derived by flexural and tensile testing thus determining the most effective laminate.

Project Methodologies

BS EN ISO 12215-5:2008 [2] served as the basis upon which the laminate was characterised. Focus was given to ensure that any limitations imposed by the standard were not infringed. The design category adopted for the craft is category “C”. The resulting design pressure stated as being the bottom pressure in planing mode is of 34.94 kN/m^2 in magnitude.

A ‘stack analysis’ technique was adopted whereby the laminate properties were tailored by carefully selecting each individual ply formulating the overall laminate thereby achieving an efficient and cost-effective laminate that satisfies the required criteria. The technique assumes that the laminate is fabricated with a resin compatible to all fibre types. Furthermore, it was ensured that any characterised laminate is to have an odd number of plies in order to ensure that the mid-plane consists of the reinforcing fibres and not a resin layer since the mid-plane is more prone to delamination due to shear forces acting within this ply.

Following the computation of design stresses and strengths, computation of specific properties such as the laminate thickness, section modulus and bending stiffness were carried out. Focus was given to ensure that the laminate would meet set requirements, typically with regards to stresses, shear strengths and deflections.

Results and Achievements

The most effective characterised laminate consisted of a total of nine layers where the two most outer layers are carbon fibres with the remaining being glass fibres. Both reinforcements are woven roving weave type with the matrix being a compatible resin, either epoxy or polyester. The open mould epoxy laminate achieved the highest modulus of elasticity as seen in Figure 1, followed by the vacuum bagged laminates with epoxy whereas the most effective characterized laminate resulted in being a vacuum bagged epoxy laminate. The discrepancy can be attributed to the different thickness and fibre mass content values of the fabricated laminates in comparison to those characterised.

The achieved results were compared to those of characterised laminates. It can be concluded that the fabricated laminates have moduli of elasticity comparable to those of the characterised laminates and of sound mechanical quality. By referring to the derived results, it was determined that the most effective laminate is that utilising epoxy as matrix resin, fabricated under an open mould process.

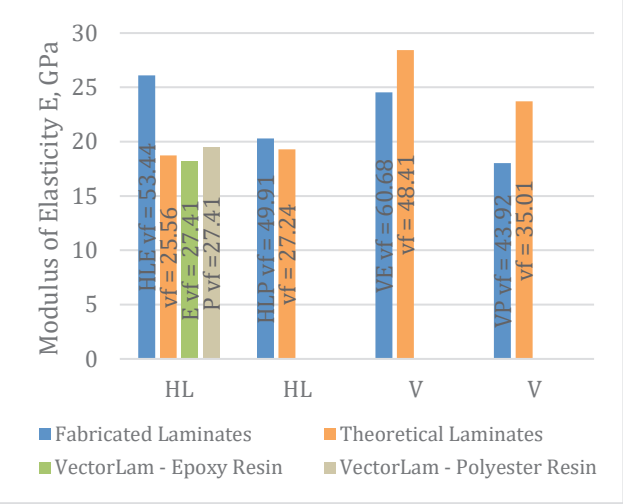

Figure 1: Comparison of moduli of elasticity

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An Exploratory Study on the Development of a Prosthetic Variant of the UM-MAR Hand

Student: Maria Cutajar / Supervisor: Prof. Ing. Michael A. Saliba

Introduction

Over a fifth of amputees who make use of upper-limb prostheses abandon their prosthesis [1]. This project aims to combine research conducted at the University of Malta with regard to the development of an anthropomorphic robot hand with existing research in the development of upper-limb prostheses [2, 3].

Project Objectives

The project's primary objective was to perform an exploratory study into adapting the University of Malta Minimal Anthropomorphic Robot (UM-MAR) Hand to be used as a prosthetic device. Moreover, the objectives for this dissertation were to:

- Compile and develop detailed design requirements for a dexterous prosthetic hand
- Generate conceptual design solutions to the problem, and select the best solution
- Build a physical model to investigate the functions of the design.
- An evaluation report of the prototype

Project Methodologies

Once the design guidelines for the design of a hand prosthesis were gathered, a variant of the existing design of the University of Malta Minimal Anthropomorphic Robot Hand (UM-MAR Hand) was developed. The force transmission of the prosthetic variant employed a different mechanism involving a bar linkage system rather than a cable system. With this design, the variant coupled the motion of the proximal and metacarpal joints, while fixing the distal joint thereby saving on the number of actuators required for the hand.

The design was manufactured by 3D printing of the parts which has become an increasingly popular and more affordable means of generating rapid prototypes. The advantages of this method of fabrication include the ease of manufacturing, since no expert skill would be required in order to manufacture the various parts. Moreover, such designs can be customized according to the individual needs of the user by amending the design on making use of Computer Aided Design (CAD) software.

Results and Achievements

Following 3D printing and assembly of the hand, tests regarding the weight, speed, tip force and grasp capabilities of the hand were executed. The resulting design fits well within the weight criteria, weighing in at 280g. Its force and speed capabilities are comparable to commercial hands already on the market and were considered satisfactory. The design is ideal for amputees suffering from wrist disarticulation and does not have a functional wrist joint. Future work can focus on developing the electrical control interface using electromyography (EMG) control signals.

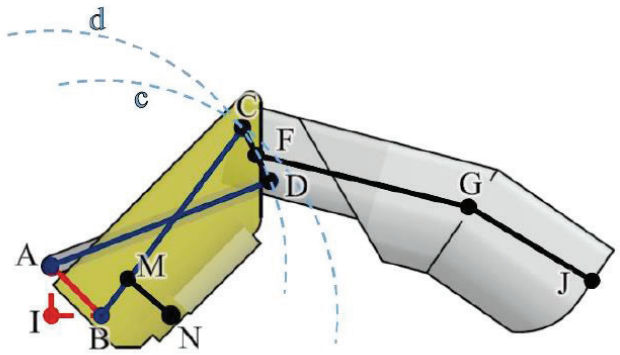

Figure 1: Kinematic model of the flexion-extension mechanism of the finger. Curves c and d denote the locus of points through which links BC and AD pass. MN is the lever connecting the actuator to the linkage mechanism

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Optimising the Thermal Comfort in a Church

Student: Zachary De Giovanni / Supervisor: Prof. Ing. Robert Ghirlando / Co-Supervisor: Dr Ing. Charles Yousif

Introduction

The Parish Priest of the Stella Maris Church intends to install an air conditioning system, and has accepted the proposal of Prof. Ghirlando to analyse the thermal performance of the church to optimise the installation of an HVAC system.

Project Objectives

The project objectives are the following:

- To create a model of the church using Design Builder.
- To take measurements of temperature and relative humidity inside the church at various points and days in the year.
- To use these measurements to validate the model.
- To test various simulations of air conditioning models.
- To obtain a state of thermal comfort for the occupants.

Project Methodologies

The problem was initially defined by taking on-site. The church is in Sliema, surrounded by housing around two to three storeys high. The building layout is that of a traditional cross shaped church, with the bottom side of the cross bordering the Triq Il-Kbira. The site in question is surrounded by a mixture of external spaces and unconditioned spaces. Design Builder was used to build the model using internal dimensions obtained from architectural drawings produced by architect Mollicone.

Once the geometrical features of the model were completed, the rest of the building conditions such as construction materials, occupancy schedules, metabolic activity and cooling set point were set through the various tabs in the software, adjusting the model to replicate real-life conditions as closely as possible. Once the model was completed, simulations could be performed at various conditions to observe the behaviour of the structure as well as determine the capacity of the HVAC equipment using cooling design calculations. Finally, a validation exercise was carried out to ensure the applicability of the results.

Results and Achievements

Thermal comfort assessed using ASHRAE Standard 55 showed that the most comfortable environment was that cooled at 22°C, however, this is deemed cold for the Maltese island, and a combination of cooling at 23°C and use of fans for evaporative cooling will be implemented. This lessens the required HVAC system capacity and reduces consumption.

A design and costings exercise was performed, and a VRF system of 110 kW selected, with ten indoor units of 11.2 kW each conditioning the building. This would allow the building to reach a state of thermal comfort for the occupants.

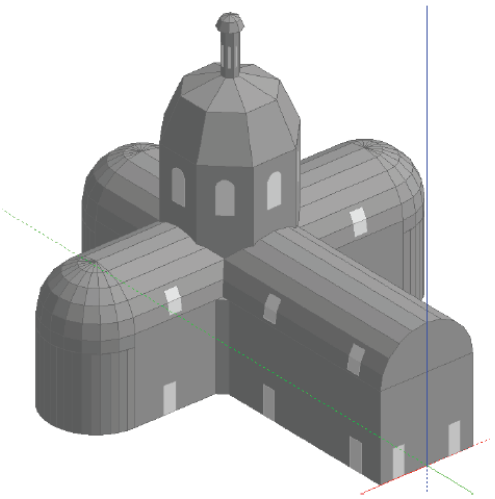

Figure 1: Model created using Design Builder

Finite Element Analysis of UOM Racing Chassis

Student: Raniero Falzon / Supervisor: Dr Ing. Pierluigi Mollicone

Introduction

The UoM Racing team participates in the Formula SAE (FSAE) international competition. The team is required to design and manufacture a racing car in line with regulations. A crucial sub-system of a racing car is the chassis which, for maximum performance, needs to meet certain technical requirements such as low-weight and sufficient torsional stiffness. Simulations are used to aid in the design and optimization of the chassis. Finite element analysis (FEA) is used as a tool to calculate stresses and deformations and also to compare design alternatives, such as a change in material. For the results to be considered as reliable, the model has to be validated against sound experimental data.

Project Objectives

This research aims to validate the FEA results through experimentation and compare simulation results derived from the use of beam and shell elements. From the experimental results the effects, if any, of residual stresses on stiffness are analysed. Finally, the potential advantages of utilizing chromium molybdenum steel instead of mild steel in the chassis is identified.

Project Methodologies

To study the application of FEA for determination of torsional stiffness in a tubular welded chassis, it was decided that it would be imperative to validate simpler structures made using a manufacturing technique similar to that used in the chassis. Three specimens having different geometries were designed for the purpose of analysis and testing. The main difference between these geometries lies in the number of welds included. Finite element analyses require the material properties to be defined quantitatively. A tensile test was carried out to obtain material properties, i.e. the Young's modulus, yield strength and Poisson's ratio.

Five samples of each different geometry and the appropriate clamping mechanisms were manufactured. The samples were tested and following the first set of tests the samples were stress relieved in order to relieve the residual stresses created by the welding. Similar testing was then carried out again.

Results and Achievements

The data for each type of geometry was compared by plotting it on moment versus displacement graph, with the gradient representing the stiffness. The finite element analyses carried out were also used to compare the results calculated by the beam and shell element.

The results revealed that for structures comprised of two welds or less, the discrepancy between the simulation and experimental results was acceptable. The results for the structure having six welds showed that a large error existed and therefore the finite element model was not adequate to predict the deflections. Upon stress relieving the error between the simulation and experimental results was reduced drastically but it still was very significant.

This discrepancy can be due to the present residual stresses which upon loading of the structure increase the stresses beyond the yield point thus resulting in a loss of stiffness. The difference in geometry can also be a factor for the increase of error in the six-weld specimen. The specimen having six welds consisted of a closed (triangulated) structure while the other two samples did not.

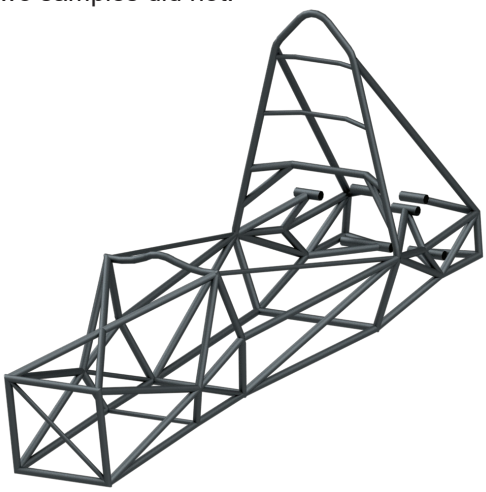

Figure 1: UoM Racing Space-Frame Chassis

Analysis of the Wind and Wave Induced Dynamic Response of an Offshore Energy Storage System

Student: Daniel Farrugia / Supervisor: Prof. Ing. Tonio Sant / Co-Supervisor: Dr Ing. Daniel Buhagiar

Introduction

To address the intermittency of offshore renewable sources, a novel energy storage system has been proposed [1] whereby air stored in a seabed-mounted chamber is compressed by pumping in seawater. The water is then released through a hydraulic turbine to extract the energy. A floating air chamber serves to absorb pressure fluctuations.

Project Objectives

To design a hypothetical full scale prototype of the proposed system integrated with a floating offshore wind turbine. The hydrodynamic performance of the design was to be investigated for variation in the design parameters and metocean conditions.

Project Methodologies

The conceptual system consisted of a 5-MW wind turbine mounted on a tension leg platform anchored to the seabed through a gravity foundation (anchor). As shown simplified in Figure 1, the seabed-mounted air storage chamber is integrated with the gravity foundation, whilst the floating chamber is integrated with the tension leg platform. The two chambers are connected via an air umbilical.

The scope of this project was to analyse the effect on the system's hydrodynamic performance for variation in the platform diameter and the umbilical inner diameter. Moreover, two metocean conditions were considered: one representing a normal operating scenario, and another representing an extreme scenario. To simplify the analysis, the umbilical was omitted from the design when analysing the platform diameter, and then included for the superior platform diameter identified in the analysis.

After computing the wind loads acting on the exposed surfaces, sizing the required thickness of steel plating for the vessel and designing the umbilical, the system was modelled in ANSYS AQWA®. This is a hydrodynamic analysis software that is capable of generating the response amplitude operators of the model as well as predicting its temporal displacement response in all six degrees of freedom. The results obtained were then analysed.

Results and Achievements

From the results it was noted that the hydrodynamic performance of the platform improved for smaller diameters within the range considered (12 to 18 m). Moreover, the smaller the diameter, the thinner the steel plating required to withstand the internal pressure due to the compressed air. However, if the internal volume is kept constant, then the draught increases for smaller diameters and this implies an overall increase in the mass of steel required.

With regards to the umbilical inner diameter, it was found that the platform's hydrodynamics improved for larger inner diameters within the range considered (0.15 to 0.25 m). However, the actual improvement is marginal and of little consequence.

