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FINAL YEAR ENGINEERING PROJECTS EXHIBITION

1 & 2 July 2011

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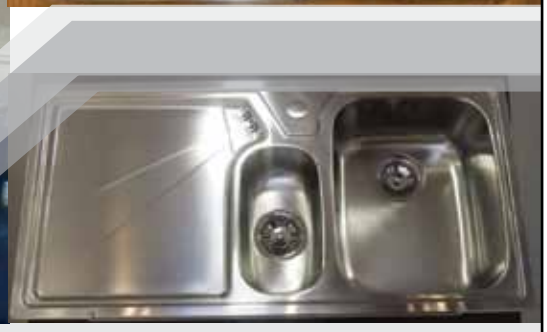

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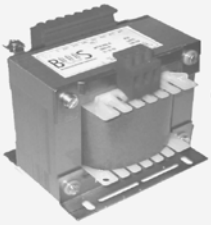

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Faculty of Engineering
University of Malta

Final Year Engineering Degree Projects Exhibition

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Projects Supervised by members of the Department of Mechanical Engineering

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

Foreword

Dear Reader,

This publication is a compilation of the final-year projects that students reading for the B.Eng.(Hon.s) degree at the Faculty of Engineering of the University of Malta undertook and completed during the academic year 2010-2011.

In these pages each student in turn briefly describes her or his project, providing us with an overview of their objectives and achievements. Browsing these pages you will very soon realise the breadth of the range of topics tackled by our students – we are very proud to call them 'our students' - in their work, spanning so many different aspects of our chosen profession: engineering.

This diversity of projects are united by some elements common to all: a lot of hard work, dedication, some almost-inevitable degree of frustration and a fundamental place in the educational experience of our students. Work on these projects spreads over both semesters of the final-year, and culminates in the dissertation, a document of around 100 pages, the creation of which requires the skills acquired by the students over the course of the engineering degree. These include a capability for technical research, the design and actuation of experiments, the application of scientific methods and the analysis and interpretation of data to attain valid engineering conclusions. This activity is reported in students' dissertations, structured in a sound and logical manner, according to widely recognised academic rules and standards. It is this work which seals the formation of our graduate engineers, and which gives them the qualities required to undertake projects and tasks expected of our profession.

In conclusion I wish to take this opportunity to thank all three pillars of our Faculty: academic, technical, administrative and other support staff members and students for their hard work and their essential contribution to our degree courses, our Faculty and our community.

Dr John C Betts

Facilities for the Faculty of Engineering

Department of Electronic Systems Engineering

Electronic Systems Laboratory:

- 25 workstations individually equipped with circuit construction and test equipment.
- Standard grade equipment for calibration and verification
- Digital storage oscilloscopes
- Logic analyzers
- PCB etching facility
- IC programming facility

Embedded Systems Laboratory:

- ARM7 microprocessor development boards
- OrCad circuit simulation and PCB design software licenses
- National Instruments LabView licenses
- National Instruments analogue/digital data acquisition boards

Avionic Application Laboratory:

- Presagis VAPS and VAPS XT - HMI rapid prototyping tools
- MicroNav Best - ATM simulator
- Class A Aircraft simulation test bed
- Model Aircraft simulation and training software
- UAV flight control application board
- UAV test bed

Department of Industrial and Manufacturing Engineering

CAD LAB

- CAD Systems (2D, 3D, Animation)
- CAD/CAM Systems
- Mechanical Desktop, 3D Studio, AutoCAD, Autodesk Inventor

CERU LAB

- Concurrent Engineering Research Facilities
- Thermoplastic Design Guidelines
- Picza LPX-250 3D Laser scanner

RIA LAB

- PUMA 260 Industrial Robot
- Mitsubishi MELFA RV-6SL Industrial Robot
- Epson Industrial Robot
- DVT (Direct Vision Technology) Series 600 SmartImage sensor and Accessories
- Various actuators, sensors, and other auxiliary equipment
- Interfacing Hardware
- Various power supplies, oscilloscopes, signal generators, multimeters, etc.
- 1-DOF three-fingered versatile robotic gripper, with force and proximity sensing (designed and built inhouse)
- 5-DOF anthropomorphic hand/wrist, teleoperated by a glove input device (designed and built inhouse)
- 1-DOF two-jaw gripper, with force and slip sensing (designed and built inhouse)
- Motorised flat belt conveyor with proximity sensing (designed and built inhouse)
- Autonomous guided vehicle (AGV) with inductive sensing and dead reckoning capabilities (designed and built inhouse)
- Mitsubishi PLCs

METROLOGY LAB

- Metrology Equipment Including CMM and Surface Roughness Measurement
- Calibration of Metrology Equipment in Roundness, Linear and Angular Measurements

UNIVERSITY (ENGINEERING) WORKSHOP

- Conventional Machine Tools

CNC LAB

- CNC Vertical Milling Machine
- CNC Vertical Machining Centre

NON CONVENTIONAL MACHINING LAB

- CNC Electric Discharge Machining (EDM) with Micro EDM capabilities
- Rapid prototyping equipment Plastic – Dimension 1200es
- Rapid prototyping equipment Titanium - ARCAM EBM S12 (Electron Beam Machining)

Department of Industrial Electrical Power Conversion

Electrical Energy and Efficiency Laboratory

- Electrical Systems Software for: Power System Analysis, Power Electronics and Electric Machine Design Software
- Renewable Energy Sources (RES) Area: Inverters for grid/stand-alone applications, Micro VAWT system for urban environment, Environmental Monitoring Station, Photovoltaic systems & Flywheel Storage Systems & basic Micro-grid set-up.
- Medium Scale Generation: Grid synchronised CHP generator.
- Domestic Energy Applications : Set-up for analysis of domestic equipment utilisation of energy, Domestic Power Management & Metering
- Power Quality and Energy Efficiency: PFC equipment, Power Quality Instrumentation, Harmonic sources, Active Filter for dynamic Power Harmonic Correction
- Industrial Energy Applications: Flexible Torque Transducer Set-up, Industrial High Power Dynamometer
- Special Electrical machines: PM servo drives, Linear motors, Switched Reluctance Motors, High Efficiency Induction Motor (medium to high power), PM drive motors for land/aerospace applications.

Power Electronics Lab

- Digital Control of Power Converters,
- High Bandwidth Instrumentation & Calibration Equipment (dedicated for power conversion topologies)
- Single and Three Phase interface-able inverters (ranging from 1kW to 75kW)
- Battery Lab
- Fuel Cell & Battery Energy Storage Systems
- Electrical Technology Lab
- Undergraduate teaching in electrical technology
- Electrical Machines Lab
- Undergraduate teaching in electrical machines (including transformers)

Department of Mechanical Engineering

Thermodynamics Laboratory

- Laboratory experiments for thermodynamics and heat transfer
- Testing 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
- Solid Body Mechanics Laboratory
- Machine diagnostics
- Vibration monitoring
- Run-up Run down vibration testing
- Order analysis
- Modal analysis
- Dynamic balancing of machines
- Sound level monitoring

Computer Aided Engineering Laboratory

Computer facilities to run the following engineering software:

- FEA – Finite Element Analysis – ANSYS: academic and research licenses
- CFD – Computational Fluid Dynamics Fluent: academic licenses
- MATLAB/Simulink: academic licenses
- CAD – Computer Aided Design SOLIDWORKS
- WindPRO (EMD)
- WAVE/VALDYN (Ricardo)
- FloTHERM
- Maxsurf

Structural Mechanics Laboratory

- Strain measurement equipment
- Instron 4206 tensile testing machine (150 kN and 50 kN)
- Avery Impact testing machine
- Wolpert Testa Universal Testing Machine U60 – 60 tonne
- Fluids Laboratory
- Low wind speed wind tunnel 38 x 38 cm
- Low wind speed wind tunnel 900 mm diameter
- Wave making generator 8 m long and 750 mm wide and 1 m deep
- Multi-channel hot wire anemometry
- Fluid mechanics data acquisition systems

Department of Metallurgy and Materials Engineering

DMME Laboratory

Processing Equipment:

- Plasma Assisted Physical Vapour Deposition (PA-PVD)
- Gas Nitriding Furnace
- Vacuum Furnace
- Laser Material Deposition Centre
- Air Furnace
- Aluminium anodising Facility
- Low temperature foundry furnace
- Martempering salt bath

Support Equipment:

- Manual sample grinders
- Manual/ automatic sample polishers
- CNC and Manual Milling
- Lathe
- Multistage Ultrasonic cleaners
- Degreasing Facility
- Sand blasting
- Power hacksaw
- Welding (GTAW, MMA)
- Oxyfuel gas brazing / welding

Mechanical Testing:

- Tension/ Charpy Impact tester
- Compression Testing (5 Ton)
- Bending Testing (10 Ton)
- Multipurpose dynamic testing (25 Ton)
- Macro hardness tester
- Micro hardness tester
- Shore hardness tester
- Pin-on-disk wear tester
- Rotary bending fatigue tester
- Gear tribological tester

Characterisation Equipment:

- Optical Microscopy with real time image acquisition.
    - Incident light metallographic Microscope
    - Side projected stereo Microscope
- Support metallographic microscopes
- Confocal microscope
- Potentiodynamic wet cell corrosion tester
- Laser Induced Breakdown Spectrocopy (LIBS) for elemental qualitative analysis
- Scanning Electron Microscope (SEM) with:
    - In-lens backscattering detector
    - In-lens secondary electron detector
    - External secondary electron detector
- Electron Probe Micro-analysis (EPMA) within SEM including:

    - Energy dispersive spectroscope
    - Wavelength dispersive spectroscope
- Electron Backscatter Diffraction (EBSD) within SEM
- Ultra high vacuum Integrated Characterisation Facility including:
    - Surface analysis by electron analysis
- Monochromated X-Ray source
- High energy multi wavelength X-ray source
- High intensity electron source
- Low energy UV source
- Electron energy analyser
- Rastering ion source
- Large area ion source
- Quadrupole mass spectrometer
- Low energy electron diffraction (LEED)
- Secondary electron detector
    - Surface analysis by surface probe microscopy
- Atomic force microscopy (AFM)
- Scanning tunnelling microscopy (STM)
- X-ray diffraction (Cu-tube) for thin film analysis with:
    - Parallel beam / Bragg Brentano optics
    - Variable temperature reaction chamber
- X-ray powder diffraction (Mo-Tube) with:
    - Bragg Brentano optics
    - Variable temperature reaction chamber
- Nano Indentation equipment with:
    - Wet cell attachment
    - Variable temperature reaction chamber
    - Dynamic testing attachment

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 Toolboxes Research Licenses

Control Systems Laboratory:

- Programmable Logic Control (PCI) 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

Areas of Research

Electronic systems engineering
Electronic system design; aviation safety; avionics systems; air traffic management, trajectory optimisation, flight control and guidance, traffic collision avoidance; surveillance, cockpit display and instrumentation design, flight simulation and modelling.

Industrial and manufacturing engineering
Concurrent engineering; intelligent systems in design and manufacturing; computer aided engineering design; product development technologies and methodology; rapid prototyping; industrial sustainable development; industrial robotics and mechatronics; robotic grasping and handling; industrial automation; quality engineering; micro manufacturing.

Industrial electrical power conversion
Sensorless control of A.C. Machines; control of electrical machine drives; electromagnetic design of electric machines; direct AC-AC converters; Switching power converters; emc of power converters; electric transportation technology (electric cars, electric boats); wind and p.v. grid connected systems; analysis of renewable energy systems for grid integration; microgrids and smart grids; quality of electrical supply; domestic and industrial electrical energy efficiency; energy efficiency in buildings.