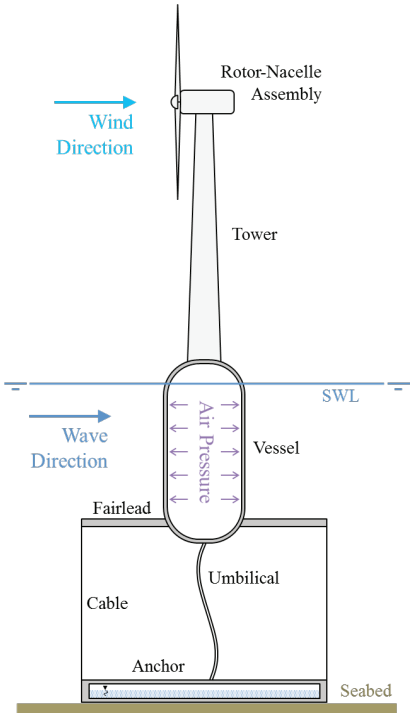

Figure 1: Illustration of the hypothetical full scale prototype showing the main components

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Waste to Energy

Student: Daniel Frendo / Supervisor: Prof. Robert Ghirlando

Introduction

For this dissertation, the biological process and purifying techniques for biogas were assessed. The best purifying technique for the Maltese Islands was found to be Pressure Swing Adsorption. The general composition of biogas is made up from: CH_4, CO_2, CO, N_2, O_2, H_2, H_2S and H_2O. [1] From all of these gases, CH_4 is the most important gas, since it has a high calorific value. The other gas impurities must be removed in order to achieve a higher calorific value. To do so, a small pilot system was recycled from last year's final year projects and improvements were implemented in order to achieve higher purification results.

Project Objectives

The objective of this final year project was to analyse two types of Zeolite 13X at different operating pressures. Also, tests were conducted to check the effects of the orientation of the pressure vessels on CH_4 purity.

Project Methodologies

The new gas analyser could read the calorific value of the biogas. An experiment was conducted using the Boys calorimeter to determine the percentage difference between the two instruments. From the final results, it was concluded that the percentage difference for the gross calorific value was of 2.02% while the net calorific value was of 5.29%.

In order to purify the biogas, a small pilot system was used. This setup works by first suppling the biogas from the 62-litre tank to a small 9.56-litre tank. This smaller tank acts as an expansion vessel in order to better mix the gas constituents. After the 9.62-litre tank is filled with biogas, it is then passed through the demister to remove any H_2O present in the feed. The next step is to pass the biogas into the first pressure vessel. The first pressure vessel is filled with activated carbon and the aim of the activated carbon is to adsorb the H_2S. Then, the biogas is passed through another pressure vessel but this time it is filled with zeolite. The aim of the zeolite is to adsorb the CO_2. Once the biogas is treated, it is then passed through a pressure regulator, which is connected to the gas analyser. Figure 1 shows the complete setup.

Results and Achievements

The results achieved showed that in order to achieve good CH_4 purity, a high-quality Zeolite 13X has to be used. The percentage difference in CH_4 purity between the two Zeolites utilized was 45.71%. It was also concluded that the best operating pressure is between 3 to 4 Bar. When the pressure vessels were positioned in the vertical position, higher CH_4 purity was observed. In fact, in the vertical position an increase of 19% in CH_4 purity was calculated. The net calorific value was found to be 34 MJ/kg while the gross calorific value was found to be 37 MJ/m^3, which also showed an increase from the low-quality zeolite. The percentage increase for the net calorific value was calculated to be 45.31%, while the increase in the gross calorific value was 35.07%. it was also noted that as the operating pressure increases, the calorific values increases. The reason behind it may be that as the pressure is increased, more gas impurities are being adsorbed by the zeolite.

Figure 1: Complete setup for the pilot system

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Effect of Weight Distribution and Lateral Load Transfer on Understeer Gradient of a Formula SAE Car

Student: Christian Gauci / Supervisor: Dr Ing. Mario Farrugia

Introduction

Vehicle Dynamics includes a number of subsystems within a car which when combined together results in a car which is either controllable or uncontrollable. One of the objective metrics used to measure the performance of a car is the understeer gradient. The understeer gradient is a measure of the steering wheel angle required to negotiate a corner at a particular lateral acceleration.

Project Objectives

The scope of this dissertation was to give UOM Racing, a Formula SAE team, possible ways with which the understeer gradient of a Formula SAE car could be changed, mainly through variation of weight distribution and roll stiffness.

Project Methodologies

A modified bicycle model by Gillespie was considered and analytical analysis was carried on this equation in order to monitor the behaviour of the weight distribution, lateral load transfer and cornering stiffness of the car. In order to do so, information such as weight distribution, steering ratio, centre of gravity height and motion ratio had to be measured from the car. The effect of weight distribution and lateral load transfer were also tested out using one of the team's car. This was achieved by measuring the understeer gradient of the car at different setups by going round a constant radius at different speeds, monitoring both steering wheel angle and lateral acceleration.

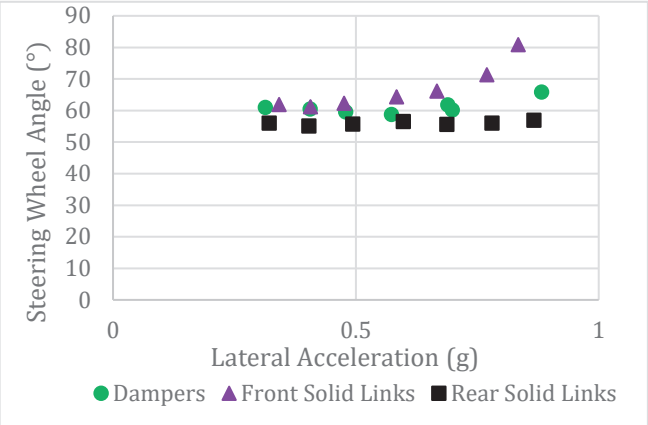

Figure 1: Variation in Roll Stiffness

Results and Achievements

From the analytical analysis it was concluded that at small lateral accelerations the weight distribution has the biggest effect on the understeer gradient. On the other hand with increase in lateral acceleration, effect of lateral load transfer increases and starts having an effect on the cornering stiffness of the tires. From the testing carried out it was concluded that at low lateral acceleration, the weight distribution had minor effect on the understeer gradient. On the other hand with variation in roll stiffness and thus affecting lateral load transfer, it was concluded that for an understeer car, front roll stiffness should be increased while for an oversteer car the rear roll stiffness should be increased.

References

[1] D. L. William F.Milliken, in *Race Car Vehicle Dynamics*, Warrendale, Society of Automotive Engineers, 1995.

[2] T. D. Gillespie, in Fundamentals of Vehicle Dynamics, Warrendale, Society Of Automotive Engineers, 1992.

[3] A. Toso, Head of Research and Development and U.S Racing Business Leader for Dallara. Masterclass 9th to 13th February 2015, 2015.

Figure 2: Constant Radius Testing

Heat Exchanger Lab Test Bench

Student: Michael Grech / Supervisor: Dr Ing. Christopher Micallef

Introduction

The scope of this Engineering Dissertation is to design and build a heat exchanger lab test rig to be used in the Heat Transfer Undergraduate Module. Such a test bench would be beneficial as users carrying out tests would further their understanding and appreciation for heat exchangers.

Project Objectives

The project objectives of such a dissertation is to perform a literature review on existing heat exchangers and their testing standards. A design is carried out including both hardware and instrumentation selection. This is important in order to build and test a heat exchanger test bench and to set requirements and operating constraints for the test rig. The design and construction was also done for two heat exchangers, a Shell and Tube shown in Figure 1, and a Concentric tube shown in

Project Methodologies

A study on different types of heat exchangers and testing standards used in industry was carried out. Such literature helped in the designing of the test rig. Designs were carried out by Computer Aided Design (CAD) and material selection was done in order to select the proper materials both for the bench and the heat exchangers. Numerous considerations were taken when choosing the hardware such as performance, cost and flexibility. It was essential to get the best performance at a reasonable cost. Once the test bench and heat exchangers were built, testing could be done and their performance was calculated.

Results and Achievements

With such a test rig, any heat exchanger can be mounted onto the test bench and filtered water (both hot and cold) can be pumped through the heat exchanger. Flowmeters and thermocouples throughout the test bench can gather data and the data is logged by means of a data logging software. This data is later analysed and processed in order to understand and quantify the performance of the heat exchanger. Such a test bench is highly flexible as various conditions for flow can be adjusted by valves, a large range of flow rates can be read by means of low flow and high flow flowmeters and numerous temperatures can be set due to the heaters present.

Calculations were carried out during the design stage in order to set the dimensions and parameters for the heat exchangers [1]. Once testing was completed certain further calculations and error analysis were done in order the calculate the effectiveness and also calculate the confidence interval range in which repeated tests can be carried out that produce results in the same range.

References

Book:

[1] D. B. L. Incropera, “Fundamentals of Heat and Mass Transfer,” 2007,

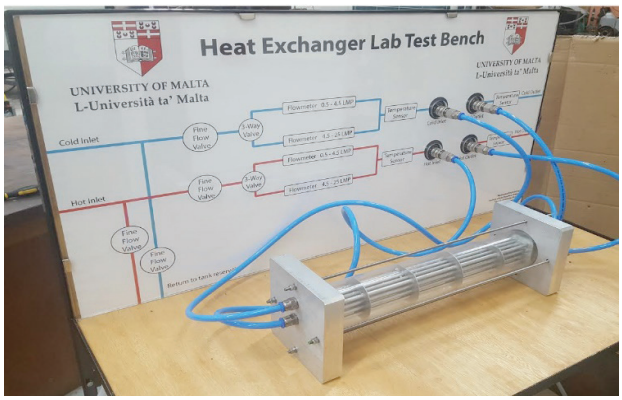

Figure 1: Shell and tube heat exchanger

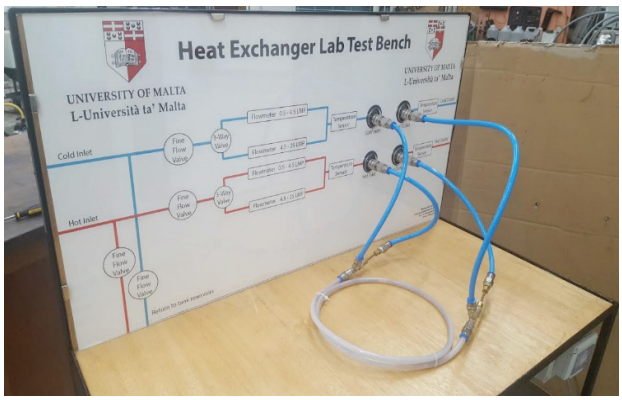

Figure 2: Concentric tube heat exchanger

Upgrades on the Common Rail Diesel Engine Set-Up

Student: Wayne Gregoraci / Supervisor: Dr Ing. Mario Farrugia

Introduction

The focus of this dissertation was based on common rail diesel injection engines and their engine control module. A second-hand 2.0HDi Peugeot engine, similar to the one used in previous projects, was purchased for testing purposes. The previous engine was required for motoring testing in a Master's thesis. A new setup was created to restore the diesel engine project back to the benchmarked state, and to implement upgrades.

Project Objectives

- Start an on-going diesel emission analysis by researching on diesel smoke opacity.
- Create a new stand-alone wiring loom for the programmable Reata ECU.
- Setup the purchased Diesel engine on the Stuska Waterbrake Dynamometer.
- Review and create a coolant conditioning system.
- Start and map the purchased 2.0HDi engine.
- Bring the purchased engine in a state where it can be loaded and used in MEC4011 laboratory experiments
- Explore idle conditions on the Reata Engine Management with the introduction of the engine's transmission.

Project Methodologies

A new wiring loom was designed and created specifically for the Reata control module to work in a stand-alone configuration. A full comprehension of the work done by previous authors on the vehicle wiring loom was done before designing the new harness.

Another improvement on the previous projects setup was the introduction of the transmission, which was purposely included for idling mapping. The purchased engine was thus set up and coupled to the Stuska Dynamometer present in the Thermodynamics Laboratory.

An additional upgrade to the previous diesel setup was the cooling system, where the objective was to understand and benchmark an external coolant conditioning strategy, obtaining an independent control of the engine's operating temperature.

Results and Achievements

The new harness was successfully tested on the previous engine, which was then removed from the testbed. Following a thorough debugging process, the purchased second-hand engine was successfully started up and mapped to the desired state for optimum performance. Figure 1 shows a final graph of Torque (Nm) and Power (BHP) vs Engine Speed (rpm). The maximum torque achieved was 239Nm happening at 2700rpm whilst the maximum power achieved was 109BHP happening at 3700rpm. The full control accomplishment of the purchased engine, was managed solely by the calibrated Reata ECU, breaking ground for future dissertations and for MEC4011 module laboratory sessions.

The idling mapping was also successfully executed, with the understanding of the fuel pump's duty cycle control at low engine speeds, as determined by the previous dissertation. Injection timings were also logically varied, obtaining a respectable engine idling with a better fuel consumption. It was determined that after the idling mapping, 20%(4g) of fuel were being saved every minute.

In addition, the coolant conditioning station was developed and introduced to the system with satisfactory results. Finally, an additional project regarding diesel emission and smoke opacity was initiated. Although the physical design wasn't developed in this project, a detailed literature research was conducted, paving the way for future dissertations.

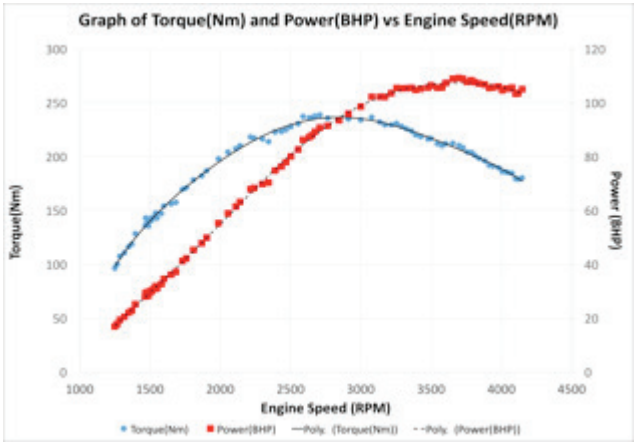

Figure 1: Graph of Torque(Nm) and Power(BHP) vs Engine speed(RPM) developed on the 2.0HDi

Solar Cooling

Student: Jonathan Martinelli / Supervisor: Prof. Robert Ghirlando

Introduction

Working on a system used to cool wine in Buskett, this project follows the use of a licensed software simulation package called TRNSYS, which stands for TRaNsient SYstem Simulations. With climate change being the prime motivator for this a project, the Oenology and Viticulture Research Centre is exploring ways how the wine industry can use solar cooling technology as means of sustainable energy. [1]

Project Objectives

The main objective of this dissertation was that of validating the software package TRNSYS, by running several simulations of the system, and comparing the results to real data measured by the system and sensors located on site.

Project Methodologies

The system is comprised of an array of vacuum-tube solar collectors, two thermal energy storage tanks, one used as a drain back tank for storing hot water and the other as a chilled water storage tank, a vapour absorption chiller and a dry fluid cooler. Certain parameters and specifications of the components were unknown, so the initial tests and simulations were run on individual components such that the sizing of each component could be modelled as accurately as possible. Once this was complete, the system was divided into three circuits; hot water circuit, cool water circuit and chilled water circuit. Component models were grouped in their respective circuit and simulations were run again and compared to the real data. Finally, the entire system was modelled and connected and simulations were run to obtain the results required.

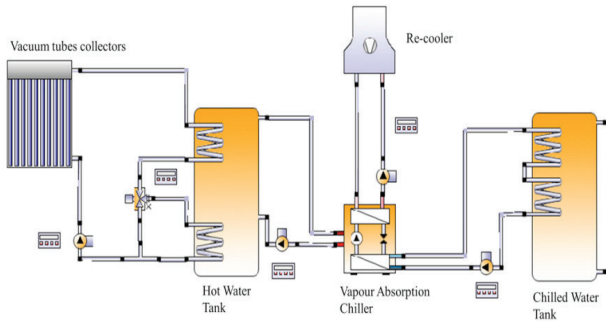

Figure 1: Schematic diagram of system components [1]

Results and Achievements

Following the arrangement of the real data measurements, the individual components were modelled as accurately as possible, with several manufacturer data and specification sheets being used. The sizing was successful and the important parameters could be used in the following tests.

Two of the compound tests were successful, however the chilled water circuit had some accuracy problems in modelling in which tech-support from the software company explained as inevitable.

The full system simulation was hindered by the chilled water circuit problem, and accurate results could not be obtained although a lot of effort was put into obtaining the best possible results.

It was therefore concluded that the software package TRNSYS could not model the entire system accurately enough, thus it was not validated. Despite this, the software is excellent in helping the user understand better what certain modifications to the system could change, and how it is affected, although not to a desired accuracy.

References

[1] Ghirlando R., 'Solar Cooling at the Oenology and Viticulture Research Centre, Buskett, Rabat', Sustainable Energy 2016: The ISE Annual Conference, Valletta, Malta, 2016.

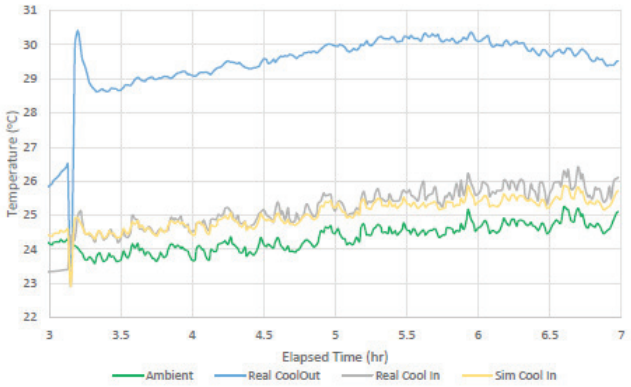

Figure 2: Individual simulation of the dry fluid cooler

Development of a Robotic Teleoperation System

Student: James McElhatton / Supervisor: Prof. Michael A. Saliba

Introduction

Teleoperation (also known as telerobotics) involves the control of a robot in a remote-like manner. A signal travels to and fro between the remote-like device and the robot that is interpreted by a controller. The sensors that are used may vary depending on the need. Sensors may be used to provide touch feedback, visual feedback or both.

Project Objectives

The primary objective is to achieve a fully operational teleoperated system. This system is built around a pre-existent robotic hand [1] and robotic arm that would be controlled through a glove worn by the operator.

Project Methodologies

The work revolves around bringing the system to an operational level whilst looking for ways to improve the system. In order to do so familiarisation with the system is paramount. Once these requirements were met and any faulty parts were replaced, data collection became the next step. All the sensors were tested and their operation curves were obtained.

The next step involved controlling the robotic hand through the bend sensors in the glove. Upon completion the robotic arm was next. The arm was controlled through a gyroscope and accelerometer that determined the user's hand position.

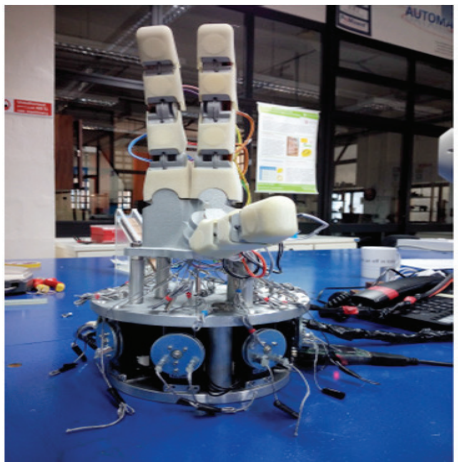

Figure 1: Robotic Hand

Results and Achievements

The Robotic hand is fully operational with a lag time of just under 1 second from operator movements to robot hand response. Values were further substantiated through a display that showed the angle of the operator's hand during use. The system is lacking when it comes to finer control due to an inherent accuracy flaw within the sensors which can only be rectified by purchasing ones that are higher end.

The data for the accelerometer and gyroscope was collected and filtered through a Kalman filter. This was done in order to remove any bad data. The values were then converted to angle and displacement of the operator's hand.

References

[1] D. Dalli and M. A. Saliba, "The Univerity of Malta Minimal Anthropomorphic Robot Hand II," in *Advanced Intelligent Mechatronics (AIM), 2016 IEEE International Conference*, Banff, AB, Canada, 2016.

Figure 2: Sensor Glove

Cavitation in Maritime Control Surfaces

Student: Jacqueline Mifsud / Supervisor: Dr Simon Mizzi

Introduction

Cavitation is a notable concern in the maritime industry mainly because it leads to increased maintenance costs. Vessel structural integrity and safety are compromised by prolonged ship vibrations and erosion, which in extreme cases lead to the failure of components such as propellers, rudders and other appendages.

Project Objectives

An improved understanding and an accurate prediction capability of this phenomenon are required to mitigate cavitation damage. The scope of the project is to build an experimental test-rig to investigate the influence of section shape and angle of attack (α) on cavitation inception.

Project Methodologies

Three different hydrofoil section shapes were manufactured and tested in this project. Experimental testing was carried out for each section shape, each at three different angles of attack, (0°,10°and 20°) in the visible test area shown in Figure 1. Experimental results were validated with numerical data from XFoil. The profiles were chosen to represent as much as possible section shapes used in maritime applications, such as the NACA 0020 profile whose symmetrical nature makes it suitable for use as rudders or keels on yachts. A cavitation-resistant profile, namely the HSVA MP 71-20, was also tested such that it is possible to investigate the influence of section shape on cavitation inception.

A cambered profile having only 2% camber, namely the NACA 63-215 was also included in the analysis to investigate the effect of camber on cavitation inception. Cambered profiles are more suited to be used as pitch control foils or stabiliser fins amongst others, but not as a rudder. Unlike a symmetric profile, a cambered section is not capable of providing equal lift to both port and starboard.

Results and Achievements

Pressure measurements at two different chord positions on the hydrofoil were performed. Some results showed reasonable agreement with XFoil data, but a discrepancy was recorded for some angles of attack. Cavitation was distinguished from its intermittent pattern which varies continuously with flow, as well as from the white colour of the vapour phase. Different types of cavitation were characterised depending on the location at which the phenomenon was observed. The cavitation types observed on the different profiles included fixed cavities, back-sheet cavitation as in Figure 2 (especially at the leading edge), as well as travelling cavities (or bubbles) which imploded further downstream of the hydrofoil sections. Travelling cavities were distinguished from their ability to move with the fluid past the hydrofoil. The fixed cavities were recognised from their smooth or glassy appearance and their location on the hydrofoil, typically at the leading edge. Although further work needs to be done to improve the experimental-rig capabilities, this project lays down the foundations for experimental cavitation-testing.

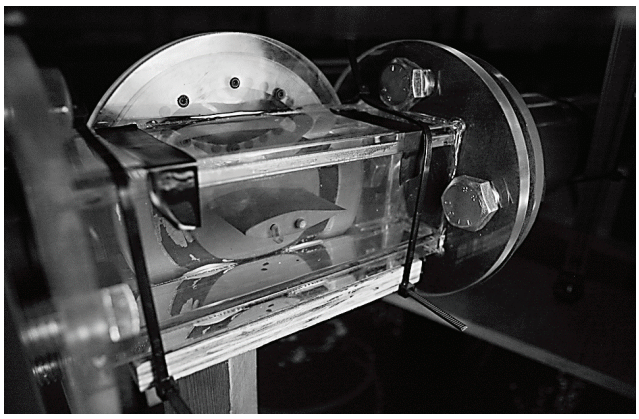

Figure 1: Visible Test-Area with hydrofoil at $\alpha = 0°$

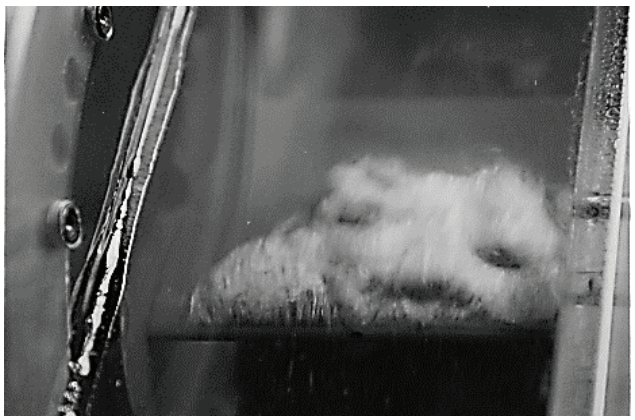

Figure 2: Sheet Cavitation on HSVA MP-71-20 $\alpha = 20°$

Thermal Energy Model of an Injection Moulding Machine

Student: Kurt Mifsud / Supervisor: Dr Ing. Chris Micallef / Co-Supervisor: Dr Ing. Paul Refalo

Introduction

The energy consumption by injection molding industry nowadays is in the Giga scale globally. Work on improving the energy consumption of these machines in ongoing daily. To do so, studies and models are being developed to further understand where the energy is going. This dissertation will focus on the thermal energy being lost in an injection moulding machine. Further to that, a mathematical model will be constructed to further sustain and understand the concept.

Project Objectives

- Rig and test the thermal energy transfer in the cooling system in an injection moulding machine
- Construct a mathematical model to the exact dimensions of the machine and test it.
- Validate the results of both testing methods and make sure they have the least possible error.

Project Methodologies

An injection moulding machine located at the University of Malta has three cooling pairs of supply and return pipes rigged up with temperature and flow sensors. The parts selected for testing where the mold, hopper water jacket and oil cooler. RTD and Thermistor sensors, together with Omega flow sensors were used to conduct multiple tests and different configurations to ensure that the readings agree to each other. These were connected to a data logger ensuring that the readings were correct and have as little error as possible. The values were then entered into the fluid heat transfer formula $\dot{Q} = \dot{m}c\left(T_{return} - T_{supply}\right)$ from which the heat transfer for each point was calculated. An uncertainty analysis was conducted to evaluate the range of accuracy.

A mathematical model was also constructed, which resembled the same dimensions as the injection moulding machine under investigation. The injection and clamping unit schematic was created and split into nodes, as shown in Figure 1. Each node has a unique equation which is built up from the conservation of energy. The transfer of heat is calculated using a resistance network technique and solving using a finite-difference method. Many assumptions had to be taken such as the dimensions of the screw and shear heating generated due to the rotation of the screw. The barrel heaters were modelled as in reality, but the model did not simulate the movement of the carriage while injecting the melt.

Results and Achievements

The experimental results showed that the heat sink of the cooling system is of about 600W. It was also calculated that the thermistor measurements have less uncertainty when compared to RTD's. These results were compared to another data logger connected to the machine, as well as values outputted by the machine's computer. All the values agreed with a maximum of 10% variation. To reduce the uncertainty of the sensors, a bigger machine could be used so the supply and return temperatures have greater variations.

The mathematical model showed that the barrel heaters worked effectively while heating the system, but still has some losses in the ambient air. On the other hand, it showed that only a total of 30W was being lost in the cooling system. This big difference is due to some inaccuracies in the dimensions and difference in material properties. From the sensitivity analysis carried out, it resulted that the most influential boundary conditions were the ABS temperature entering the system and the shear heating generated by the screw. Further work can be done on the model to incorporate the true dimensions of the screw and actual values of heating due to shearing effects.

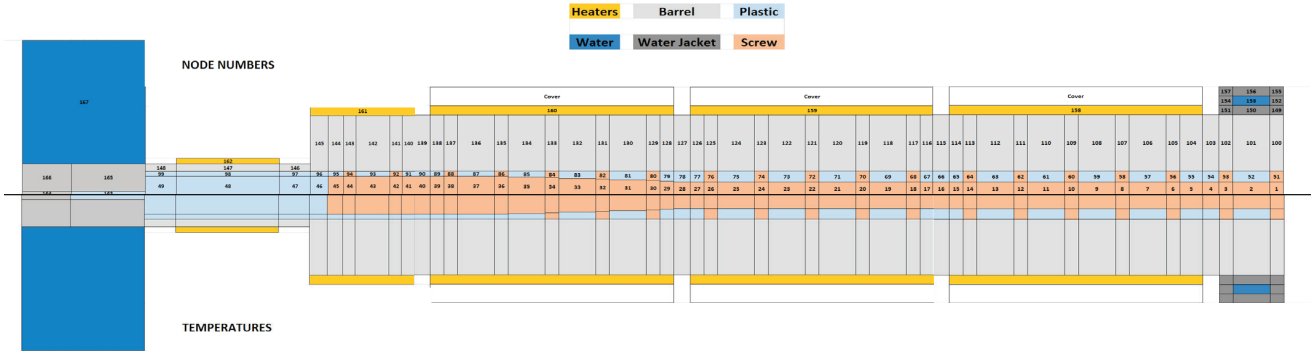

Figure 1: Mathematical Model Schematic

Aerodynamic Cooling of Rotating Devices

Student: Nicholas Pace / Supervisor: Dr Simon Mizzi

Introduction

Aerodynamic cooling is the study of the flow of air around the object of interest with the primary focus on how heat is dissipated from the object. The cooling performance is monitored mainly by the rate of heat dissipation. The rate of heat dissipation can be increased by modifying or improving the aerodynamic conditions around the object.

Project Objectives

The scope of this project was to carry out a thorough study on aerodynamic cooling and identify available computational fluid dynamics (CFD) modelling techniques for heat transfer, with specific emphasis on the applicability of such methods for high velocity axial gas turbine discs.

Project Methodologies

Three main CFD modelling techniques were identified for modelling heat transfer, namely conjugate heat transfer (CHT), coupled and non-coupled analysis. The validity or otherwise of two of these CFD modelling techniques (CHT and coupled) was investigated via the use of Ansys Workbench. Two relatively simple scenarios were considered; (i) flow over a flat plate and (ii) a disc rotating in still air. The procedure consisted of creating the geometry, generating the mesh and setting up the boundary and initial conditions. Following this, a conjugate heat transfer analysis was carried out on a more complex geometry with conditions similar to that of a gas turbine disc of the aerospace industry.