Mechanical engineering
Structural Mechanics and Thermo-Fluid: Aerodynamics; biomechanics; structural analysis of composite materiials; computer aided engineering (CFD: computaitional fluid dynamics and fea: finite element analysis); energy; environmental engineering;formability of sheet materials; internal combustion engines; naval architecture; pressure vessels; refrigeration; solar desalination; solar heating and cooling; sound and vibration; structural integrity; welding; wind turbines;

Metallurgy and materials
Metallurgy and materials ion-beam assisted deposition; laser surface engineering, material deposition and rapid fabrication; plasma assisted physical vapour deposition; plasma anodizing of light metals; thermo-chemical processing of medical grade stainless steel; novel dental materials; surface coating for conservation of metallic artefacts; development of nano coatings for high efficiency solar energy absorption; degradation of composite materials; tribology and corrosion; triode plasma-assisted diffusion treatments for titalnium alloys; material selection;

Systems and control engineering
Computational intelligence; signal and image processing; biomedical signal processing; neural networks; machine and computer vision; automatic control systems; adaptive and intelligent control; robot control systems; spatio-temporal system modelling; bayesian estimation.

Externally Funded Projects

ALICIA - 0.25 Million Euro programme
Department of Electronics Systems Engineering
Funding Source : EU FP7

Clean Sky JTI, Systems for Green Operations ITD - 1 Million Euro programme
Department of Electronics Systems Engineering
Funding Source : EU FP7

ODICIS - 0.3 Million Euro programme
Department of Electronics Systems Engineering
Funding Source : EU FP7

Title: Undertaking Of Research Projects in Manufacturing: Research Services For Innovation in Manufacturing
Department of Industrial and Manufacturing Engineering
Funding: MCST Tender 14/2010, Lot 3, part of ERDF083 Manufacturing Research Projects

EEE - Electrical Energy and Efficiency Laboratory for the University of Malta
Department of Industrial Electrical Power Conversion
Funding Source: European Regional Development Fund-Cohesion Policy Programme 2007-2013

Energy Efficiency in Manufacturing
More Efficient Electric Motors for the Manufacturing Industry
Increasing Energy Efficiency during Reliability Testing of Electrical/ Electronic Equipment through Grid-Connected Load Units
Department of Industrial Electrical Power Conversion
Funding Source : ERDF 083 managed by MCST

Design and Analysis of an Innovative Offshore Wind Turbine Support Structure for Deep Water Applications in the Maltese Islands
Department of Mechanical Engineering
Funding Source: MCST R&I 2009 Programme

Innovative Fibre Reinforced Composites for Higher Structural Perfomance – Numerical and experimental analysis to optimize and develop new fibre reinforced composites able to withstand higher structural strength
Department of Mechanical Engineering and Department of Metallurgy and Materials
Funding Source: MCST R&I 2009 Programme

Solar Desalination – Production of portable water in a completely sustainable manner
Department of Mechanical Engineering and Department of Metallurgy and Materials
Funding Source: MCST Programme

Investigation of Advanced Metal – Diamond Composites for Thermal Management Applications (DIACOM).
Departments of Metallurgy and Materials
Funding Source: European Regional Development Fund-Cohesion
Policy Programme 2011-2013

The setting up of a characterization and rapid prototyping Laboratory
Departments of Metallurgy and Materials and Department of Industrial Manufacturing Engineering
Funding Source: European Regional Development Fund-Cohesion
Policy Programme 2007-2013

Modernizing the Control Systems Engineering Laboratory
Department of Systems and Control Engineering
Funding Source: European Regional Development Fund-Cohesion Policy Programme 2007-2013

The setting up of a new Biomedical Engineering Laboratory
Department of Systems and Control Engineering
Funding Source: European Regional Development Fund-Cohesion Policy Programme 2007-2013

Intelligent Control of Solar Water Heaters
Department of Systems and Control Engineering in collaboration with ESDL Ltd
Funding Source: National RTDI-2008

Faculty of Engineering – Members of Staff

DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING

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Dr. Ing. David Zammit-Mangion, B.Elec. Eng. (Hons.), M.Sc. (Cranfield), Ph.D.(Cranfield), Eur. Ing., MSAE, SMAIAA, MRAeS

Professor:

Prof. Charles Pule`, B.Sc. (N'cle.), Ph.D. (N'cle.), C.Eng., MIET

Assistant Lecturers:

Mr. Mark Azzopardi, B.Eng. (Hons.)
Mr. Andrew Sammut, B.Eng. (Hons.), MAIAA
Mr. Brian Zammit, B.Eng. (Hons.), MAIAA

Researchers

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Senior Lecturer:
Dr. Ing. Michael A. Saliba, B. Mech. Eng. (Hons.), M.A.Sc. (Brit. Col.), Ph.D. (Brit. Col), MASME, MIEEE, MAPS

Lecturers:
Dr. Ing. Philip J. Farrugia, B.Eng. (Hons.), Ph.D. (UoM)., GradIED
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Assistant Lecturers:
Ing. Emmanuel Francalanza, B.Eng. (Hons.)MSc (IPD).
Ing. Pierre Vella B.Mech. (Hons), M.Sc

Part Time Lecturer:
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Dr. Ing. Conrad Pace, B.Eng. (Hons.), M.Sc. (Lanc.), Ph.D (Lanc.), MIEEE
Ms. Dawn Zammit, B. Eng. (Hons)

Researchers
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Mr.Joseph Curmi, WELD & FAB (Full Tech.)
Mr Josef Attard

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Associate Professor:

Prof. Joseph Cilia, B.Elec. Eng. (Hons.) M.Sc. (Nott.), Ph.D(Nott.), MIEEE

Senior Lecturers:

Dr. Ing. Maurice Apap, B.Eng. (Hons.), M.Sc., Ph.D. (Nott.), MIEEE
Dr. Cedric Caruana, B.Eng. (Hons.), M.Sc., Ph.D. (Nott.), MIEEE, MIET

Assistant Lecturers:

Mr. Alexander Micallef, B. Eng. (Hons.)
Mr. John Licari, B. Eng. (Hons.)

Researchers

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Mr. Francarl Galea, B.Eng. (Hons.)

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Clerk:

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Lab. Officer IV:

Mr. Charles Azzopardi

Lab. Officer II:

Mr. Donald Cassar

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Professor:
Prof. Ing. Robert Ghirlando, B.Sc.(Eng.), M.Eng.(Liv.), Ph.D.(Liv.), F.I.Mech.E., Eur.Ing.

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Dr. Ing. Zdenka Sant M.Sc.(VUT Brno), Ph.D.(VUT Brno)

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Mr. Brian Ellul, B.Eng.(Hons.), M.Sc.
Ing. Robert N. Farrugia, B.Mech.Eng. (Hons.), M.Phil.
Mr. Thomas Gauci, B.Eng.(Hons.)
Mr Daniel Micallef, B.Eng. (Hons.)
Ing. Paul Refalo, B.Eng. (Hons.)

SUPPORT STAFF:

Clerk:
Ms. Vanessa Borg

Systems Engineer:
Ing. Noel Balzan, B.Eng. (Hons), M.Sc.(Oakland)

Lab. Officer III:
Mr. Andrew Briffa, METC (Full Tech.).

Lab. Officer II:
Mr. Kevin Farrugia, HTD
Mr. James Saliba

Lab. Officer I:
Mr. Daniel Pisani, HND, B.Sc.(Hons.) (MCAST)

DEPARTMENT OF METALLURGY & MATERIALS ENGINEERING

Academic Staff:
Head of Department and Lecturer
Dr. Ing. John C. Betts, B. Mech. Eng. (Hons.), M.Sc. (Astronomy)(SUT), Ph.D.(UoM).

Professor:
Prof. Ing. Maurice Grech, B.Sc.Mech.Eng. (Hons.), M.Sc.(Birm.), Ph.D.(Birm.), C.Eng., FIMMM., MICME

Senior Lecturers:
Dr. Stephen Abela, B.Eng. (Hons.), Ph.D.(UoM)

Lecturers:
Dr. Joseph Buhagiar, B.Eng. (Hons.), Ph.D. (Birm.).
Dr. Bertram Mallia, B.Eng. (Hons.), Ph.D. (Leeds).

Assistant Lecturers:
Mr. Glenn Cassar, B.Eng. (Hons.)
Mr. Daniel Vella, B.Sc. M.Sc.
Ing. Ann Zammit, B.Eng. (Hons.)

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Ms. Pierina Cortis

Executive Officers:
Ms. Ruth Frendo

Lab. Manager:
Mr. Maurizio Fenech, B. Eng. (Hons.)

Systems Engineer:
Mr. James C. Camilleri, B. Eng. (Hons.)

Lab. Officer III:
Mr. Noel Tonna, HTD

Lab. Officer I:
Daniel Dimech

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Head of Department and Associate Professor

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Electrical Engineering Stream

Surveillance RC Car: A CCTV system images and data sent to a base station

Student: Christian Barbara
Supervisor: Prof. C. Pule

Introduction
Robots are widely used nowadays, and there's no shortage of jobs for robots to do. A significant task robots perform is to go places or do things that no human would want or is able to do. In this project, a surveillance RC car was built to perform such task. This was done by introducing a wireless router on an RC car and connecting a network camera to it.

Project Objectives
The main purpose of this project was to build a machine that can be controlled by a human operator from a distance. A camera was required so as to permit the user to drive the machine even when it is out of line of sight.

Project Methodologies
Figure [1] depicts exactly an overview of the project. The user's laptop, connected to the router by the IEEE 802.11g standards, will send the desired directions by pressing the arrow keys. These are passed to the router as bits. The router then directs them to the serial port which is connected to the microcontroller. Consequently the microcontroller, which has the RC motor and steering servo connected to its digital pin, would translate the bits coming from the router as respective output.

The project was carried out as follows:

- Literature review on wireless communications, focusing extensively on the IEEE 802.11 and its various generations.
- Studying socket programming, Unix Networks and typical server-client programs. [2]
- Familiarization with third party firmware, WRT54GL Linksys router hacks and projects. [3]
- Acquaintance on 'cross compiling' since the router has not sufficient memory for a compiler to be installed on it. [4]
- Modify the router for serial communication.
- Using Visual Basic for Graphical User Interface. (Figure [2])

Results and Achievements
When applied indoor, changing the transmission power of the router, did not make any difference. This is due to severe interference caused by equipment such as cordless phones and due to propagation. However, the car's Wi-Fi range will be tested in a football ground where interference is minimal. The range is estimated to be 500m.

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[3] Paul Asadoorian and Larry Pesce. Linksys WRT54G Ultimate Hacking. Syngress, Burlington, MA, 2007.
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Figure 1 - System Overview

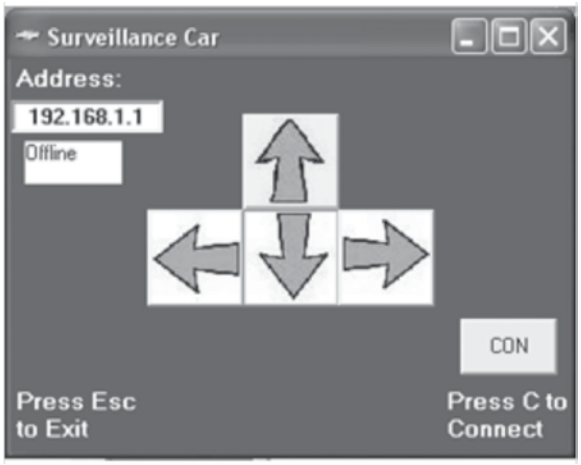


Figure 2 - Graphical User Interface

A very fast line following Wheeled Machine adopted to imitate Aircraft Landing Systems

Student: Rosemarie Mangion
Supervisor: Prof. Carmel Pule'

Introduction

The project is about an imitation of an aircraft landing system which is very useful in bad weather conditions especially fog. Weather conditions like fog can prevent an aircraft from taking off or landing at airports. This presents a hazard, because the pilot may think that visibility is suitable for landing while in fact it wouldn't be.