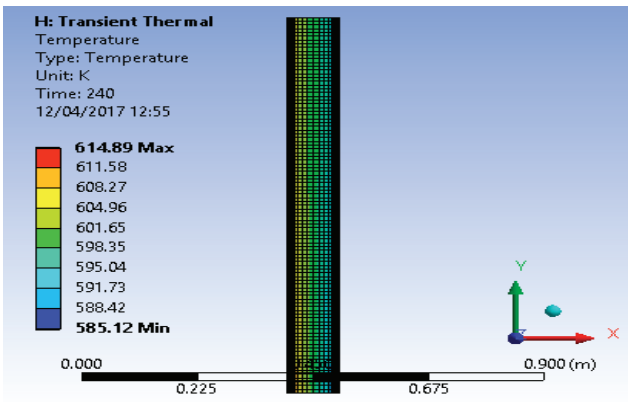

Figure 1: Coupled Analysis of Flow over a Flat Plate

Results and Achievements

Regarding the initial validation of the software, results outputted by Ansys were analysed and compared with readily available experimental or analytical data. For the two simple geometries considered, the results were sufficiently close to justify the use of CHT and coupled analysis for heat transfer modelling under both steady state and transient conditions.

For the CHT analysis on the gas turbine disc, the model was tested and analysed both in steady state and transient conditions. Whilst modelling in steady state conditions was successful, modelling transient conditions proved to be more difficult owing to the unsteady nature of the flow and the significant length of time required in generating a solution. However this is in direct accordance with the study carried out

References

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[2] Incropera F.P., Dewitt D.P., Lavine A.S. and Bergman T.L., 'External Flow in Fundamentals of Heat and Mass Transfer' Wiley and Sons, Jefferson City, 2011.

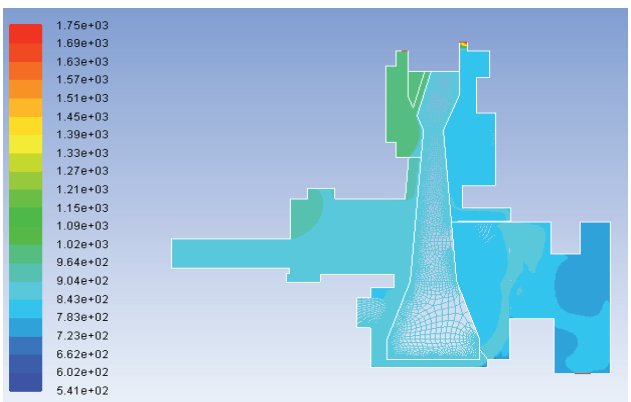

Figure 2: CHT analysis of Axial Gas Turbine Disc

Experimental Testing of a UAV Propeller

Student: Anthony T. Saliba / Supervisor: Prof. Tonio Sant / Co-Supervisor: Dr Ing. Philip Farrugia

Introduction

Unmanned Aerial Vehicles (UAVs) [1] are developing rapidly. The success of these aircraft depends on components such as the propeller since the speed, endurance and the payload capacity are affected directly. Design and selection of small scale propellers requires reliable knowledge and data. Research has to be performed to understand and model the fluid mechanics of small scale propellers.

Project Objectives

This project developed an experimental testing setup to measure performance parameters of small scale propellers concurrently, namely thrust, torque and rotational velocity. The 3D geometry of a small scale propeller was also obtained via a reverse engineering procedure.

Project Methodologies

Figure 1 shows the test setup developed. The propeller thrust and torque were measured using beam type load cells. The rotational velocity was obtained by measuring the frequency of the motor supply signal. Data was acquired using an Arduino Uno board which also controlled the motor speed signal. The test setup was tested using an APC Thin Electric 9x4.5 propeller in both static and non-static tests.

The propeller was scanned to obtain the 3D geometry. The cross sectional geometry as shown in figure 2, was obtained using Autodesk Inventor and a spreadsheet with various VBA functions was developed to determine the characteristics of the cross sectional geometry.

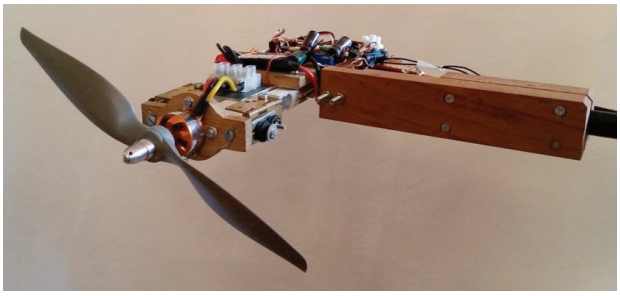

Figure 1: Experimental testing setup

Results and Achievements

The test results agree with the results obtained in other projects [2]. Effects due to electrical interference were observed in both static and non-static tests. Results show that the circuitry suffered from parasitic inductance and capacitance and the torque measurement suffered from electro magnetic interference due to the wind tunnel operation. The project has successfully developed a measurement system at a significantly low cost.

The propeller blade cross section characteristics obtained via the reverse engineering process matched with the data obtained by another method [2]. The reverse engineering process performed in this project allows future projects to analyse mathematical models.

Future work can improve the measurement system by eliminating electrical interference. Various tests can be performed to obtain the performance data of multiple small scale propellers and investigate Reynolds number effects. Research can extend to investigate contaminated propellers such as dirt contamination or ice formation.

References

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[2] Brandt J., "Small-Scale Propeller Performance at Low Speeds", Master's thesis, Department of Aerospace Engineering, University of Illinois at Urbana- Champaign, Illinois, 2005.

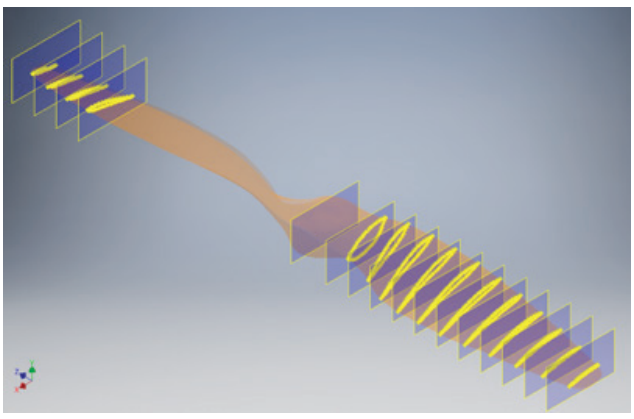

Figure 2: 3D model of propeller

Solar Assisted Heating Ventilation and Air-Conditioning

Student: Julian Sammut / Supervisor: Dr Ing. Christopher Micallef

Introduction

As years go by the amount of electricity being consumed is increasing at a fast rate. One of the sectors consuming a considerable large amount of electricity is air-conditioning. Thus renewable energy systems have been developed. In this project a solar assisted air-conditioning unit kindly donated by a local distributor was analysed.

Project Objectives

This final year project investigates the effect that a solar assisted air-conditioning system has on the Coefficient of Performance. The objectives were to repair and analyse the system, build and test an experimental setup to test the efficiency of the solar assisted air-conditioning unit.

Project Methodologies

The solar assisted air-conditioning unit consists of the same components of a normal air-conditioning unit, which are a compressor, condenser, evaporator and a throttling device working on a vapour compression cycle. The main difference to that of a conventional air-conditioning unit is that a solar water tank is included after the compressor and before the condenser. In order to analyse the Coefficient of Performance (COP) of the system, experiments were conducted under three different conditions.

1. System operating as a normal air-conditioning unit (no water tank)
2. System operating with water tank (no water flow)
3. System operating with water tank (flowing water)

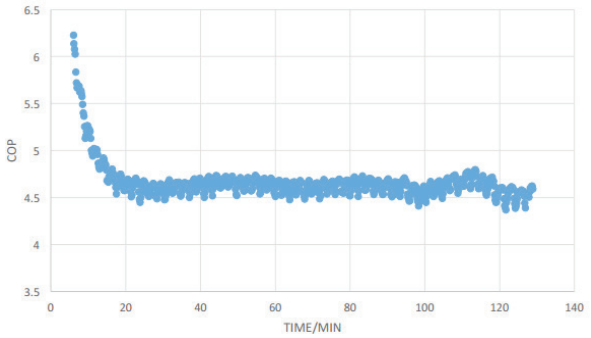

Figure 1: A Graph of COP vs Time for a system operating with water tank (flowing water)

Results and Achievements

In the first experiment the system was analysed as a normal air-conditioning unit, obtaining a COP of 3.70 ± 0.05. In the second experiment the water tank was included, having stagnant water inside.
As the refrigerant passed through the water tank, heat exchange between the refrigerant and the water took place. Thus increasing the water temperature. A COP of 4.10 ± 0.05 was obtained. In the last set of experiment, a constant flow of water through the water tank was present, thus the temperature in the tank remained low. The COP obtained was 6.25 ± 0.05 at the beginning of the test when the temperature was 20ºC and 4.60 ± 0.05 when the temperature reached a steady state conditions of 25ºC. From the results obtained it was concluded that the lower the water tank temperature inside the water tank the better the value of the COP. Therefore, the system becomes more efficient. This can be clearly seen in Figure 2, where a graph of COP vs Water Tank Temperature is shown. The values of COP obtained and those given by the manufacturer were compared, where the manufacturer claimed a COP between 3.70 and 7.99. From the results obtained it can be said that the high COP values claimed by the manufacturer can only be achieved if a low water tank temperature is used. Hence a use for the water flowing must be found, else the system won't remain cost effective.

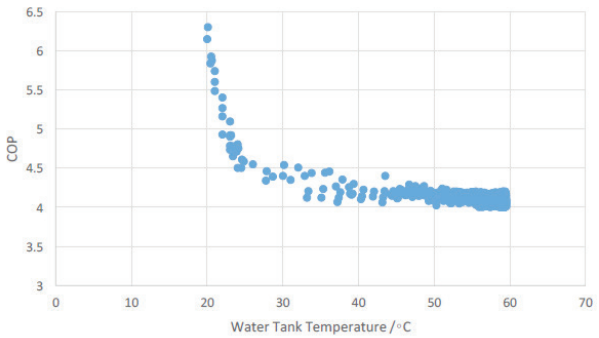

Figure 2: A Graph of COP vs Water Tank Temperature

Free-Piston Engine

Student: Ryan Sammut / Supervisor: Prof. Ing. Robert Ghirlando

Introduction

The extensive use of fossil fuels as an energy source is leading to research to design and promote more environmentally sustainable technologies. Free-piston engines have been investigated to serve as alternative devices to generators, to power hybrid cars and for the production of hydraulic power in off road vehicles.

Project Objectives

The main objectives of this project were to review the work carried out by past students, to improve the engine by replacing and redesigning certain components, and to test the engine to assess the effects of the modifications carried out on the engine.

Project Methodologies

Due to the cylinder bore and piston rings flaws present in the engine cylinder blocks, new ones were sourced to eliminate completely these problems. In order to cater for this modification, a number of engine components such as the cylinder flanges, cylinder heads and the piston adapters had to be redesigned and machined from scratch.

Once all the parts were ready, these were assembled to the engine while making sure that each one was aligned properly. Once the engine was assembled, the stroke was adjusted in order to achieve the required compression ratio, and other engine parameters such as the scavenging ratio and crankcase ratio were calculated to compare with previous values.

A number of trials were carried out to test the starting capabilities of the free-piston engine and to test its reliability. Compressed air was supplied to the engine compressor in order to start the piston motion and fuel was injected to check whether there was enough flow through the cylinder transfer ports and to check whether fuel combustion was achieved. Due to a relatively slow engine stroke speed, the supply pressure to the compressor was increased from 6.5 to 8.5 bars so as to achieve a higher stroke speed and to improve the fuel flow through the inlet manifold to the engine.

Results and Achievements

When fuel was injected manually to the intake ports with a syringe, a number of consecutive combustion cycles occurred successfully. Once the intake manifold was assembled to the engine, the slow speed created a back pressure which prevented the fuel from reaching the engine. The decision to increase the supply pressure to the compressor proved to be helpful to reach proper fuel flow.

Even if these changes were not enough to achieve an engine start, a list of possible improvements was created which would help in improving the engine even more so as to reach the desired final working conditions.

Figure 1: Free-Piston Engine

Optimisation of Hull-Propeller-Rudder Interaction

Student: Matthew Schembri / Supervisor: Dr Simon Mizzi

Introduction

Over the past years the shipping industry has faced multiple challenges with regard to increases in fuel prices and stringent regulations that seek to reduce harmful fuel emissions. The design of a vessel that requires less power at normal operating conditions is thus the aim of any ship designer.

Project Objectives

The interaction between the hull, propeller and rudder systems was studied with the aim of finding the optimal shape and dimensions of the three systems, ultimately decreasing the power required to operate. To arrive at an optimal solution, three objectives were sought. The first two objectives were to minimise ship resistance and maximise propeller efficiency at the cruising speed. The third and final objective was to have a vessel that has exceptional coursekeeping (directional stability) characteristics when cruising while at the same time having a rudder that facilitates ship steering at lower speeds.

Project Methodologies

Ship resistance was minimised by analysing the hull in order to determine which regions have the most impact on the resistance. Propeller efficiency was maximised by using performance charts that give the advance speed, thrust, torque and efficiency of the propeller. Coursekeeping and manoeuvrability characteristics were assessed by determining the moment produced by the rudder. When cruising, the rudder had to have a moment value close to zero in order for the vessel to be directionally stable. On the other hand at lower speeds, the rudder had to produce a large turning moment in order to initiate the steering of the vessel.

To attain the above mentioned objectives a design of experiments (DoE) was created using *ANSYS*. *ANSYS*, through *VBA* (*Excel* programming language), would use *Maxsurf Modeler* to vary the hull shape in an automated fashion. The hull would then be imported to *Maxsurf Resistance* where vessel resistance is calculated.

In order to utilise the propeller performance charts, these charts had to be digitised and this was done by using *Engauge Digitizer*. Once digitised, a propeller code was written that would find the optimal propeller efficiency based on the information given by the performance charts.

The final step in creating the design of experiments was to find the rudder shape that would satisfy the coursekeeping and manoeuvrability criteria. These two criteria were assessed by using experimental data and *XFLR5*, which is an analysis tool for aerofoils, where the aim was to minimise rudder moment at cruising speed while maximising rudder moment at a lower speed. Once having acquired all the data for the DoE, a response surface which fits the points from the DoE was created. After which, an optimisation process was carried out.

Results and Achievements

From the optimisation study carried out, a 15.1% decrease in power requirement was obtained when compared to a previous study which, in the maritime industry, is a massive improvement that would lead to substantial fuel savings over time. This decrease in resistance was achieved by means of a design of experiments created in *ANSYS* which, through an optimisation process, yielded the minimum resistance and therefore minimum power requirement. At the same time propeller efficiency and rudder manoeuvrability were also considered and the respective objectives were met.

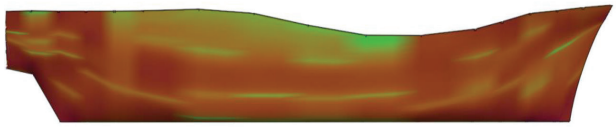

Figure 1: Optimised Ship

Fluid Flow Measurements in Rotating Channels

Student: Ryan Vella / Supervisor: Dr Christopher Micallef / Sponsor: Cummins Generator Technologies UK

Introduction

Electrical components are becoming more complex and compact in a wide range of applications. Many applications are subject to large rotational speeds such as turbomachines. The consequences are inefficiencies and high temperatures due to thermal and vibration stresses. In this project, fluid velocities in rotating channels situated on a generator rotor were measured to investigate the cooling airflow.

Project Objectives

An improvement was developed from previous years to measure fluid flow. The objectives include a better means of data acquisition using Bluetooth technology from data gathered by hot wire anemometry and analysis on how the whole setup operates on an alternator.

Project Methodologies

A literature survey was carried out to study previous works of fluid flow in rotating ducts as well as hot wire anemometers. Four hotwire anemometer circuits were built and connected to a microprocessor and Bluetooth module. This enabled digital data to be recorded on an external device. A housing to accommodate the electronic circuits was designed and constructed using plastic acetal. It was designed in such a way as to minimize airflow obstruction and hold the electronic circuits safely in place whilst being rotated at high speeds. A test bed accommodating the generator and driving motor was designed using Finite Element Techniques and built, as shown in Figure 1. Calibration of the instruments was performed in the wind tunnel. The hotwire sensors were then mounted in the generator rotor channels to measure the airflow velocity. Velocity measurements were also taken between the frame and stator using pitot static tubes. The total air flow rate through the generator was calculated by integrating pitot static velocity measurements over the duct outlet area.

Figure 1: Test Rig Setup

Results and Achievements

The wireless instrumentation setup was successful in collecting valid results. The hot wire measurements in the rotating channels show that at 1500 RPM, the velocity was 17 m/s, while at 1800 RPM the velocity was 23.5 m/s. This compares well with the CFD analysis results conducted by the sponsor. The tests were again made with the channel inlets blocked, thus inhibiting air from flowing through the generator rotor channels. The results were 0.633 m/s and 0.638 m/s for 1500 and 1800 RPM respectively. The results are shown in Figure 2. This guarantees that the hot wire probes were indeed measuring the fluid velocity rather than sensor deformation due to centrifugal forces. Pitot Static velocity measurements were taken between the frame and the stator showing an average velocity of 13.506 m/s and 15.767 m/s at 1500 and 1800 RPM respectively. The total air flow through the generator was measured at 0.234 m^3/s and 0.321 m^3/s at 1500 and 1800 RPM respectively.

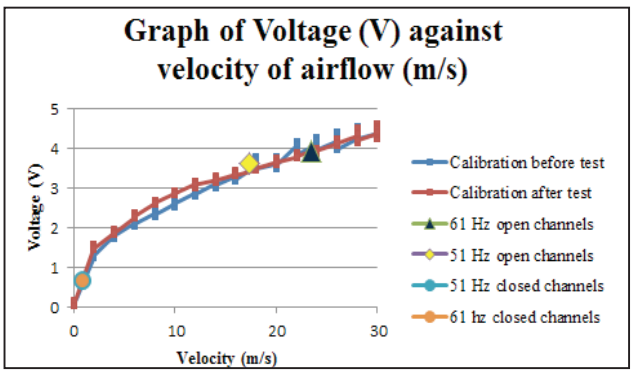

Figure 2: Hotwire Calibration curve and Results

Design by Rule (DBR) Small Craft Construction

Student: Annelise Zammit / Supervisor: Prof. Ing. Claire De Marco

Introduction

With an increase in the number of small crafts for recreational or working purposes, the aim is to create two programmes to be used by boat builders and designers during preliminary design. The small craft design will be suitable for crafts with a length overall between 2.5 and 24 metre fabricated from fibre reinforced plastic (FRP) or sandwich composites registered to operate in the Maltese territorial waters.

Project Objectives

Scantling rules [1] along with the BS EN ISO 12215-5 small craft code [2] were to be used as guidelines and rules and regulations respectively. Using the mentioned two tools, a *Scantling Analysis* and *Rules and Regulations Analysis* programme were created.

Project Methodologies

The user is required to input the basic data available in the programmes. Results are then computed via analytical equations assigned to cells providing automatic computations. Comments regarding whether values pass or fail criteria are generated by implementing Macros using Visual Basic Applications (VBA) [3]. Figure 1 provides a flowchart of the *Scantling Analysis* programme which calculates dimensions for the hull components. Figure 2 shows the *Rules and Regulations Analysis* programme flowchart which ensures compliance with the small craft code [2]. Validation of both programmes was first required to analyse the programme's results using two previously studied crafts. A craft was then analysed to ensure certification and

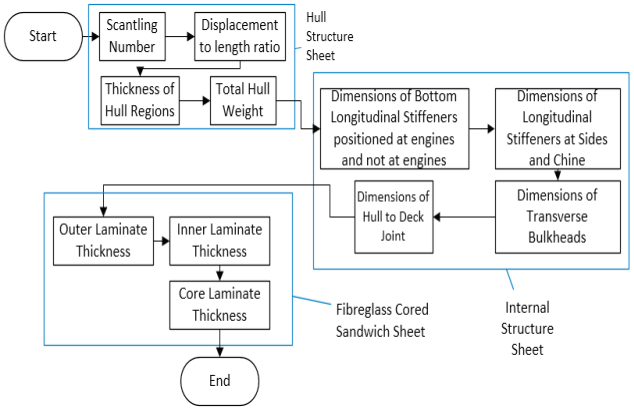

Figure 1: Scantling Analysis programme flowchart

Results and Achievements

Validation of the programme was carried out by analysing three different small crafts. The first two analysed crafts were previously studied planing crafts. First, the dimensions obtained via the *Scantling Analysis* programme were verified by the *Rules and Regulations Analysis* programme ensuring compliance with rules. Similarity between the provided data and programme results of the analysed crafts affirmed that both previously discussed programmes operate correctly.

The third analysed design was provided by a local boat builder with no previous studies. With the programmes being validated by the two previous design studies, analysis of the third design served to determine that the tested craft could be certified by BS EN ISO 12215-5 [2] leading to commercialisation.

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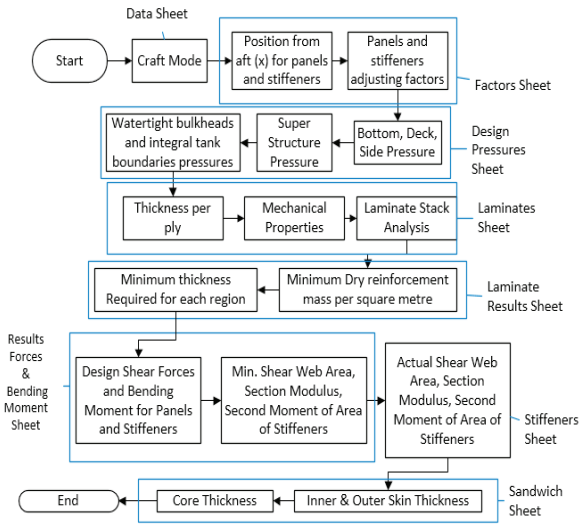

Figure 2: Rules and Regulations Analysis programme flowchart

Aerodynamic Modelling of a Model Wind Turbine using CFD

Student: Julian Zammit / Supervisor: Prof. Tonio Sant / Co-Supervisor: Dr Ing. Chris Micallef

Introduction

Aerodynamic modelling plays a significant role in the design of wind turbines. The prediction of loads on the rotor is particularly important for wind turbines to produce an expected amount of power. Predictions can be made through the use of experiments or through computational methods such as CFD.

Project Objectives

The aim of this project is to generate a CFD model of a small scale wind turbine in Fluent, and to validate this model by comparison to experimental data. A further objective is to extract aerodynamic parameters, namely the angle of attack, lift coefficient and drag coefficient, for a number of blade sections distributed along the radial coordinate.

Project Methodologies

To obtain reliable CFD results, it is essential to produce a mesh which resolves the main flow features. A structured hexahedral mesh, partly shown in Figure 1, was created in ICEM. Solutions were obtained in Fluent for a range of tip speed ratios, using two RANS turbulence models.
The angle of attack of a blade section was found through the velocity components at the rotor disc. Forces were extracted from the CFD data and transformed to lift and drag coefficients. Fluent and MATLAB were used in the extraction of these parameters. In order to establish how the three-dimensional nature of the flow around a wind turbine affects force coefficients, it was necessary to obtain the same aerodynamic parameters using a two-dimensional CFD model of the blade aerofoil.

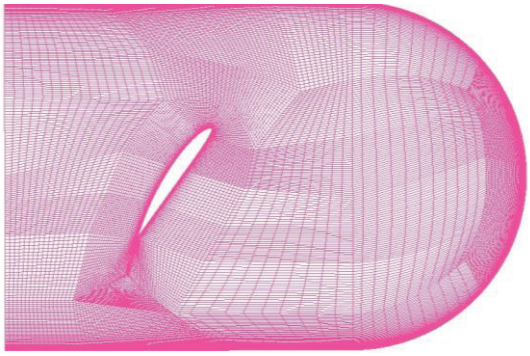

Figure 1: Surface Mesh of Wind Turbine Hub

Results and Achievements

The wind turbine CFD model yielded accurate performance predictions relative to experimental data from previous works [1,2,3]. From this comparison, it was found that at low tip speed ratios, the SST k-omega turbulence model was more effective than the Spalart-Almaras turbulence model.
The two-dimensional CFD model of the S3024 aerofoil was also successfully validated through a comparison with data obtained using XFOIL.
At low angles of attack, the extracted aerodynamic parameters for the blade sections were found to coincide with the data obtained through two-dimensional CFD of the aerofoil. Furthermore it was noted that at higher angles of attack, where stall occurs, the inboard sections experienced an increase in lift. This is a characteristic of stall delay, which is dominant near the root of a blade. At outboard sections the lift was found to decrease, likely due to tip losses. These behaviours are shown in Figure 2.

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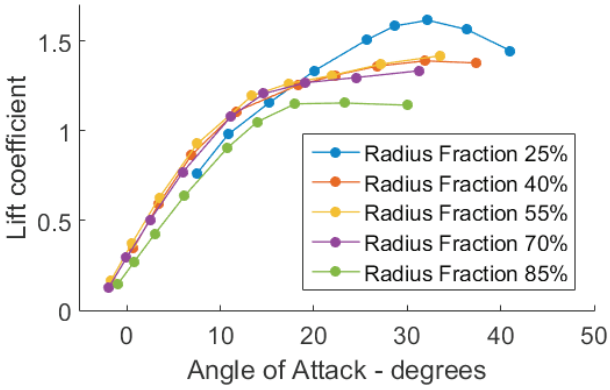

Figure 2: Lift Coefficients at various Radius Fractions

Preliminary Design Concept of a Trimaran

Student: Kristian Zammit / Supervisor: Prof. Ing. Claire De Marco

Introduction

The demand for low resistance high speed displacement crafts used for military, commercial and recreational use is constantly increasing. Due to the ever-rising prices of oil, it is imperative to design ships having lower resistance at operating speeds. The aim of the dissertation is to obtain a preliminary design concept of a trimaran operated as a ferry.

Project Objectives

The objectives are: to obtain a preliminary design of a ferry with a trimaran hull, carry out weight estimation lightship, perform resistance and stability analyses, obtain installed power requirements and create drawings of the final configuration.

Project Methodologies

Firstly, research was carried out on current trimarans available to obtain a better notion of what trimarans offer at present time. Theories regarding weight estimation, resistance, stability and powering were studied and discussed to obtain better knowledge prior to design.

Secondly, a trimaran hull was designed from pre-existing body plans, named MED, by Luhulima, Utama and Sulisetyono [1] while adding alterations to further reduce the resistance. A second trimaran hull was designed from observed hulls to further reduce the resistance while increasing the displacement value and lowering the vertical centre of gravity, named KZ102m. Attention was also given to the route on which the trimaran shall be embarking to, especially to the depth of the ports and the travelling range.

Finally, both hulls were designed in the naval architecture software. Weight estimation was carried out for both hulls together with an analysis to obtain advantages and disadvantages of both hulls. The analysis carried out on both hulls was for the stability and resistance characteristics at different separation and stagger ratios.

Results and Achievements

From the stability analysis, it was concluded that with an increase in the separation ratio, an increase in transverse stability was achieved for both designs. With regards to the stagger ratio, it was concluded that increasing the stagger ratio, moving the side hulls forward, the transverse stability remained the same. No change in transverse stability was expected as the beam also remained the same hence, no increase in the righting lever.

From the resistance analysis, it was concluded that with an increasing the separation ratio, the resistance will decrease. With regards the stagger analysis for resistance, for an increase in the stagger ratio from $\varepsilon = 0.1$ to $\varepsilon = 0.4$, a reduction of 26% in resistance was achieved for both designs.

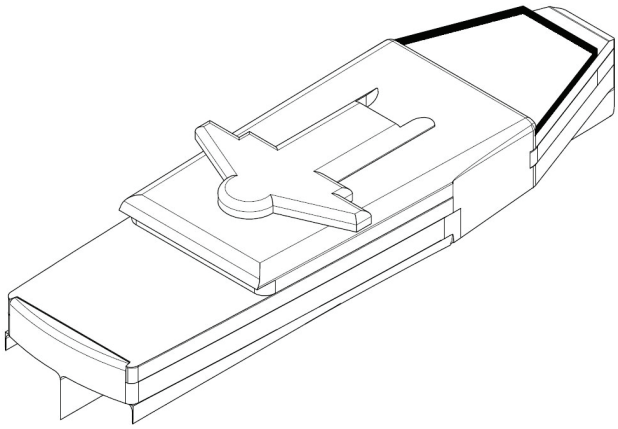

Figure 1: KZ102m 3D model

References

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Paradigm Shift: Fe-Mn Alloys for Biodegradable Implants

Student: Daniel Aquilina / Supervisor: Dr Ing. Joseph Buhagiar / Co-Supervisor: Dr Ing. Glenn Cassar

Introduction

Fe-Mn based alloys are one of the most promising potential candidate materials for biodegradable metallic implants mainly due their moderate corrosion rate (higher than pure Fe and lower than pure Mg) and antiferromagnetism. Thermomechanical treatments can be used to modify the material's properties depending on application [1].