Project Objectives

The aim of this project is to create a very stable and reliable system which is mounted on wheels and has to follow light, leading the aircraft to the appropriate touchdown point. Only a simulation of the vertical contour was achieved. The modulation for the two side lobes was not tackled.

Project Methodologies

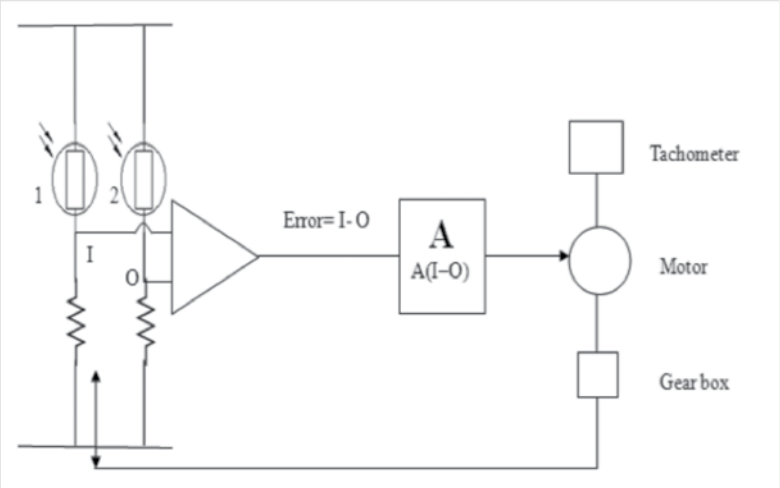
During the implementation of the project the following steps were carried out:

- Literature Review of current ILS (Instrument Landing System) technologies and also how aircraft landing was facilitated in the past.
- Construction of electronic circuit, prediction of its behaviour and tested later on. Electronic circuit basically consists of two LDR's which are present to compare light intensities. Differences in light introduce an error which is amplified and fed to the motor.
- Control System analyzed using BBC BASIC
- System implementation and observing its performance.

Results and Achievements

When obtaining the error from the LDR's, system was stable. To obtain a more reliable system an observer can be introduced in order to model the real system. When plotting curves on BBC BASIC the desired results were obtained since real and ideal system curves were approximately near each other.

While testing the model, the platform moved along the rod following the light indicating that the circuit was working correctly. Varying the position of the torch light, it could be seen clearly that as the torch light was far away with minimal light falling on the LDR's, the platform was moving slowly towards the light but it gained speed as the torch light was brought closer to the platform. Also, changing the direction of light instantly, the system seemed to respond efficiently as the direction in which the platform was heading changed abruptly and smoothly.



Optimisation of flight trajectories using Genetic Algorithm (GA) Techniques

Student: Matthew Micallef
Supervisor: Ing. Kenneth Chircop

Introduction

Optimisation of flight trajectories is currently a major area of research in aviation. In this dissertation optimisation of energy required by the aircraft's engines or fuel consumed and time needed to complete a trajectory were considered. One technique how to solve multi objective optimisation problems is by using evolutionary algorithms based on the Genetic algorithm.

Project Objectives

The objective of this dissertation was to build a multi-objective optimiser which could be applied to flight trajectory optimisation. This optimiser had to be integrated with an Aircraft Performance Model to optimise the flight trajectory of a generic aircraft similar to an A320 and a B737.

Project Methodologies

A review of the existing evolutionary genetic algorithms was carried out. NSGA, SPEA, NSGA2 and SPEA2 were considered in detail. These algorithms were compared and the best one was chosen. SPEA2 and NSGA2 give almost identical results, but SPEA2 gives more diversified solutions and can be applied to more than two objective functions[1]. A modified SPEA2 to handle constraints was implemented in JAVA.

To validate the optimiser, several tests were applied. Multi-objective functions with constraints found in literature were applied to the optimiser and the resulting Pareto fronts were compared to the global Pareto fronts which were obtained by Deb[2]. After obtaining satisfying results, the optimiser was used together with an Aircraft Performance Model developed by the department of Electronic Systems Engineering to optimise for the total fuel or total energy and total time required by the aircraft to complete a segment .The four segment climb and eight segment cruise trajectories were considered to find the best optimiser settings.

Results and Achievements

The optimiser succeeded in reaching the global Pareto front for all flight trajectories considered. Eight segment and four segment results were compared. Eight segment results were more accurate due to the fact that it emulates a true aircraft trajectory better. Figure 1 shows the optimal trajectories obtained for minimum energy and minimum time for a four segment climb. Figure 2 shows the Pareto front obtained for the four segment climb.

References

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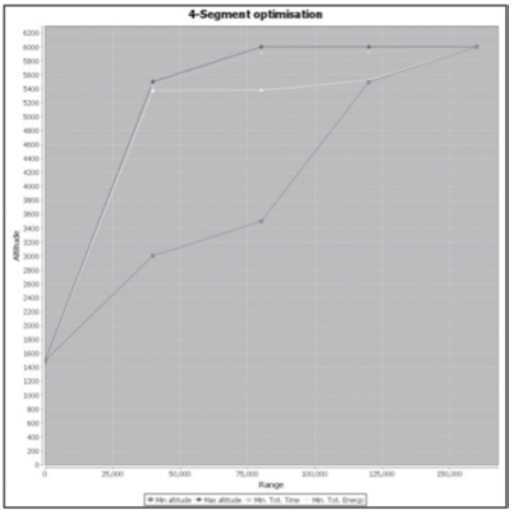


Figure 1: Minimum time and Minimum energy trajectories for 4 segment climb

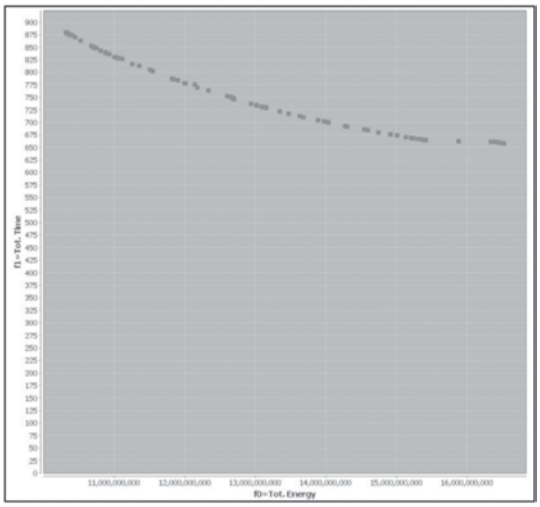


Figure 2: Global Pareto front for 4 segment climb

A Digital Platform Stabilization System

Student: Daniel Pisani
Supervisor: Dr. Ing. David Zammit Mangion]

Introduction

Digital platform stabilization is a technique by which an object is stabilized to keep a constant line of sight (LOS). Such systems are used in a large array of fields with the two most common fields being the aviation and military. In the aviation field, such platforms are used to stabilize cameras for filming and also for guidance purposes. These are becoming more common in unmanned aerial vehicles (UAVs). This project is a continuation of a previous project, in which an analogue based platform stabilization, was implemented using analogue electronics [1]. The main disadvantage of using an analogue system is the fact that random noise from components could make the signal loose important information and would also result in distortion of the signal. However, if these are eliminated the accuracy of the system could be improved.

Project Objectives

The aims of this project included the following:

1) Implementation of the analogue system on a microprocessor.
2) Improve the system by making use of a digital proportional-integral-derivative (PID) controller and other digital techniques. Then comparison between the systems is to be completed.
3) Implementation of a new control algorithm by placing MEMS (micro-electromechanical sensors) on the platform.
4) Study of sensor characteristics and performance.

Project Methodologies

Initially a detailed analysis of the analogue system and a literature review on several sensors and control loops was carried out. Several digital control laws were then designed by making use of MATLAB® and Simulink®. These control laws included the design of a digital PD (proportional-derivative) controller, a digital PID controller and since the transfer function of the system was known, pole-placement techniques were also carried out. The design of the system was implemented using a microprocessor. Several comparisons between different techniques were then carried out. These comparisons focused mainly on the use of different sensor configurations, most importantly placing the sensors on the platform rather than on the aircraft's fuselage. The sensors used throughout the project included MEMS accelerometers and gyroscopes which are relatively low cost and accurate sensors. Sensor calibration was also carried out for improved results.

Results and Achievements

The results obtained in the project included the digital stabilization version of the algorithm used in the previous thesis. This algorithm consisted of stabilizing the platform using a potentiometer to read the aircrafts pitching angle and the motor encoder to note the platform angle. Then, stabilization was obtained by making use of different control loops and sensor positioning. Stabilization of the platform was obtained by making use of an accelerometer and a gyroscope strapped down with the fuselage. Then, stabilization was obtained by using a single gyroscope placed on the platform and a digital PID controller. The final stabilization was then obtained by making use of two gyroscopes placed on the platform (using averaging) and an inclinometer to initialize the system.

References

[1] Grixti S, "Platform Stabilization for Airborne Applications," B.Eng dissertation.

Figure 1: A commercialy available stabilized camera

Construction and Autonomous Control of a model Helicopter

Student: Josef Pollacco
Supervisor: Professor C. Pule'

Introduction

Unmanned Aerial Vehicles (UAV) can perform tasks which would be difficult or even hazardous for a manned vehicle. In modern days, UAVs are used for an extensive range of applications, starting from filming movies, through search-and-rescue missions, up till military reconnaissance missions. An autonomous helicopter falls under such a category, having various advanced capabilities over other aircrafts, with the main capability being the ability of hovering. However, due to their advanced and complex nature, helicopters are more difficult to control when compared to fixed wing aircrafts. In fact, modern helicopter aerodynamics is still a demanding field for researchers due to its difficulty in measurement, modelling and prediction.

Project Objectives

The main objectives of this project are to implement an autonomous helicopter, which will go through the flight dynamics of lift, hovering and landing, by using gravitational and physical sensors to perceive any disturbance affecting the over-all inclination and correcting the error caused by disturbance to achieve stable flight. Such correction computations will be quantified by an on-board microcontroller, which will control the helicopter servos accordingly.

Project Methodologies

The project was divided in three stages: (i) Helicopter construction: choosing the appropriate equipment, such as the frame, motor, servos and speed controller was crucial in order to observe some factors that were included in the project. Such a factor is the weight limit (ii) Inertial Measurement Unit (IMU) design and implementation: the IMU in this project is composed of physical sensors (such as accelerometers and gyroscopes) that perceive an inclination or a rotational displacement around any of the three axes. The design consisted of choosing the appropriate sensors, the power supply unit and its corresponding smoothing and biasing components and drafting the PCB on which all the components were going to be placed. After testing the functionality of the merged components, a box was fabricated so as to contain the electronics and be attached to the helicopter (iii) Software code implementation: an Arduino Mega is the helicopter's chosen on-board microcontroller, on which the software code is implemented. The main function of the programme will be to combine the sensor data through a sensor fusion process. In this project, such a process is achieved by utilizing the Kalman filter. This algorithm will be used so as to compute an estimate of the inclination, by utilizing the input data of the accelerometer and gyroscope. After achieving all the objectives, all the equipment was merged together as shown in Figure 1.