Project Objectives

The aim was to characterise the effect of cold rolling on Hadfield (Fe-Mn-C) steel alloy in relation to mechanical properties, phase texture evolution and corrosion response in protein and non-protein containing Hanks' solution.

Project Methodologies

Three different material conditions were investigated; as-received hot rolled and annealed, 10% and 20% cold rolled conditions.

X-ray diffraction, optical microscopy, hardness and chemical analysis were used for basic material characterisation. Potentiodynamic testing was used to investigate the corrosion response in protein and non-protein environment. Electron Back scattered analysis was used to analyse the effect of cold work in relation to phase texture evolution.

Results and Achievements

The Hadfield steel alloy characterised was identified as a twinning induced plasticity (TWIP) alloys. XRD and EBSD analysis confirmed that material remains fully austenitic after cold work. This confirms that cold working will not have an effect on the antiferromagnetic properties on TWIP alloys hence does not compromise their use for biodegradable implants as they remain MRI compatible.

EBSD texture analysis did not produce any significant results. It was concluded that the materials rolled at a higher percentage reduction is required for an in-depth texture analysis.

Figure 1 shows the corrosion rate in mm per year obtained from potentiodynamic testing. This shows that an increase in cold rolling reduction was accompanied by an increase in degradation rate. Statistical analysis using Kruskal Wallis H-test showed that addition of bovine serum albumin had no significant effect on the degradation rate.

The corrosion mechanism for this alloy was identified as galvanic coupling between grains of varying orientation and intragranular corrosion between plastic deformation defects and the rest of the grain.

This study concluded that TWIP Hadfield steel has a much lower degradation rate than that required for biodegradable implants applications. This study attributed the low corrosion rate to two main reasons;

the formation of corrosion layer on top of the based material and;
the corrosion mechanism not being effective enough for accelerated degradation.

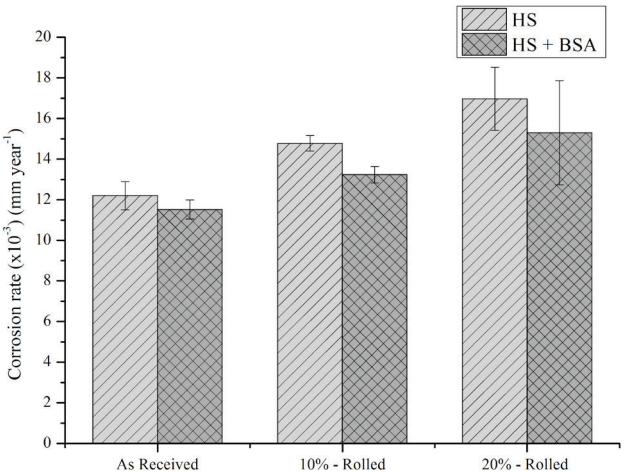

Figure 1: Graph of corrosion rate (mm year $^{-1}$) in Hanks' and Hanks' + BSA with standard error bars

References

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Defect and Damage Tolerance of PVD Coatings for Medical Implants

Student: Jeanelle Arpa / Supervisor: Dr Ing. Bertram Mallia

Introduction

Physical Vapour Deposition (PVD) is used for the application of thin, hard coatings to tailor surface properties of different components. Although effective, PVD coatings present their own challenges. Omnipresent deposition defects and incurred damages, such as cracks and perforations, are well known for instigating localized attack when operating in corrosive environments such as the human body [1, 2]. A better understanding of their contribution to implant failure is thus needed.

Project Objectives

The aim of this dissertation was to assess the electrochemical behavior of four PVD coatings on 316LVM: single layer Cr-C and Cr-N, and duplex layer Cr-C/Cr-N and Cr-N/Cr-C. The coatings' performance with the limitations of deposition defects and incurred damages was tested under static conditions. The role of deposition defects during tribocorrosion testing was also explored.

Project Methodologies

The coating surfaces were characterized to determine defect type and density. Different coupons were then deliberately damaged using a Rockwell C indenter, or perforated by a ball cratering machine. The damaged coatings were subjected to corrosion testing in simulated body fluid held at a temperature of 37 °C. Tribocorrosion wear scars were also thoroughly analysed for identification of defects and sites of failure.

Results and Achievements

Defect type was found to be consistent amongst the four different coatings, but varied widely in terms of density, with the duplex Cr-N/Cr-C and Cr-C/Cr-N coatings showing very high values. An example of some of the most common defects is shown in Figure 1. Defect sites were contaminated by foreign particles of Al and Si during coating growth, and they are speculated to promote their formation.

Potentiostatic corrosion testing results on the defective, cracked and perforated coatings suggest that such breaches in the coating do not provide a breakpoint for corrosion resistance under the static conditions examined.

Characterisation of the wear scars however, indicates that deposition defects may have a larger role in coating integrity during tribocorrosion, and may even contribute extensively to blister formation and coating delamination (Figure 2).

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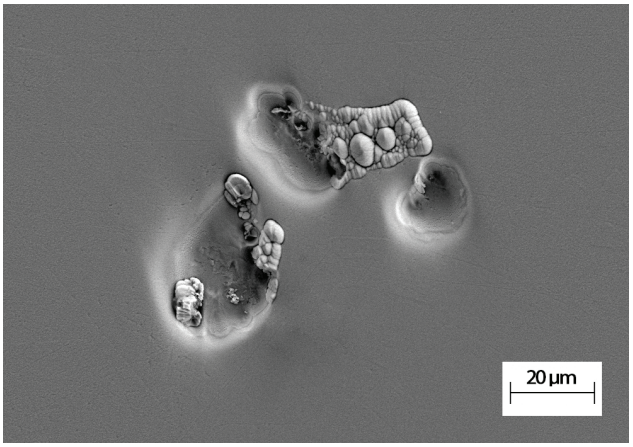

Figure 1: Deposition defects on the PVD coated 316LVM

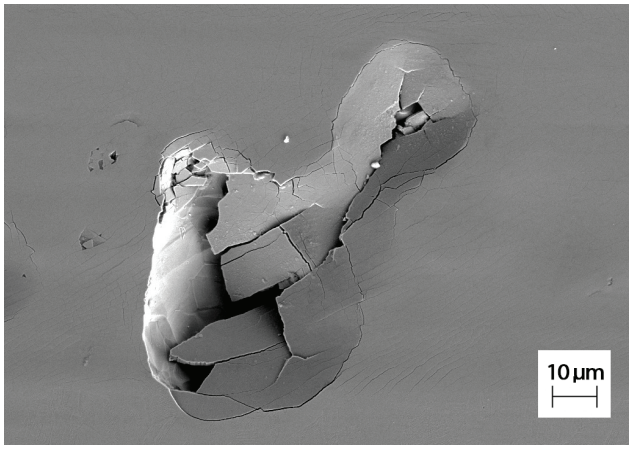

Figure 2: Blistering damage on Cr-N coated 316LVM following tribocorrosion testing

Shape Memory Alloy: Augmentation of Corrosion Resistance by Nitriding

Student: Lisa Asciak / Supervisor: Dr Ing. Joseph Buhagiar / Co-Supervisor: Dr Ing. Glenn Cassar

Introduction

Shape memory alloys such as NiTi are known for their ability of memorizing a predefined shape upon a change in temperature or stress. NiTi has been implemented in various applications, including biomedical devices such as orthodontic arch wires. However, the high nickel content present in the alloy raises concerns due to the possibility of nickel release as a result of corrosion [1].

Project Objectives

The main objective of this project is to improve the corrosion resistance of NiTi by modifying the surface with a diffusion treatment known as PIRAC nitriding. This is then followed by assessing crevice corrosion using a modified crevice corrosion jig and investigating the shape recovery ability after nitriding.

Project Methodologies

The PIRAC conditions used in this study include nitriding at 800 °C for 8 hours with Cr_2N powder (designated as 800T8HCr_2N) and nitriding at 800 °C for 8 hours with TiN powder (designated as 800T8HTiN). Apart from NiTi coupons, NiTi springs were also nitrided under the same conditions in order to be able to assess shape recovery. For PIRAC nitriding at 800 °C for 8 hours with Cr_2N powder, a titanium alloy (Ti6Al4V) reference control was used. The resulting compound layer was investigated using X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) analysis. Hardness and adhesion properties were assessed using nano-indentation and nano-scratch tests respectively.

Pitting corrosion was investigated via cyclic polarization tests. Crevice corrosion tests were conducted using a modified crevice corrosion jig equipped with a serrated crevice washer that was specifically used to initiate crevice. Both tests were performed using Ringer's solution at a temperature of 37 ± 1 °C to further mimic body conditions.

Spring deformation tests were performed by extending the NiTi springs and placing them in a water bath that was heated to various temperatures. Shape recovery was calculated by measuring the lengths before and after deformation.

Results and Achievements

PIRAC nitriding of NiTi was not successful in achieving a golden coloured surface similar to PIRAC nitriding of Ti6Al4V. Instead, the samples in both conditions resulted in a range of colours from dark golden yellow to purple, blue and grey, which indicate that oxidation occurred during the nitriding process.

The surface hardness of PIRAC nitrided NiTi did improve when compared to that of the untreated NiTi. However, the hardness obtained was not as high as that of PIRAC nitrided Ti6Al4V reference control. Shape recovery was indeed affected by the nitriding process, as the springs did not return to their original shape upon heating in a water bath. The 800T8HTiN springs resulted in peeling of the oxide layer as shown in Figure 1.

Potentiodynamic tests and crevice corrosion tests showed that the 800T8HCr_2N did result in better corrosion resistance when compared to the 800T8HTiN sample. However, in both conditions repassivation did not take place.

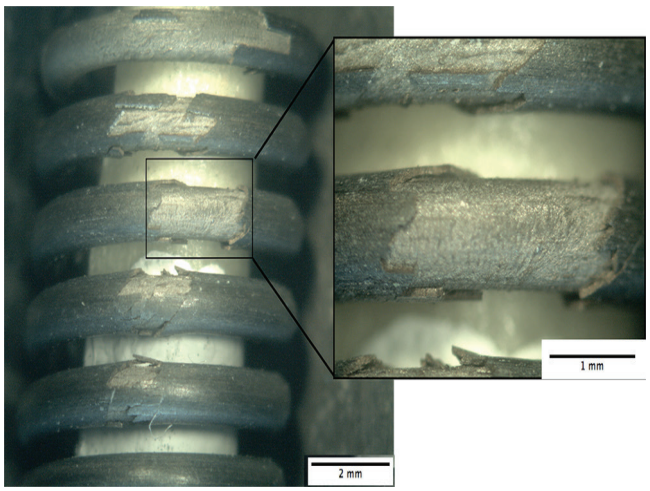

Figure 1: 800T8HTiN spring after deformation tests

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Study of Nitrided and Shot-peened Aerospace-grade Titanium Alloy

Student: Marlon Attard / Supervisor: Dr Ing. Glenn Cassar / Co-Supervisor: Dr Ing. Ann Zammit

Introduction

The demand for lighter, more energy efficient aircrafts promotes the utilisation of light, strong materials such as titanium alloys. However, these alloys suffer from poor wear resistance that limits their application to static structures. Powder Immersion Reaction Assisted Coating (PIRAC) nitriding is one effective surface engineering technique that improves the wear resistance of these alloys by diffusing nitrogen and forming hard compound layers at the surface. Regrettably, recent studies have shown that high temperature nitriding processes may cause a reduction in fatigue resistance [1] – an essential characteristic for materials in use in aerospace applications. Nevertheless, fatigue properties can be enhanced by a cold working surface engineering technique known as shot peening.

Project Objectives

This project aimed at studying the potential effect that combinations of shot peening and PIRAC nitriding have on fatigue properties using a number of characterisation techniques including microscopy, profilometry and X-ray Diffractometry (XRD).

Project Methodologies

Coupons of Ti-6Al-4V alloy were shot peened by air blasting cast steel shots having a diameter of 300 µm at two distinct air pressures, 1 and 3 bar.
Untreated and shot peened coupons were immersed in an unstable Cr_2N (chromium nitride) powder (the source for nitrogen) and enclosed in high chromium stainless steel containers which were heated at 700ºC and 800ºC for 8 hours.

The surfaces produced by shot peening, PIRAC nitriding and hybrid treatments combining both shot peening and PIRAC nitriding, were studied using optical and scanning electron microscopy such that features including the compound layer that was produced by PIRAC nitriding and the plastically deformed surface produced by shot peening could be analysed. The hardness and surface roughness produced by the different treatments were also measured.

The residual surfaces stresses (on which the fatigue strength of a component highly depends) produced on shot peened, PIRAC nitrided and hybrid treated surfaces were measured by X-Ray Diffractometry.

Results and Achievements

PIRAC nitriding successfully produced a compound layer and a diffusion zone of nitrogen in titanium which are shown in Figure 1 (denoted as CL and α-Ti(N) respectively). The golden coloured ceramic compound layers produced by PIRAC nitriding were roughly 35% thicker after hybrid treatments and together with the work hardening effect of shot peening resulted in a maximum of three-fold increase in surface hardness after hybrid treatments as compared to the untreated alloy. An increase in surface roughness was also recorded after both treatments (more pronounced by the hammering effect of shot peening) and their combinations.

Shot peening treatments were successful in creating highly compressed surfaces which were validated by XRD residual stress analysis. However, surface contamination by cast steel shot media drastically increased the oxygen content on the surface, resulting in a negative impact on the subsequently applied PIRAC nitriding treatment.

Apart from inhomogeneities in the compound layer, hybrid treatments led to relaxation of the majority of the beneficial compressive residual stresses created by the shot peening pre-treatment.

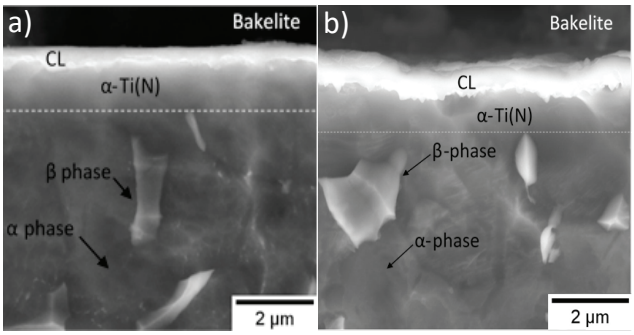

Figure 1: SEM showing the compound layer (CL) and solid solution of nitrogen in the α phase (α-Ti(N)) produced after a) PIRAC nitriding at 700ºC and b) hybrid treatment at 1bar of air pressure and 700ºC

References

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Effect of Austenitising Conditions and Initial Structure on the Microstructure and Mechanical

Student: Marlon Bajada / Supervisor: Prof. Ing. Maurice Grech / Co-Supervisor: Dr Ing. Ann Zammit

Introduction

Austempered ductile iron (ADI) is a material produced by applying an austempering heat treatment on ductile cast iron. This treatment involves heating to the austenitising temperature (normally in the range of 850-950°C) and holding for long enough to dissolve sufficient carbon in the parent austenite. This is followed by quenching to the austempering temperature which is normally between 250 and 425°C, and held isothermally for a controlled time, followed by cooling to room temperature [1]. The resulting microstructure is known as 'ausferrite' which consists of bainitic ferrite and high carbon austenite, figure 1. The microstructure of ADI is determined by the austempering process parameters, which are in turn influenced by the initial structure of the ductile iron. Subsequently the mechanical properties of ADI are dependent on its microstructure.

Project Objectives

This study investigates the effects of the austenitising temperature and time, and seeks to establish a correlation between the initial matrix structure on the mechanical properties and final microstructure of ADI. The main focus is to determine the conditions that contribute to optimum mechanical properties and to investigate the corresponding microstructure.

Project Methodologies

Samples having different initial structures, namely pearlitic, ferritic and a mixture of both were austenitised at different austenitising temperatures (900 and 950°C) for 60 to 360 minutes, and austempered at 360°C for 180 minutes. The impact energy and hardness were measured for each condition and were explained in terms of the corresponding microstructure and kinetics of transformation. X-ray diffraction (XRD) techniques were used to obtain quantitative measurements of the volume fraction of retained austenite and its carbon content. Optical microscopy and scanning electron microscopy (SEM), were used to study the microstructure and fractured surfaces respectively.

Results and Achievements

Increasing the austenitising temperature and time resulted in structures containing fewer and coarser ferrite needles and higher quantities of blocky type retained austenite located between the widely spaced ferrite needles having a relatively low aspect ratio.
Structures having large blocky type austenite grains are less stable than thin austenite grains held between acicular ferrite needles. The former frequently transformed to martensite.
Given the same austenitising conditions, initially pearlitic irons contained higher volume fractions of retained austenite, compared to the initially ferritic and ferritic-pearlitic irons.
The highest impact energies were attained by structures having stable high carbon retained

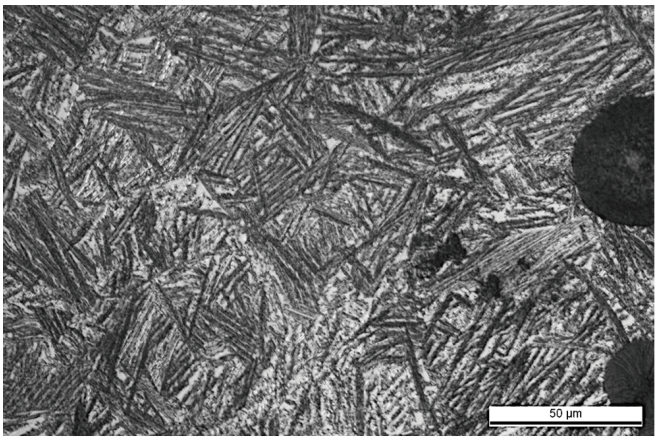

Figure 1: Typical microstructure of ADI having bainitic ferrite needles (dark phase) and high carbon retained austenite (light phase)

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Plasma Arc Surface Modification for Tool Steels

Student: Marvic Cordina / Supervisor: Dr Ing. Stephen Abela

Introduction

To limit the impact on the environment, industries are need to limit the use of lubrication and improve efficiencies of their products and practices. In this pursuit, machine components are subjects to ever increasing normal loads and are yet are required to yield longer lifespans. Diamond-like Carbon coatings are used on several engineering components to provide a potential solution to tribo problems and improve efficiency by reducing sliding characteristics.

However, DLC coatings are often ineffective in dry air and vacuum conditions, without the presence of humidity or oil. Upon exposure to high temperatures, DLC coatings can also be subjected to an increase in friction and wear rates due to the removal of water vapour leading to unpredictable results. Dry lubricants are emerging as promising candidates to be used in favour of liquid and other oil-based lubricants where they offer lubrication at far greater temperatures.

Project Objectives

This study takes a first step towards finding better alternatives at reducing the friction and wear characteristics without the use of Diamond-like carbon coatings, which require expensive vacuum technology and perform poorly with high temperature exposure and in dry air.

Project Methodologies

Plasma arc surface modification, is a treatment which can be performed in atmosphere. The process can be conducted at low substrates temperatures and in various atmospheres. In this study, heat-treated tool steels were immersed in oil and exposed to transferred arc plasma using different feed rates and extents of overlap using a CNC automated plasma torch, as illustrated in Figure 1. After this process, tribological testing of the treated samples was performed using a pin-on-disc tribometer, an instrument which measures frictional forces and wear rates.

The wear tracks of pins and discs were then studied by various techniques including light optical microscopy, Scanning Electron Microscope, Energy Dispersive Spectroscopy, X-ray Diffraction analysis, nanoindentation and using surface profilometry. Information that was obtained from these characterization techniques were used to gain further insight regarding the improvements in the tribological properties obtained by such plasma treatment.

Results and Achievements

Experimental results show that by increasing the exposure to the plasma arc the tribological performance kept increasing up to highest interaction time used. Furthermore, unlike DLC coatings, difference in humidity had no effect on the tribological properties obtained by this surface treatment. An increase in wear resistance of up to 17 times was evident between an untreated sample and another sample which was treated with plasma arc.

In light of these findings, it can be concluded that plasma arc surface treatment, performed in atmosphere, can drastically enhance the tribological properties of a substrate in a cheap and reliable manner.

Figure 1: Plasma Arc Surface treatment

Development of a Novel Coating Process for Alloy Steels

Student: Matthias Debono / Supervisor: Dr Ing. Glenn Cassar / Co-Supervisor: Dr Ing. Joseph Buhagiar

Introduction

Moulds made out of AISI P20 tool steel are generally subjected to gas or plasma nitriding surface modification processes prior to their use in the industry [1]. This is done so as to improve their performance and extend their service lifetime. Inherent disadvantages, such as high capital cost, of both processes, can be overcome with the use of the innovative powder immersion reaction assisted coating (PIRAC) nitriding treatment [2, 3].

Project Objectives

The main project objectives include the setting up of a working PIRAC process able to successfully nitride steel, and also to investigate the effect of varying the principal parameters of the process on the end results.

Project Methodologies

Samples that were subjected to PIRAC nitriding processing can be divided into three groups; as-received material, titanized and Physical Vapour Deposited (PVD) titanium coated. A number of specimens were treated for each condition at temperatures of 525^0C, 600^0C and 800^0C for a duration of 8 h. Other coupons were also treated to investigate the effect of changing additional parameters, such as the bag closing method and the powder quantity. The titanization processing was carried out at temperatures of 600^0C and 800^0C using different titanium powders.

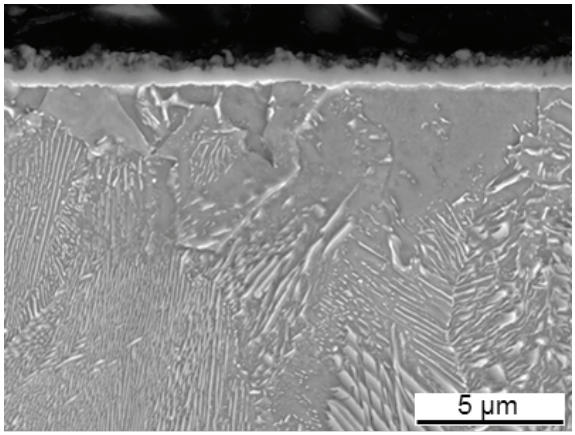

Figure 2: A cross-sectional SEM image of the sample titanized in Ti-6Al-4V powder at a temperature of 800^0C for a duration of 8 h

Results and Achievements

A uniform $TiC_{0.5}$ coating with a thickness of 0.7 µm was obtained on the surface of the sample titanized at 800^0C using Ti-6Al-4V powder, as presented in Figure 1. Microhardness measurements on the surface of the PIRAC nitrided samples in the as-received material and titanized pre-conditions revealed that no significant increase in microhardness was achieved. On the other hand, the PVD Ti coated samples subjected to a PIRAC nitriding treatment achieved a surface coating with a considerably enhanced microhardness due to the formation of titanium nitride phases. Additionally, the PVD coated sample subjected to PIRAC nitriding at 800^0C achieved a surface microhardness in excess of 1500 HKN and a coating rich in TiN, as presented in Figure 2.

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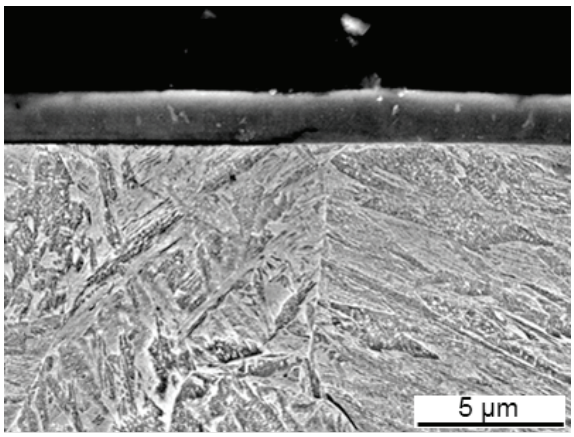

Figure 1: A cross-sectional SEM image of the PVD coated sample after PIRAC nitriding at 800^0C for a duration of 8 h

Silver Steel for Aircraft Jacking Bolts

Student: Bernice Friggieri / Supervisor: Dr Ing. Ann Zammit / Co-Supervisor: Dr Ing. Joseph Buhagiar

Introduction

BS 1407 silver steel is a plain high carbon steel [1] usually used for tooling applications. However, a local company manufactured bolts using this material, with the intention of using them during shoring of the aircraft when carrying out maintenance. However, some problems were encountered after these bolts were heat treated, since they were either not hardening, or cracking.

Project Objectives

The main aim of this project is to assess the suitability of BS 1407 silver steel for aircraft jacking by determining the appropriate heat treatment parameters that will produce strong and crack-free bolts.

Project Methodologies

The bolts were subjected to different heat treatment cycles involving: conventional and interrupted quenching. In order to determine the optimal process parameters, initial tests were carried out on uniform cylindrical specimens. The specimens were first stress relieved at a temperature of 600ºC for 2 hours. Subsequently, they were heated to an austenitising temperature of 820ºC and 800ºC for 30 minutes before quenching in oil at 50ºC and water at 60ºC, respectively. Once it was deduced that the material hardened in water, tempering was carried out where experiments were performed at tempering temperatures between 300ºC and 500ºC for 2 hours followed by cooling to room temperature in air. This was done in order to deduce which tempering temperature resulted in a hardness of around 44 HRC, which was the desired hardness for such bolts. The optimal process parameters were then used to heat treat the actual bolts. In an attempt to reduce the thermal shock, the interrupted quench (martempering) followed a similar thermal cycle as the conventional quench with the difference that after being brought to the austenitising temperature, the bolts were transferred to a salt bath at 250ºC, where they were held for 5 minutes before being quenched in water.

Throughout the process, material characterisation was carried out, which involved microscopy, X-ray Diffractometry, and hardness measurements, to determine the optimal heat treatment process parameters.

Results and Achievements

When BS 1407 silver steel was quenched in oil, it did not attain the desired hardness. This was attributed to the quenching rate not being fast enough to produce a hard martensitic microstructure. Hence, the quenching medium was changed to water in order to apply a faster cooling rate. Results showed that BS 1407 silver steel can only achieve high hardness values upon being quenched in water. This increase in hardness is significant when compared to the hardness attained upon stress relieving, which is equal to 16±2 HRC. In fact, the hardness attained upon quenching in water at 60ºC was that of 57±4 HRC, which decreased to 44±2 HRC after tempering at 450ºC.

It was observed that the bolts that were subjected to an interrupted quench resulted in a lower hardness of 32±4 HRC, which is not suitable for this application.

Both the conventional and interrupted quenches resulted in the formation of cracks on the bolts, which initiated from the threads and prolonged along the bolt's shank as can be observed in Figure 1.

Since cracks always seemed to originate from the threads, it can be concluded that either the silver steel material is not suitable for the application or else there needs to be a change in thread design.

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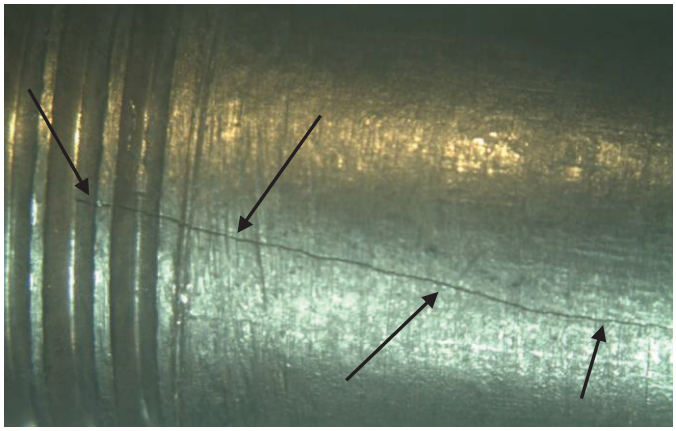

Figure 1: Crack on Bolt Shown With the Aid of Arrows

Enhanced Protective Oxide Barrier for Steel and its Alloys

Student: Jonathan Mercieca / Supervisor: Dr Ing. Stephen Abela

Introduction

Steel is one of the most widely used engineering materials: however, it offers little natural resistance to electrochemical corrosion, necessitating the use of various methods to prevent corrosion in most applications. This project investigated the use of a plasma coating process for steel to form an oxide layer on the surface, in an attempt to passivate the surface and prevent corrosion. An adequately dense and thick oxide coating would act as a barrier to atmosphere, preventing the formation of the required conditions for electrochemical corrosion to occur. This is the same mechanism that naturally occurs on aluminium, and is often augmented by anodisation.

Project Objectives

- Processing a number of samples using different parameters
- Characterization of the coating formed to understand the process
- Corrosion testing to identify the coating effectiveness

Project Methodologies

Mild steel samples were treated using a plasma arc generated at 7 KV in air. The electrode was manipulated by a CNC machine to traverse and coat the entire surface of samples being tested. The number of times samples were processed by the plasma torch was varied, allowing for comparison of results obtained by processing up to four times.

The treated samples were analysed using optical microscopy, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and X-ray diffraction (XRD), to characterise the coating formed.

Potentiodynamic testing was performed on treated samples in a 3.5 weight percent NaCl solution to identify the corrosion characteristics of the treated samples.

Results and Achievements

The results of XRD testing showed that both Magnetite (Fe_3O_4) and Wüstite (FeO) were formed at the surface of the samples, with magnetite being the most prominent oxide. This oxide layer was found to be uneven and very thin, with some regions of the surface achieving no measurable coverage. In addition, a number of pits of varying sizes as well as melt pools of steel were formed on the surface, as seen in Figure 1. Performing additional processing runs on the surface was found to increase the number of pits, with no significant change to the extent of the oxide coverage.