Figure 1: Completed Helicopter, IMU and Microcontroller combination

Results and Achievements

The IMU and Kalman filter combination proved to be an exceptional choice, successfully producing accurate and consistent output estimates. Up till now the helicopter has managed to achieve momentary flights although it tends to sway to a random direction. However this inaccuracy can be concluded to be a minor calibration issue in the software and by reviewing the code, this flaw should be solved.

An Automated Departure for Fixed Wing Aircraft

Student: Jeremy John Scicluna
Supervisor: Dr. Ing. David Zammit Mangion

Introduction

A Standard Instrument Departure (SID) is a departure route designed to meet Air Traffic Control (ATC) requests and is normally used in busy terminal areas. The main purpose of an SID is to reduce the workload for both ATC and the human pilot while still observing the minimum obstacle clearance requirements. The benefits achieved by the construction of such a departure are; effectively controlling the flow of traffic with the least communication being required between ATC and the pilot, increasing the traffic capacity within the terminal area and reducing the environmental impact by making use of the noise abatement procedures.

Project Objectives

The aim of this project is to simulate a departure. The system will need to simulate the basic autopilot and autothrottle systems with similarities to that of a Boeing 747. Both systems will need to be as accurate as possible with no instability, so as to be able to simulate the departure with the highest level of precision.

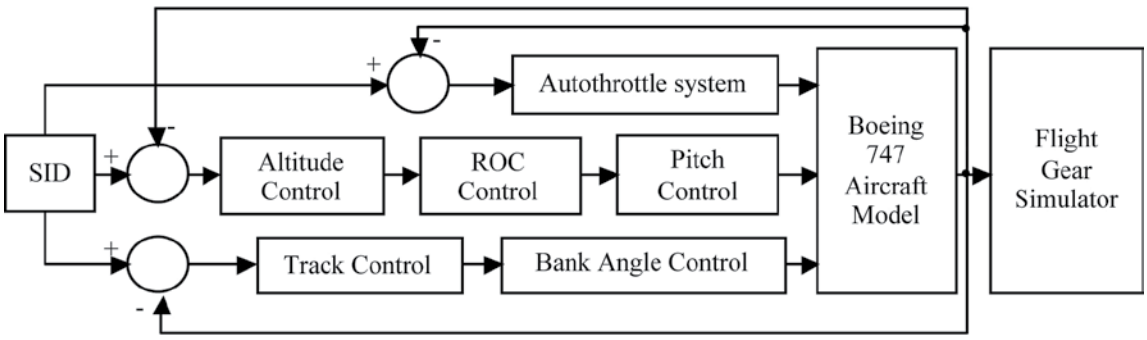
Project Methodologies

The project was carried out as follows:

- An extensive literature review covering various subjects of the aviation theory.
- Understand the Boeing 747 model.
- Design of an autothrottle system that will manage the required airspeed.
- Design of an autopilot system that will climb or descend so as to capture and hold the required height.
- Design of an autopilot system that will roll the aircraft in order to manage the required track.
- Simulate an actual SID.
- Interface with the Flight Gear Simulator.

Results and Achievements

The results obtained show that the design and implementation of both the autopilot and the autothrottle systems worked successfully, while the simulations show that the aircraft performed the desired departure successfully. Finally, the simulations were interfaced with the Flight Gear Simulator to obtain a visual result of the SID.



Stabilizing a Helicopter Platform to Facilitate Rescue Work on a Stormy Day

Student: Daniel Zammit
Supervisor: Prof. Carmel Pulé

Introduction

Helicopters play an important role both in military and in humanitarian operations. This is attributed to their agility and their ability to maintain hover over a specific target. The challenge in maintaining hover on stormy days is due to the difficulty in controlling the aircraft against external disturbances, such as wind, while a hoisting procedure is being executed. The development of Unmanned Aerial Vehicles (UAVs) is essential so as to reduce human resources and to increase the safety factor significantly.

Project Objectives

The objectives of this project are:

- To design an electronic control system to control the rotors of a helicopter platform.
- To implement the system and stabilise it.
- To demonstrate the effectiveness of the technique and the achieved performance.
- Project Methodologies
- To solve the problem and tackle the objectives, a small-scale quadrotor helicopter was designed, constructed and tested. The design is shown in figure [1]. The design allowed for easier construction and increased rigidity when compared to the traditional quadrotor helicopter design.
- Research was also carried out to select the required components appropriately. Familiarisation with an Arduino microcontroller was required. The latter was programmed to use the information gathered from the inertial sensors (accelerometer and gyroscope) and to filter this information. The filter is used to combine the sensors together and to reduce the impact of any fast movements, such as vibrations, on the system.
- A Proportional Integral Derivative (PID) controller was implemented so that the system would be able to respond to external disturbances by balancing the speed and thrust of the four motors and thus maintaining a stable hover. This controller is widely used in industrial applications because of its relative simplicity yet very effective technique. It takes into account the past, present and the theoretical future of the system's performance so as to achieve the desired control.

Results and Achievements

- The quadrotor helicopter was constructed successfully. Brushless outrunner motors are used which are very powerful for their relative size. They are controlled by Electronic Speed Controller (ESCs) and powered by a suitable Lithium-ion Polymer (Li-Po) battery.
- The Arduino microcontroller was programmed to serve as the brain of the system, incorporating the filter algorithm and the PID controller.
- The accelerometer and gyroscope were filtered and combined together to control the roll (x-axis) and pitch (y-axis) of the craft. The filtering technique is shown in figure [2] (The movement is light coloured and the filtered output is superimposed for both the roll and pitch).

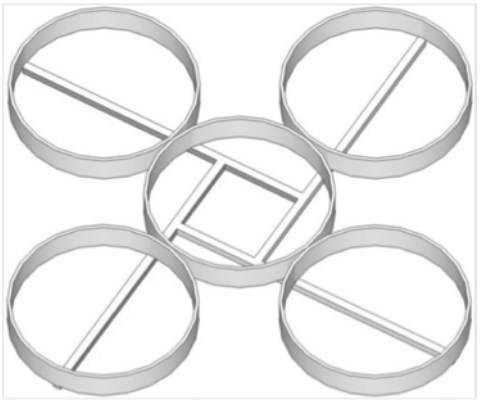


Figure [1]: The Frame Design of the Quadcopter

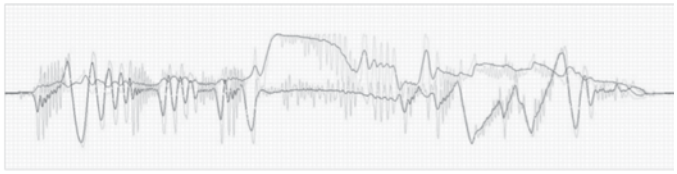


Figure [2]: The Filtering Technique

Single phase drive for elevator applications

Student: Ishmael Agius
Supervisor: Dr Ing. Maurice Apap

Introduction

This project is mainly focused to residential buildings having lift systems operating with a three phase supply, which could possibly be implemented with a single phase system leading to savings in terms of supply installation and energy consumption costs.

Project Objectives

This final year project consists in analysing the possibility of having a traction elevator being fed from a single phase supply instead of a three phase supply and also, if possible, to find out the limitations of such an elevator. The intention is to allow the use of a more cost effective single phase supply in the common area of a residential building given that it would be used only for the elevator. The typical elevator characteristics to be considered are of four to six floors, 300Kg load (equivalent to four passengers) and 0.6 m/s speed.

Project Methodologies

The initial task was to design the system's implementation, by choosing the type of motor and the drive system. The next task was to obtain some important values like the typical friction of an elevator and the mass of the cab. Then these values were used in a simulation to obtain the theoretical results of the tension and powers involved in such a system. In order to achieve the intended goal, a test rig was designed to simulate an elevator cycle. Also a case study was carried out in order to obtain the practical results and compare them with those in theory. The measurement methodology used was that described in [1]. Comparisons between the results obtained from the rig set-up with that of the practical analyses, were carried out.

Finally comparisons of the energy consumption between a commonly installed hydraulic elevator and the single phase elevator were evaluated.

Results and Achievements

From the results obtained it was deduced that in practice it is possible to have an elevator operating from a single phase supply. Hence reducing the cost of the installation charge and the service charge which currently will amount to a reduction of 600€ and 130€ respectively as indicated in [2]. Moreover, when comparing the hydraulic with the traction during worst case scenarios, it was found that the hydraulic consumed 75.6Wh whilst the traction consumed 13Wh. This makes the single phase elevator consumption 5.8 times less than the hydraulic. In general a traction elevator is more efficient than a hydraulic type whether it is three phase supplied or single phase supplied. The only gains in using a single phase type are the installation and service charges.

References

[1] A. d. Almeida, "E4-WP3 Energy Efficient Elevators and Escalators," ISR-University of Coimbra D 3.2 EIE/07/111/SI2.466703, 2010.

[2] e. corporation. (1010, Jan.) Enemalta Electricity Tariffs. [Online]. http://www.enemalta.com.mt/page.asp?p=995

Figure 1 Traction Elevators

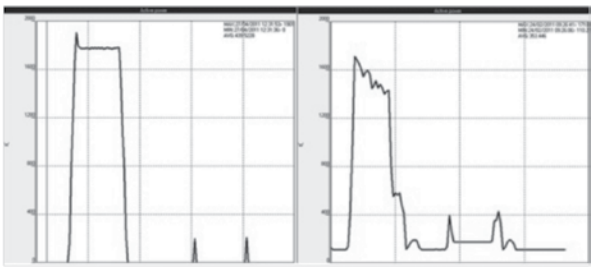


Figure 2 Test rig (left) and practical (right) power curves.

Analysis and Simulation of Power System Harmonics

Student: Samuel Bonanno
Supervisor: Prof. Ing. Cyril. Spiteri Staines
Co-supervisor: Ing. Jason Falzon (Enemalta Corporation)

Introduction

Power system harmonics have been an electrical phenomenon since the early days of electrical power systems. Harmonics are typically generated by two sources, saturable iron-core devices such as transformers and motors or power electronic devices such as switch mode power supplies and rectifier circuits.

Harmonics are major contributors of losses generated in power systems these losses have several adverse effects such as:

- Excessive overheating of transformer winding and motors.
- Neutral conductors overloading.
- Incorrect operation of fuses and protective devices.

The excessive increase in operating temperature of the transformer winding due to harmonics causes the deterioration of the winding insulation and consequently winding failure. Hence harmonics are a considerable factor in the reduction of the transformers lifetime. Other major losses are found in cables and transmission lines.

Project Objectives

- Investigation and analysis of harmonic levels produced by different entities from the domestic, commercial and industrial sectors.
- Determination of the harmonic losses caused by each individual entity dissipated in the transformer windings.
- Simulation of basic power system network and its interaction with non-linear loads and corrective measures analysing their effectiveness.

Project Methodologies

Fourteen different load samples were considered:

- 2 Domestic
- 3 Commercial
- 9 Industrial

Using a power harmonic analyser connected to the Point of Common Coupling of the transformer to the entity as illustrated in figure 1. Each entity was monitored for 1 week and the harmonic profile for each entity was determined through typical harmonic waveforms of current and voltage as sown in figure 2. This profile was analysed to determine whether the recorded levels were conformal to limits suggested by several standards and recommended practices. From the data gathered harmonic loss factors were calculated and used to determine the resulting power losses in corresponding transformer windings.

A selection of the monitored loads was then simulated in PSCAD and corrective filtering measures and resulting effects were analysed.

Results and Achievements

The results obtained from the on-site monitoring of the different entities determined the different typical harmonic profiles of the considered sectors. Considering results obtained from simulation of the typical loads gave rise to analyses between the ideal and actual scenarios and variation in losses due to filtering techniques.

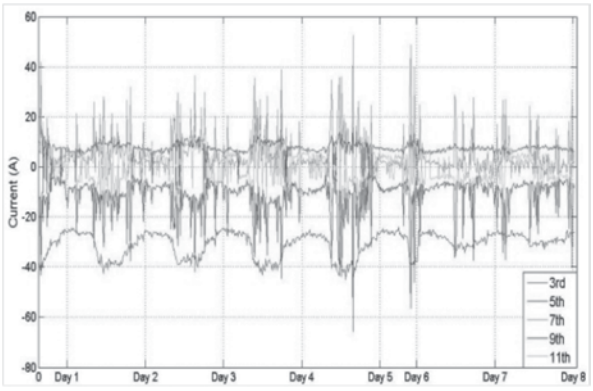


Figure 1: Connection of Power Analyser to PCC

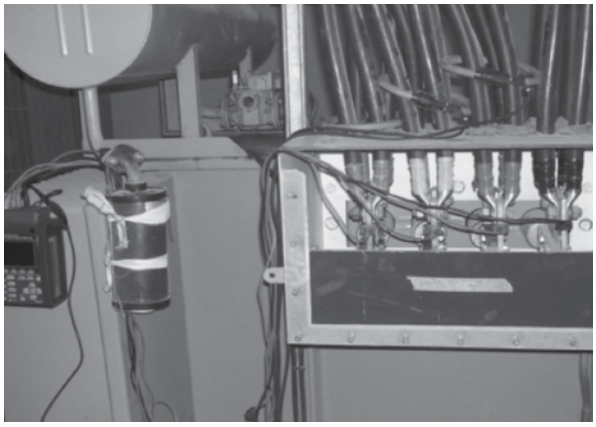


Figure 2: Current Harmonic Profile for Typical commercial load

An Investigation on the Effect of the Inverter Characteristic in Small Grid Connected Wind Energy Converters

Student: Charles Borg
Supervisor: Dr. Cedric Caruana

Introduction

Wind turbines represent an investment in the future. Small systems known as micro-wind turbine or small-scale wind turbines are becoming more popular as they can produce electricity to a typical home. Sometimes small wind turbines do not result to be as highly efficient as expected in built up areas, because of the lower average wind speed and possibly the turbulence experienced at the site.

Project Objectives

The aim of this thesis is to set a procedure for setting a wind turbine, depending on the parameters of the generator and the available wind resource at the site. Once the procedure is set, a maximum operating point can be determined.

Project Methodologies

Theoretical derivation of operating points for the Vdc settings using a set of equations. Operating points are derived for a range of wind speed from 1m/s up to 12m/s, obtaining torque, voltages and currents from the steady state equations

Two simulation test: one with load resistance and one with the rectifier.

Design hardware to carry practical tests. A number of pcb's are designed to monitor voltages, currents at strategic points at generator terminal outputs, at the dc link and at the inverter output. Current is also noted at the DC motor armature, as shown in the diagram above. A split board is also designed for the encoder at the turbine generator to split the signal, one for the dc drive and one to the microcontroller to monitor the rotational speed of the turbine, it isolates the signals from each other hence avoiding any possible interference between different equipment.

A frequency to voltage converter is build to convert a signal from the microcontroller as a voltage reference to the dc drive to set the torque required on the motor. Frequency range is up to 250Hz. All data is to be sent to a microcontroller where parameters monitored can be analyzed and result can be compared with the theoretical and simulation ones.

Results and Achievements

[The torque that can be handled at any time by the turbine generator cannot exceed 32.81Nm. This value of maximum torque already gives an indication on the range of operation for the wind turbine under analysis. For wind speeds greater than 10m/s, the torque generated at maximum value of Cp-λ exceeds the maximum torque allowed by the turbine generator. Thus turbine cannot operate at this points. Therefore optimized range of operation of the wind turbine is from 1m/s to 10m/s. From the calculations done, every type of turbine generator gives a different scenario of operation. A slight change in the generator flux would result in a drastic change in the load resistance and the dc link voltage which would have an affect on the inverter characteristics. This may be caused if the inverter settings are very sensitive to the generator parameters. It is to be tested experimentally to gauge how sensitive the yield is to the parameter tuning. Care must be taken when choosing the turbine generator to eliminate any problems like this.

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Book:

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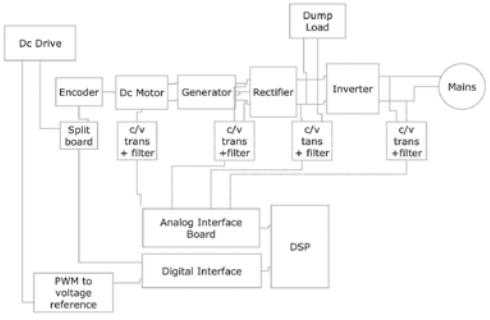

Investigating the Performance and Reliability of LEDs when compared to other lighting sources

Student: Harney Brendan Mark
Supervisor: Dr. Cedric Caruana

Background

Human activities such as burning of fossil fuels, coal, gas and oil are causing gas carbon dioxide which is being emmitted into the atmosphere causing the temperature to rise. A process called global warming. Consumers can help in saving energy by switching to LED lighting instead of incandescent bulbs. LED bulbs are much more efficient than incandescent lamps since they do not rely on a glowing filament technology to produce light. Only 10% of the energy consumed in traditional incandescent lamps is converted into light whilst the rest is all converted into heat. Thus incandescent lamps produce an efficacy of only 15 lm/W, while white LEDs reach efficacies of about 100 lm/W. LED bulbs are much more complex than incandescent to manufacture and so they are more expensive and have a greater probability of failure.

Project Objectives

LED lamps have been analysed and compared to other lighting sources in order to test their failure modes. Several test rigs have been designed on specific criteria and constructed in order to be able to test the sample bulbs under different scenarios. The sample of 67 LEDs was tested in all six setups.

Test 1 - Rated voltage (normalized setup) Test 2 - Reduced supply voltage

Test 3 - Elevated temperature controlled at 60oC Test 4 - Elevated temperature in closed enclosures

Test 5 - Reduced temperature Test 6 - Rapid cycle test

Case studies

Case study 1: Teatru Govanni Xewkija Stage Lighting

Case study 2: Ta' Pinu Church Lighting

Case study 3: Hilton Oceana Lighting

In the first two case studies, the present lighting consumption was logged to analyse if it is viable to change the installation to LED lamps. In the last case study the supply quality has been analysed since they have problems with a flickering of LED lamps.

Project Methodology

The aim of this thesis is to test different scenarios where LED lamps are used:

- Currently the voltage in Malta is 230V± 10%, LEDs may have a problem of flickering due to a decrease in voltage in the mains supply.
- To reproduce temperatures found in closed enclosures since these conditions tend to heat up the LED bulbs more than in other places.
- To produce temperatures that are found in commercial refrigerators. A refrigerator was built to test the performance of LED lamps at low temperatures.
- To setup tests for the LED lamp together with its driver circuitry in switching applications.

Results and Achievements

The majority of failures occurred in the elevated temperature setup Ideally LEDs should be installed in well ventilated areas in order to keep their ambient temperature low. An LED is not a true lamp but it's a complete electrical, electronic and optical system which then is embedded in a housing to form a lamp.

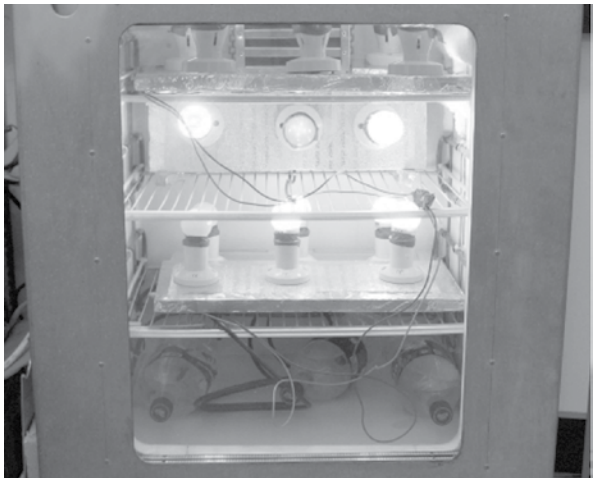

Figure 1 – Reduced temperature setup

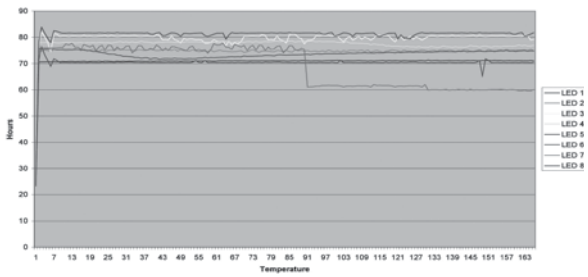

Figure 2 – Failure of LED 7 in elevated temperature setup

Analysis of the impact of distributed generation on the electrical grid

Student: Marilyn Chetcuti
Supervisor: Mr. A. Micallef

Introduction

Distribution generation (DG) provides an alternative to the traditional electricity sources i.e. coal, gas, oil, water etc. It can also be used to improve the present electrical system. Efficient clean fossil-fuels technologies such as micro-turbines, fuel cells, and environmental-friendly renewable energy technologies such as biomass, photovoltaic, hydro turbines and wind turbines, are increasingly used for new distributed generation systems. The DGs are becoming gradually more popular due to their low noise levels, low emission and high efficiency. With the increasing use of DG, it is very essential to study its impact on the low voltage grid.

Project Objectives

In this study, the main aim is to analyze the potential impacts that Distributed Energy Resources (DER`s) might have on the stability of the grid. In particular, the study shall investigate the impact on the voltage stability and power quality of the network under steady state and dynamic conditions of a large number of renewable energy sources (RES`s) connected to the low voltage grid. In addition the impact due to the intermittent nature of these RES`s on the grid shall also be investigated. A simulation of a system was created in PSCAD to analyse the impact of DER on the electrical grid.

Project Methodologies

The project was organised as follows:

- Literature review on the impacts of distributed generation on the electrical grid and on simulations of different tested power systems
- Implementing different photo voltaic models
- Using bipolar scheme for pulse width modulation and synchronising with the grid by phase locked loop
- Connecting number of PV panels in series and implementing the system using short circuit transmission line model
- Analysis of testing results

Results and Achievements

The I-V characteristics of the PV cell were simulated and verified using PSCAD as shown in Figure 2.