Results of corrosion testing, shown in Figure 2, illustrate that processed samples have an increased corrosion rate of 5.43 µm/yr when compared to the corrosion rate of 2.28 µm/yr of untreated steel samples, and that there is a slight increase in corrosion rate with additional runs. This increased corrosion rate of the processed samples is believed to be due to the uneven oxide layer resulting in pitting corrosion on the surface of the samples.

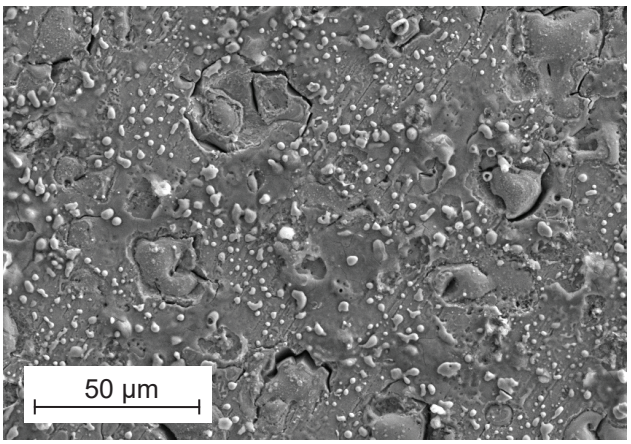

Figure 1: SEM image of resultant surface

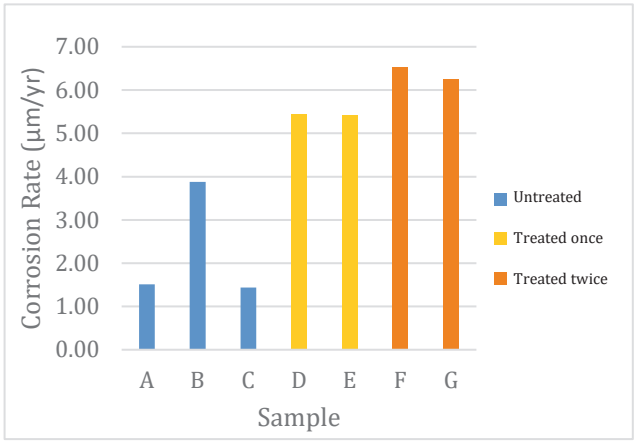

Figure 2: Comparison of corrosion rates

Surface Characteristics of Shot Peened and Laser Shock Peened Austempered Ductile Iron

Student: Matthew Pace / Supervisor: Dr Ing. Ann Zammit

Introduction

Ductile Iron (DI) is a ferrous alloy which offers various advantages, including low melting temperatures and excellent machinability, hence being a potential candidate for several components in the automotive industry. The properties of DI can be improved by an austempering heat treatment to produce Austempered Ductile Iron (ADI). The microstructure of ADI is shown in ***Figure 1***. Depending on the austempering heat treatment process parameters, ADI offers a combination of excellent properties, such as high tensile strengths and good ductility [1]. Several surface engineering process can be performed on ADI to further improve its surface characteristics, two of which include shot peening (SP) and laser shock peening (LSP). SP consists of bombarding the surface of the material with shots while LSP consists of a pulse hitting the surface of the material by the high power intensity and laser shock waves generated. Both SP and LSP usually result in an increase in the surface hardness of the material and induce residual compressive stresses at the materials surface. In turn, this results in a prolonged life of the component [2, 3].

Several studies have shown the influence of shot peening on ADI, however no research has yet been carried out to understand the effect of laser shock peening on ADI.

Project Objectives

The objectives to be achieved through this dissertation included the development of a literature review on previous studies regarding shot peening and laser shock peening, and the characterisation of the surface characteristics of shot peened and laser shock peened ADI.

Project Methodologies

ADI specimens were produced using an austenitising temperature of 900°C for 2 hours and an austempering temperature of 360°C for 1.5 hours. SP was done using S110 steel and Z300 ceramic shots at a pressure of 2 bar. LSP was done with a laser energy of 5 and 10 J, using beam sizes of 3, 5.5, 7.5 and 9.5 mm, at 0 and 50% overlap.

The resultant microstructure and phase changes in the ADI specimens were analysed by metallography, X-ray diffractometry, and also by carrying out hardness and surface roughness measurements.

Results and Achievements

The results attained indicate that shot peening of the ADI specimens resulted in phase transformation of retained austenite which was present in the as-austempered structure to martensite. However, following the laser shock peening treatment, this phase transformation did not take place and the austenite in the as-austempered specimens was retained. Moreover, shot peening caused an increase in the surface microhardness of 42% and 34% when peening with the ceramic shots and steel shots respectively. On the other hand, the attained hardness of the laser shock peened specimens was the same as the as-austempered specimens. Finally, laser shock peening resulted in a surface which was approximately two times rougher than the shot peened surface. The higher surface roughness attained by laser shock peening was due to the surface graphite nodules getting detached from the surface. Further research is necessary to improve the parameters with regards to laser shock peening of ADI in order to improve its characteristics when compared to the as-austempered state.

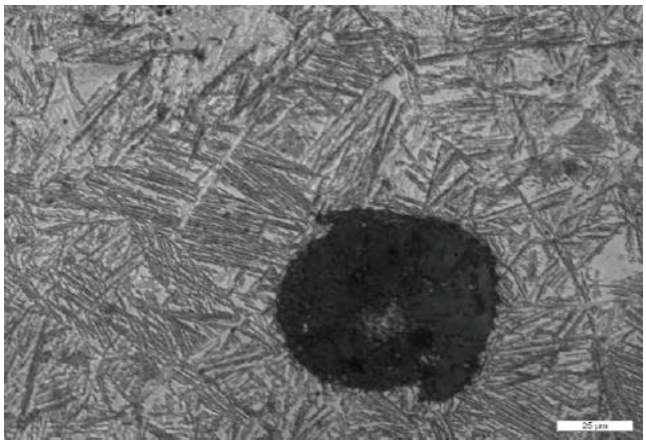

Figure 1: Microstructure of ADI consisting of nodular graphite dispersed within a matrix of acicular ferrite (dark needles) and retained austenite (light areas)

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Tribocorrosion Response of CrSiN PVD Coated 316LVM Biomedical Stainless Steel

Student: Luke Scicluna / Supervisor: Dr Ing. Bertram Mallia

Introduction

In this study, the tribocorrosion response of CrSiN coated AISI 316LVM prepared using Physical Vapour Deposition (PVD) was investigated. The main scope of this study is to better understand the tribocorrosion damage mechanisms of the CrSiN coating and comparing it with U/T 316 LVM stainless steel.

Project Objectives

This work aims to evaluate the tribocorrosion response of U/T 316LVM, and CrSiN coated 316 LVM samples. The tribological behavior of the two are compared to get better understanding of the behavior of stainless steel coated materials in an environment mimicking the human body.

Project Methodologies

In this work, AISI 316LVM stainless steel was used as substrate material. The samples were prepared to a mirror finish before being CrSiN coated using magnetron sputtering PVD. X-Ray diffraction was used to analyse the crystalline phases in both treated and U/T samples.

Nano-indentation testing was carried out using NanoTest 600 that uses a Berkovich diamond indenter. The deformation behavior and adhesion of the CrSiN coatings was studied by nano-scratch testing. The scratch scar was imaged using SEM to study the coating behaviour.

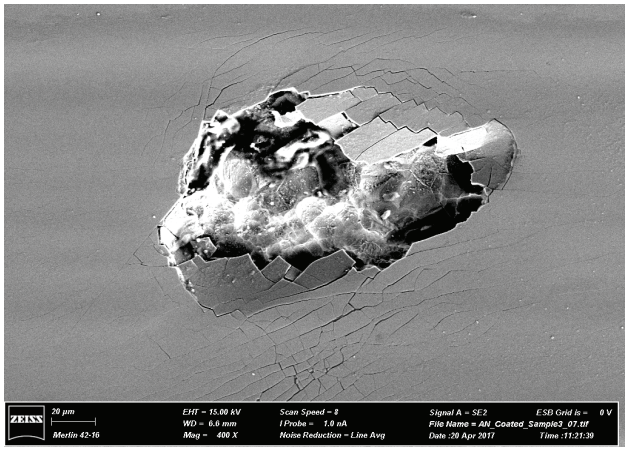

Figure 1: SEM images depicting blisters on the wear scars following tribocorrosion tests under anodic conditions

Electrochemical potentiodynamic tests were carried out by using Gamry Ref 600 connected to a three electrode setup in Ringer's solution. Tribocorrosion investigation was carried out using a reciprocating sliding tribocorrosion tester against an inert alumina ball in Ringer's solution. Tests were carried out at different electrochemical conditions (cathodic potential; OCP; anodic potential) to study the various contributions to material loss

Results and Achievements

The CrSiN coatings exhibited a high hardness (18.4 GPa) when compared to U/T samples (4.4 GPa). A very good adhesion between the substrate and the coating layer was observed following the nano-scratching test. The PVD coated CrSiN specimen exhibited high tribocorrosion resistance. The coating scars were smooth, typical of polishing type of wear. Micro-cracking within the wear track resulted under all electrochemical conditions. The morphologies of the wear scars depend on the applied potential. The wear scars morphology under OCP and CP look very similar where mainly polishing wear was observed. Under anodic conditions, blisters were observed on the resultant scar. (Figure 1). The total volume loss resulting from tribocorrosion testing was evaluated by the synergistic and mechanistic approaches. The CrSiN coated samples experienced lower volumetric losses when compared to the uncoated samples, most visible under OCP and AP. (Figure 2)

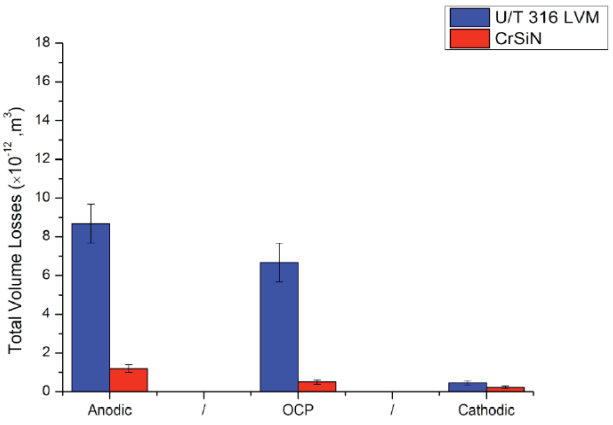

Figure 2: Total volume Losses for U/T 316 LVM and CrSiN coated 316 LVM under AP, COP and CP

Improving the Optical Properties of Fused Silica by Nano-Structured Alumina Thin Films

Student: Joseph Vella / Supervisor: Dr Daniel A. Vella

Introduction

In this work, single layer anti-reflective alumina thin films were deposited onto fused silica in order to enhance the transmission of the light through the glass and cut down unwanted reflections [1]. The film surfaces were engineered to produce surface texture on the nano-scale. This procedure was found to greatly improve the anti-reflective properties of the glass. Such coatings have applications in the manufacture of low pressure UV-lamps.

Project Objectives

The objectives of this work were two-fold:

1. to produce a stable alumina sol that can be deposited onto silica glass by dip-coating; and
2. to study the relation between the different film processing parameters (heat treatment conditions, alumina concentration, sol ageing, deposition speed, etc,) on the optical transmission properties of coated fused silica glass.

Project Methodologies

Alumina sols were produced by a standard sol-gel procedure and the liquid sols were applied to fused silica glass by a conventional dip coating procedure. Deposited alumina films (thicknesses < 400nm) were then subject to a 3-step process involving a heat treatment, a 'water' treatment and a final heat treatment. These three steps were crucial for the formation of the final nano-structured films.
In this project, the deposited alumina films were characterized by X-Ray Diffraction and Fourier Transform Infrared Spectroscopy.

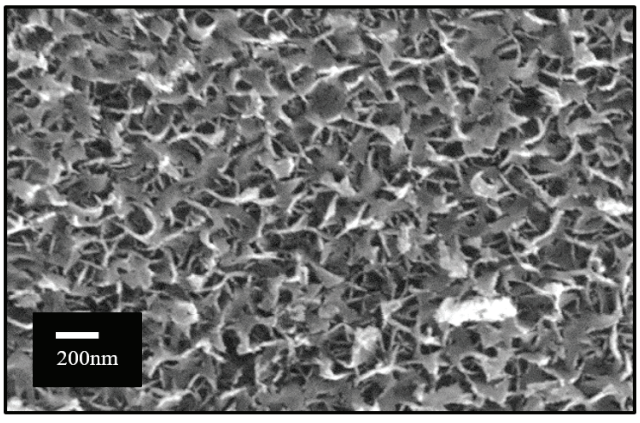

Figure 1: High magnification electron micrograph of alumina film surface generated after heat treatment, water treatment and final heat treatment

The morphological changes to the film surfaces following the different treatments were followed by Electron Microscopy. The anti-reflective properties of the deposited films were assessed by UV-Visible Spectrometry.

Results and Achievements

Alumina films deposited in this work showed promising, anti-reflection over the entire UV-Visible transmission range, with reductions in reflectance of up to 7% in the visible range (λ ~ 500nm). For optimal anti-reflective properties in the UV range however, films had to be treated to relatively high temperatures to burn out organic material remaining in the films following deposition. The water treatment procedure that followed was found to be an essential step in surface modification process. A final heat treatment in this three-step process allowed for the formation of a nano-structured coating film (Figure 1). The microstructure of the film allows it to be dense at the substrate-film interface and less dense at film-air interface. This gradual change in the density of the film structure reinforces light through the coated glass and minimizes unwanted reflections.

In this work it was found that ageing alumina sols for ≥24 hours prior to deposition gave rise to films with improved transmission properties. Thinner films (lower dip speeds and lower alumina concentrations) also presented better results.

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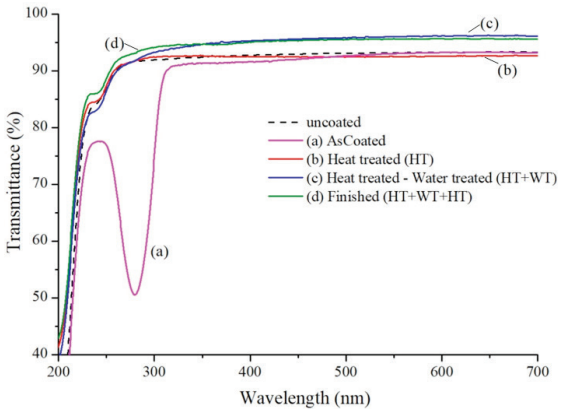

Figure 2: UV-Visible Spectra of a coated substrate with progression of treatments

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