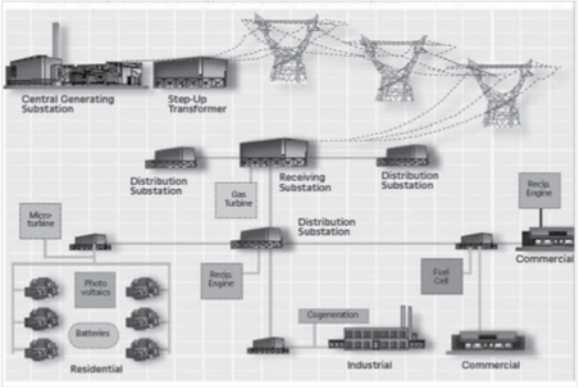

Figure1:DER placement in power system

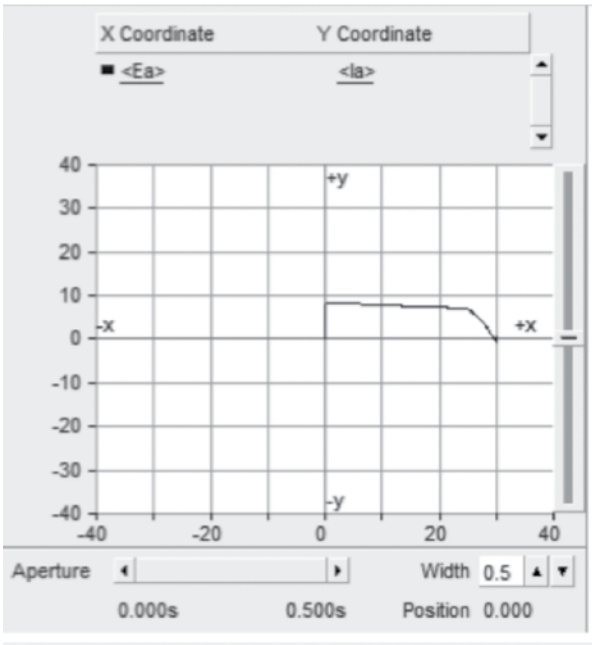

Figure 2: I-V characteristics of a PV cell

Armature Growler and Insulation Tester

Student: Trustin Farrugia Cann
Supervisor: Dr.Cedric Caruana
Sponsor: MIA, plc

Introduction

With industrial growth, it has become necessary to monitor the condition of the machine. One method to determine the condition of the motor system is via Current Motor Signature Analysis. Using this method, one is able to detect and diagnose stator insulation system, rotor winding problems and bearing faults. This technique is known as online monitoring and has the advantage that the machine does not need to be taken out of service. On the other hand offline methods are more accurate and direct. Also these offline techniques ensure the flawless operation of the machine. One type of offline method is the armature growler and insulation tester.

Project Objectives

The armature growler acts as a preliminary test to detect shorts and open circuits in the rotating part of the electrical machine, as seen in Photo 1. This type of Offline monitoring technique was required by Malta International Airport, plc, and hence this tester was designed and constructed for this prominent firm, such that it could be used in the workshop by the electrical section of the Technical Services Department. However, an online technique was implemented as seen in Photo 2 with the rig setup.

Project Methodology

As regards the offline monitoring, the following steps were conducted:

- Design of the bobbin and determination of the most suitable material for such construction.
- To cut the laminations according to our specifications.
- Design and calculations of the primary and secondary winding.
- Simulation analysis using Maxwell software package, as seen in Figure 1.
- Design and construction of the chassis.

Conversely for the online monitoring, the MCSA consists of the rig setup as seen in Photo 2 and obtains current spectra results as seen in Figure 2.

Photo 1: shows the armature growler and insulation tester

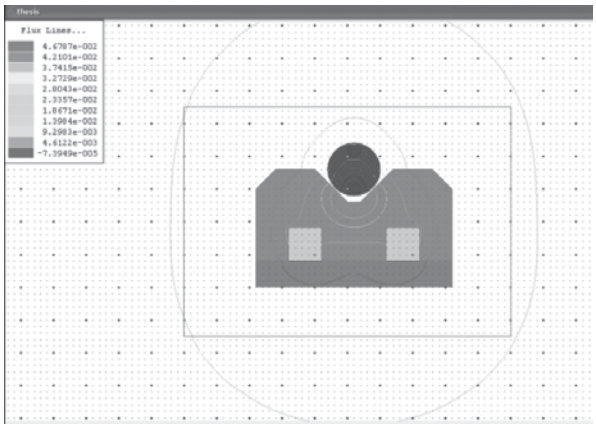

Figure 1: shows the Simulation Result.

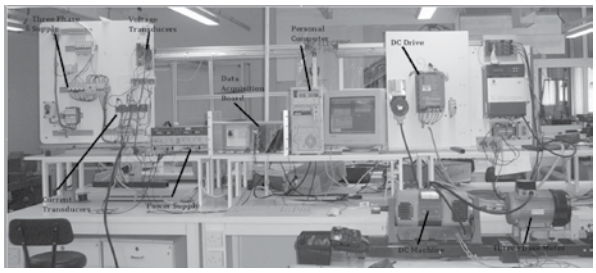

Photo 2: shows the test rig setup.

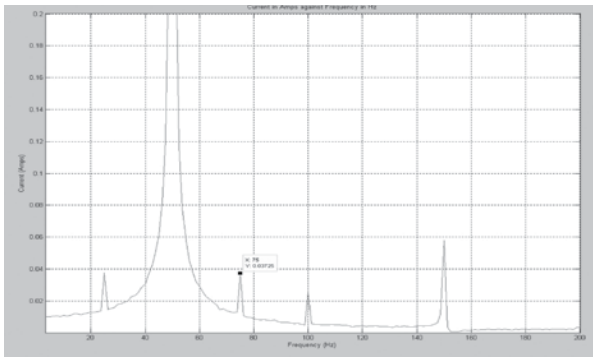

Figure 2: shows the current spectra of a healthy motor

A grid connected brushless DC drive for micro wind turbines.

Student: Josef Mizzi
Supervisor: Prof. Joseph Cilia

Introduction

The main problem in permanent magnet alternators that hinders the generation of power during light winds is cogging. Cogging is when the rotor aligns itself to the position of minimum reluctance due to the internal construction of the alternator itself. As a result, the rotor 'locks' itself and requires a larger force to initially turn the rotor, due to the summation of forces required to drive a magnetic pole across the air gap. Cogging will have an effect on the wind speed required for the turbine to generate sufficient voltage in order to be able to start to feed the grid via the inverter, commonly referred to as the cut in speed of the turbine. Thus, higher wind speeds are required.

Project Objectives

- Design, development and implementation of a brushless drive system for a micro wind turbine.
- Reducing cogging and maximising the voltage output from the alternator in order to reduce the cut in speed of the turbine.

Project Methodologies

The study is divided in this way:

- Literature review on methods of reducing cogging.
- Analysis of the permanent magnet machines used in electric bicycles and electric hub motors.
- Designing and constructing an alternator in which the magnet configuration could be varied in order to analyse the relation between the magnetic poles, cogging and output voltage.
- Construction of a vertical axis wind turbine.
- Designing and constructing of a rectification circuit, in a way to obtain the highest possible voltage from the two phases.

Results and Achievements

In most design procedures 'Finite Element Techniques' are used to model the flux in the motor, in order to design the optimum configuration of magnets. Since in this study the above mentioned testing jig was designed and constructed so that within a few hours of work the configuration of magnets could be changed and tested, the approach adopted was to make a pre thought configuration and obtain the actual results right away. Apart from using the optimum magnet configuration deduced from testing, the final design of the turbine will include two alternators. These will be aligned in such a way that when one is at maximum reluctance the other is at minimum reluctance for them to compensate and reduce combined cogging. In this way, no voltage is lost to reduce cogging since this is eliminated in a mechanical method rather than by manipulating the flux, which is required for voltage generation. Also the slots in the laminations are filled with a material which has magnetic reluctance less than air, thus reducing cogging, as there is no variation of the air gap around the motor.

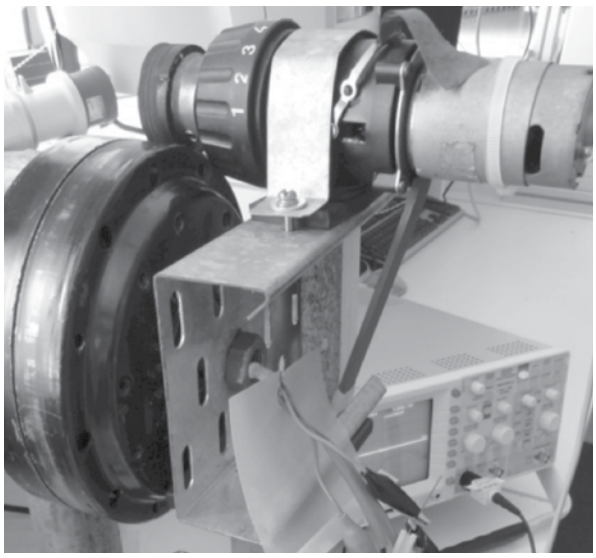

Figure 1: The testing jig built for the alternator

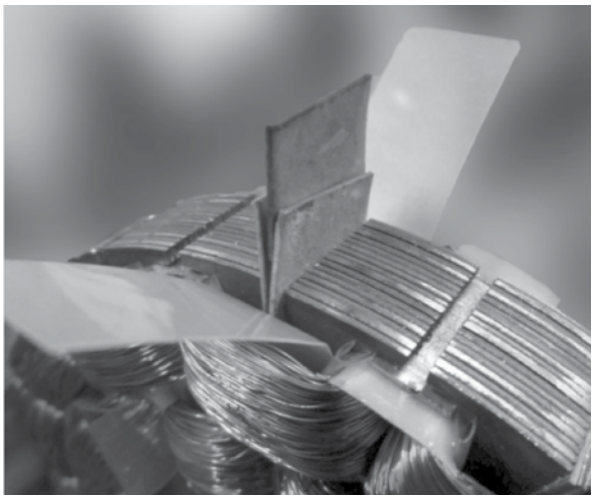

Figure 2: Inserting the metals in the stator slots to reduce the cogging effect.

Dynamics and Stability of large scale wind farm for small grid networks

Student: Annalise Xuereb
Supervisor: Prof Cyril Spiteri Staines
Co-supervisor: Ing Alan Cassar

Introduction

Climate change has become the most pressing environmental issue the world is facing due to the increase in demand for energy, the resulting dependency on fossil fuels and the many harmful impacts to human and non-human life. These actions are making it necessary for us to change the ways we produce and consume energy and while there is a need to reduce the energy consumption alternative energy sources can provide an immediate opportunity to medicate climate change.

Project Objectives

The purpose of this project is to analyse the introduction of the 100MW wind farm at Sikka l-Bajda and the submarine cable between Malta and Sicily with a maximum continuous rating of 250MVA.

Project Methodologies

The study carried out is mainly divided into four sections:

- the interconnector's behavior
- the network's behavior when the wind farm is switch off
- the transient response of the network at the instance when the wind farm is lost
- how 3 phase faults on the 132kV network effects the whole system

Results and Achievements

Through this analysis the behaviour of the system in the event of losing the 100MW wind farm is simulated. This will affect the generators' outputs and the system frequency thus the critical scenarios that the network can be operating in are identified.

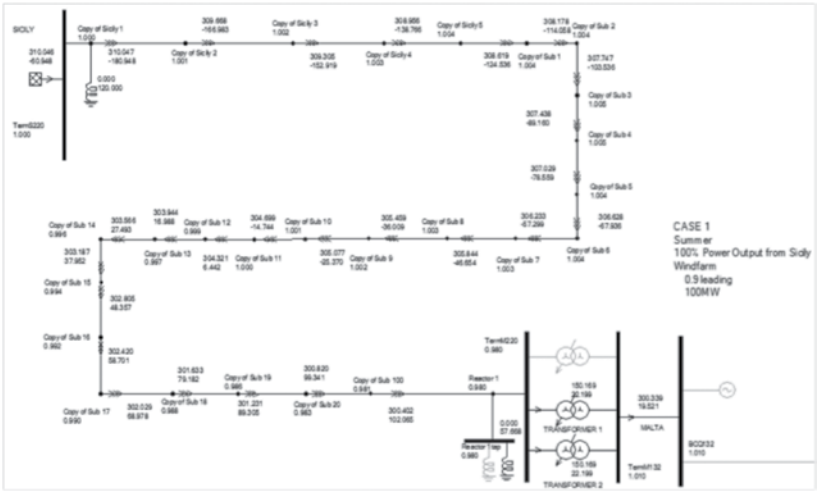

Image Classification in Capsule Endoscopy

Student: Maria Bonello
Supervisor: Mr. Carl Azzopardi
Co-supervisor: Prof. Ing. Kenneth P.Camilleri

Introduction

Wireless Capsule Endoscopy is a pill-sized imaging capsule that is swallowed by the patient, and it examines the whole gastrointestinal system with a non invasive procedure (shown in Figure 1). The examination takes about 8 hours and approximately 60,000 images are generated. These images need to be painfully examined one by one by the clinician in order to make accurate diagnosis of gastrointestinal pathologies and of possible malignancies. Manufacturers of the capsule provide a software (Rapid Reader) which helps to automatically detect pathologies and displays the route and relative position of the capsule on a graphical method, but to enable these features, first the clinician must locate and mark the pylorus valve and the ileo-caecal valve [1].

Project Objectives

The main objective of this dissertation is to the design an automatic discrimination algorithm that can distinguish between one organ and another. This is done using k-Nearest Neighbour classifier. Subsequently the rate of accuracy of performance of the classification algorithm is verified. Ultimately detection of the pylorus valve and the ileo-caecal valve is carried out using a boundary search algorithm.

Project Methodologies

The methodology implemented for this project is essentially divided into four stages:

1. Data Acquisition – Raw data is acquired from 4 capsule endoscopy videos. Each video consists of 55,000 images and these images are exported to Matlab. The images are then cropped to a rectangular area of interest.
2. Pre-Processing – The images are in their RGB colour model and they are converted into the HSI colour space which is very similar to the human eye sensitivity of colours. 2D histogram plots are built using the Hue and Saturation components.
3. Data Compression and Extraction of Features – The discrete cosine transform followed by the principal component analysis are applied to the 2D histogram plots and this results in smaller models of the histogram data.
4. Classification Process - This process is done using the k-NN classifier and finally the position of the 2 valves is detected using a boundary search algorithm.

Results and Achievements

The methodology adopted is quite promising. From the results that were obtained so far, the highest rate of accuracy for the k-NN classifier is of 99.5%. This shows that an automated image classification algorithm that can be applied to capsule endoscopy images is possible. Maybe in future work, the methodologies for automatic classification of the digestive organs and the methodologies for automatic detection of pathologies can be integrated together.

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Figure 1: Showing the pill-sized capsul endoscope as it travels down the digestive system. (source: power point presentation by Eric Goldberg M.D. Director of VA GI)

The Pendubot: Design, Implementation and Control

Student: Josef Camilleri
Supervisor: Ing. Marvin K. Bugeja

Introduction

The name Pendubot arises from the terms 'Pendulum' 'Robot'. The structure of this system is mainly composed from two links interconnected together by means of a revolute joint. This nonlinear planar robot belongs to the family of under-actuated systems because only the first link is actuated while the second link is freely hinged. As a result, the system has two outputs and one control input. These attributes and the inherent open loop instability, make this system an attractive benchmark control problem whereby advanced nonlinear control techniques are investigated. Such methods include; optimal control, robust control, adaptive control, hybrid control and switching control.

Project Objectives

- Literature review on the control of inverted pendulums, focusing on the Pendubot configuration.
- Mathematical modelling of the Pendubot.
- Design and implementation of the Pendubot mechanical setup.
- Design and implementation of the circuitry required for the control of the Pendubot.
- Design and implementation of swing-up and stabilization control strategies for this pendulum.
- Testing of the simulation and evaluation of the experimental results.
- Project Methodologies
- Literature review on the control techniques adopted to swing-up and stabilize the Pendubot system in various equilibrium positions in particular focusing on the inverted upright configuration.
- Research on mathematical models available especially the theorems used in such derivations and their application.
- Design and manufacture of the mechanical structure of the Pendubot system.
- Implementation of the electronic boards required to drive the mechanical setup and the interface to the DS1104 board from DSPACE.
- Design, simulation and implementation of the required controllers on the DS1104 board including the studied swing-up algorithms.

Results and Achievements

The applied control algorithms and the designed controllers were applied in practice and validated by the global stability achieved for the inverted unstable equilibrium position. Furthermore, the robustness of these algorithms was checked by varying the initial conditions and changing the system dynamics by attaching weights to the pendulum.

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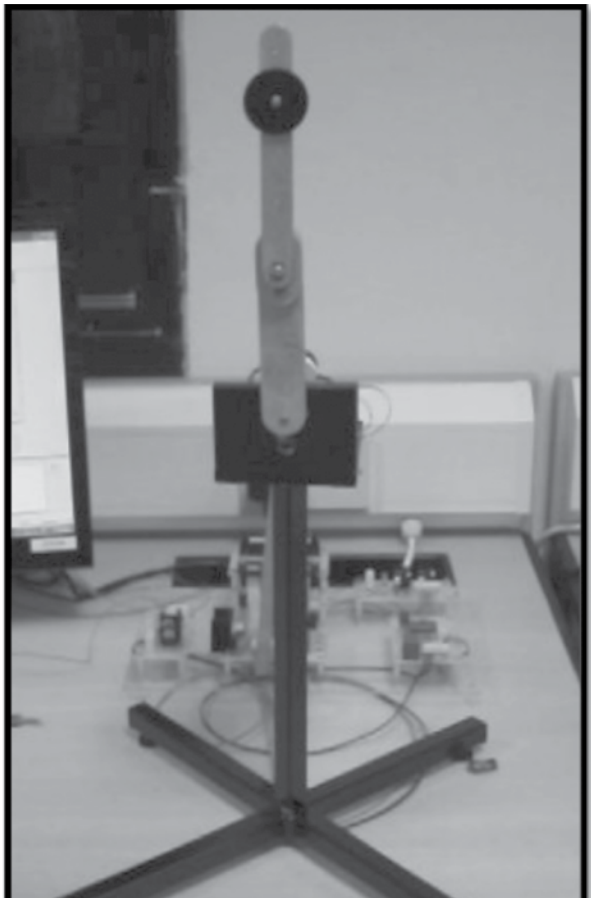

Figure 1: The Pendubot system under test with weights attached.

Eye Blink Detection for Blink Pattern Analysis

Student: John Paul Cassar
Supervisor: Ms. Stefania Cristina
Co-supervisor: Prof. K. P. Camilleri

Introduction

Eye blink detection and the analysis and classification of blink patterns, is a relatively new area in the Human-Computer Interaction field. Such systems can be applied in various situations, such as in a car to analyse driver fatigue level, or for communication purposes.

Project Objectives

The aim of this project is to i5mplement a blink detection system that imposes minimum restraints on the user. The fundamental requirement is for a non-intrusive system, which does not require the user to wear any special hardware, acquiring the input via a webcam. Ambient lighting conditions are used, as opposed to active systems which require external illumination from specialised hardware such as near infrared (I.R.) sources to operate. These specifications result in a system that is easy and cheap to implement, and imposes less constraints on the user, while at the same time retaining its effectiveness.

Project Methodologies

The implemented system consists of three main blocks: face detection, face tracking and eye and blink detection. An overview of the flow is given in Figure 1. An important consideration taken was the trade-off between accuracy and performance, as it is required that the system works in real time. The system was designed to give the user the minimum restrictions, but some assumptions are made. In the initial sequence of the system, a frontal view of the user's face is required in order to get clear eye templates. Also, it is assumed that there is enough ambient light to acquire clear camera images, and it is important for the user to have constant lighting on the face region.

The face detection algorithm initialises the system, by means of a Haar Classifier. In the initial sequence, the Harris corner detection is applied on the rough eye regions, acquired by subdividing the face location given by the Haar classifier, to accurately locate the eye to acquire the online open eye templates. Subsequently, for an (n-1) number of frames, the face is tracked via the Camshift tracker, in order to acquire the location of the face at each frame. The Camshift is reinitialised at the nth frame by the Haar classifier for accuracy purposes. The online templates are compared to the rough eye regions using cross correlation. By setting two thresholds for the similarity measure, the state of the eye can be determined, and blink patterns classified.

Results and Achievements

The Haar classifier detects only face regions based on training images, and as a result tilted faces are not detected. This proves to be an advantage when sampling the open eye templates, but a disadvantage when detecting the face throughout the rest of the system; one reason the Camshift tracker was used. The Camshift tracker, on the other hand, detects the face at all angles and is computationally lighter. Non-constant face lighting will negatively affect the Camshift tracker and the corner detector. Different lighting conditions though, do not negatively affect the system, given that a clear image is still available from the camera.

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Figure 1: System Flow

Multiclass Motor Imagery BCI System

Student: Elaine Damato
Supervisor: Prof. Simon G. Fabri

Introduction

A Brain Computer Interface (BCI) is a direct communication pathway between the human brain and electronic or mechanical devices. As shown in Figure 1, signal processing is performed on the collected data. The signal processing stage enables a more successful signal classification, which in turn increases the possibility of new applications. These applications are particularly useful for locked–in patients who have lost the ability to control the most voluntary muscles through injury or disease, but are still aware. Their brain activity can be used as a source of communication. The brain activity of a patient imagining doing a particular movement is recorded and translated into a particular computer command. The importance that the movement should be imagined and not performed is because BCIs are used by locked-in patients [1].

Project Objectives

The main goal of this project is to develop a multiclass BCI system where EEG signals are captured whilst a subject can imagine doing any one of four possible tasks – left hand, right hand, foot or tongue movement. This involves identifying which brain areas are activated when the subject performs each of these movements, extracting reliable features that characterize each of these tasks and feeding selected features to a suitable multiclass classifier to identify which task the subject was imagining.

Project Methodologies

- Researched about signal processing in biomedical engineering.
- Identifying the project's objective which was used to divide the project into five blocks; Common Spatial Pattern, Band-pass Filtering, Feature Extraction, Feature Selection and Classification.
- The theory behind each block was researched and various methods on how to perform each block were identified. The pros and cons of each method were studied, and a final decision on which approach will be adopted was made.
- The first three blocks were designed and tested using Matlab, each block was verified to be working correctly by testing the algorithm on dummy data.
- Feature Selection was made by using the correlation-based feature selection developed by Hall [3] and is available as an in-built algorithm in Weka. Weka is a collection of machine learning algorithm for data mining tasks developed by The University of Waikato [4]. It was also used for the classification stage since it enables different classification methods which can be examined carefully and methodically.
- Dataset IIIa from the BCI III Competition was used to analyse our system. It provided brain activity recordings from three subjects having different levels of experience. The performance of each subject was recorded and compared to other two.
- The project's limitations and possible improvements were identified.

Results and Achievements

The classification results obtained are satisfactory and their values are close to the ones achieved in [5]. The top four classifiers for each subject were as follows:

- for Subject 1: 1 and 5-Nearest Neighbours, Random Forest (all 86.1%) and Ada Boost (83.3%)
- for Subject 2: Radial-bases Network (62.2%), Naïve Bayes (59.5%), 1 and 5- Nearest Neighbours (both 56.8%)
- for Subject 3: Logistic Regression (67.5%), Multilayer Perceptron, Bagging and Random forest (all three 62.5%)

Currently work is being done to improve further these accuracy results by altering the different variables affecting their performance.

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Closed-Loop Control of a Laser Cladding System using a Video Camera

Student: Michael Farrugia Magro
Supervisor: Dr. Kenneth Scerri

Introduction

Laser cladding is being employed in the field of rapid prototyping to manufacture metallic components. The process is dependent on a large number of parameters and when it is carried out in open-loop, results are heavily dependent on the skill of the operator. The controllable parameters of the process, which may include laser beam power, powder feed-rate and scan velocity, have to be determined for different intrinsic parameter combinations through extensive experimentation which is costly and time consuming. These parameters are left unchanged through the course of the process. However, without any means of feedback, disturbances in process parameters usually result in the deterioration of the clad quality [1]. Even more critical in rapid fabrication is the problem of heat accumulation and continuously changing geometry of the structure. Process parameters do not remain optimal and this often results in deformation of the component. Most of the time operators resort to manually changing the control parameters to reduce imperfections. However this is based on extensive knowledge of the setup and parameter relationships and results are often not reproducible.

Project Objectives

The objective of this project is to research and develop a camera based feedback control system which provides significant improvements in quality and reproducibility of the prototypes. Using a coaxially mount CCD camera the interaction zone is to be monitored and controllable parameters adjusted in real-time to manufacture a prototype with the desired clad characteristics.

Project Methodologies

The objectives of this project were achieved by carrying out the following steps:

- Literature review on the equipment used for laser cladding, the relationship between different controllable parameters and characteristics of the cladding layer, sensing methods and the underlying physics of the process.
- Modification of the existing optical system to allow monitoring of the melt pool using a camera which is coaxially mounted.
- Interfacing the existing hardware controllers with the dSPACE DS1104 R&D board.
- Development of a fast and accurate image processing algorithm using the MATLAB© environment in order to extract melt pool width and intensity in real-time.
- Development of a graphical user interface for testing and control of external hardware.
- Implementation and optimization of different feedback controllers for use in rapid prototyping.
- Investigation of the performance of the different type of controllers.

Results and Achievements

Analysis of the experimental results suggests that a correlation exists between the average melt pool width and the heat accumulation over time. Apart from heat accumulation, the melt pool width is also indicative of the disturbances in process speed, powder variations and substrate imperfections in single clad experiments. So far, a camera-based control system was successfully implemented by controlling the input power to keep the width to the specified reference value. Work is underway to test different feedback controllers.

References

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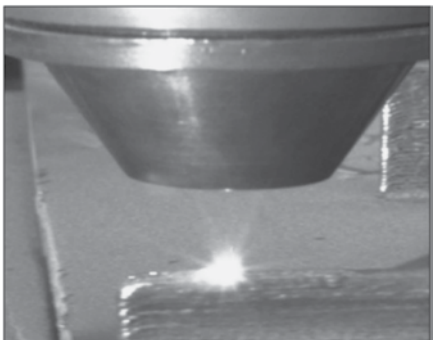


Figure 1: Coaxial laser cladding

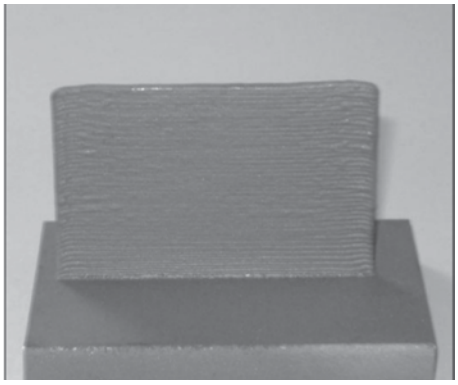


Figure 2: Finished prototype

Spatio-Temporal Modelling, Analysis and Control of Air Pollutants in Malta

Student: Gaynor Grech
Supervisor: Dr. Kenneth Scerri

Introduction

Recently, great interest has been given to assessing and improving air quality of the Maltese Islands. As a monitoring assessment the Malta Environment and Planning Authority (MEPA) is collecting monthly average data of various air pollutants from a network of diffusion tubes located across the Maltese territory as shown in Figure 1. Motor vehicles are today's main treat to clean air in urban areas and are chief producers of the pollutant; nitrogen dioxide (NO_2). This study focuses on the most dense traffic area, shown in Figure 2 and considers nitrogen dioxide measured data.

Project Objectives

[The main objective of this project is to analyse pollutant data and develop the best mathematical model that represents the data. This model is then used to predict future pollutant levels within the analysed sites, to identify factors that affect pollution characteristics and to assess the effectiveness of possible remedies.

Project Methodologies

The following steps were carried during the implementation of the project:

- Literature review on models used to describe pollutant diffusion
- Interpolating and eliminating outliers from the data
- Removing identified trends and seasonal variations from the data
- Fitting univariate AutoRegressive (AR) and Spatio-temporal AR (STAR) models to the filtered data
- Model Validation
- Predicting future pollution levels
- Simulating scenarios for air quality improvement

Results and Achievements

[Temporal models and spatio-temporal models for the sites in Figure 2 were developed to a reasonable predictive accuracy. Similar temporal patterns were observed for all sites since they take input from the same stable source (traffic). However, it was noted that if at a site there is a change in the source level input (e.g. less traffic) the behaviour of this site even though being relatively close to another, is independent. This concluded that for a data resolution of one month, spatial dependencies of the analysed sites is not attributable to pollution dispersal but to local factors, mostly similar traffic patterns.

References

[1] http://www.mepa.org.mt/air
[2] Chatfield C.], 'The Analysis of Time Series An Introduction' CHAPMAN & HALL/CRC , USA, 2004.

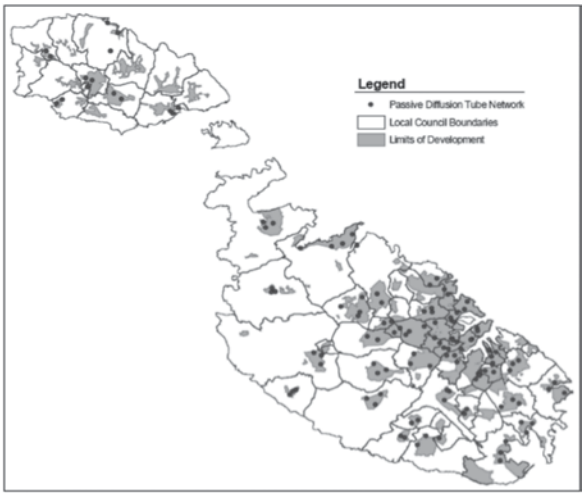


Figure 1: Diffusion Tube Network

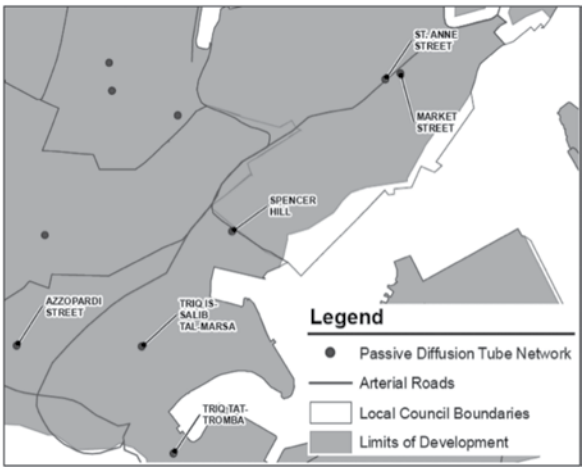


Figure 2: Case Study- Area

Particle Swarm Optimization for Control Design

Student: Julian Mercieca
Supervisor: Prof. Simon Fabri

Introduction

Witnessing computing power forging ahead at an unparalleled rate, we face an increasingly compelling question of how best to exploit these advances. This question presents both the tempting approach of throwing as much computational power at a problem as possible, or not taking advantage of available computing power at all. This thesis addresses the delicate interaction between theory and computation in the context of proportional-integral-derivative (PID) control and optimal control.

Project Objectives

[Despite the widespread use of PID control, this exhibits the short-coming of having no efficient tuning methodology. This calls for an optimization strategy that determines optimal PID controller parameters. Furthermore, nonlinear optimal control constitutes yet another challenge in control theory. While the solution of the Hamilton-Jacobi-Bellman equation remains intractable in all but the simplest cases, a receding horizon methodology may exploit metaheuristic optimization algorithms to provide an alternate more computationally feasible approach. Having shown particular promise in multimodal problems, particle swarm optimization (PSO) is employed in the aforementioned control design problems.

Project Methodologies

A PSO-based PID tuning method is developed in MATLAB and simulated for different linear plants. Additionally, linear quadratic optimal control strategies are implemented using PSO and compared with their analytical counterpart. After gaining an empirical insight into PSO tuning, the nonlinear model predictive control problem is treated. A nonlinear model predictive controller based on PSO is proposed, and a case study of the inverted pendulum on cart problem is considered and examined in a Simulink environment.

Results and Achievements

The PSO-based PID tuning method proved to be a successful application of PSO and the optimal controller parameters, based on a time-domain performance criterion, were obtained. All linear quadratic optimal controllers implemented using PSO matched the analytical results, with very fast convergence rates and negligible standard deviation. The proposed nonlinear model predictive controller exhibits superior performance, achieving a significantly lower performance index than a numerical linearization technique employing conventional convex optimization methods. This is evidenced by the simulation results of Figure 1, illustrating the less work done by the cart for the swing-up phase of the constrained nonlinear model predictive control problem, offering a promising new paradigm for nonlinear optimal control design.

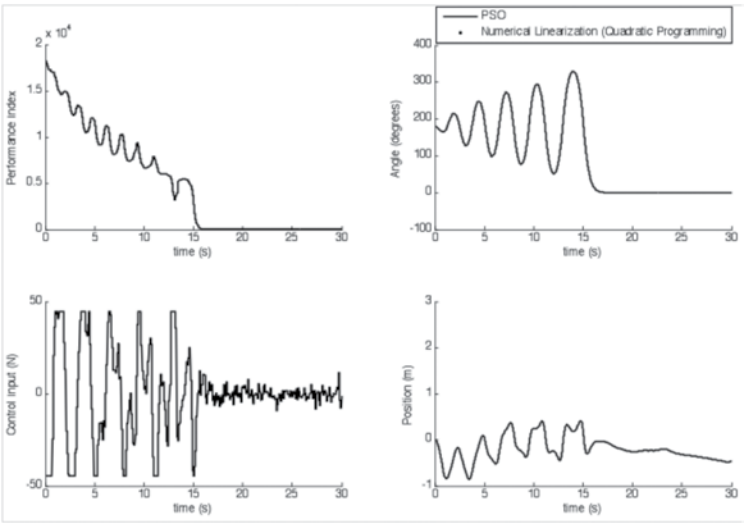


Figure 1: Simulation results for the constrained nonlinear model predictive control problem, considering an inverted pendulum on cart.

Classification of Neurotransmitter Voltammograms through Neural Networks

Student: Mario Sammut
Supervisor: Mr. Carl Azzopardi
Co-supervisor: Prof. Kenneth Camilleri

Introduction

The human brain coordinates all the functions of the body, the different muscles, and actions and even thought. The human nervous system is the network which the brain uses to coordinate everything, and its complexity arises from the vast range of tasks and processes that the brain controls.

Project Objectives

- Identification and quantification of the pure state neurotransmitter signals acquired a priori through voltammetry, using Neural Networks
- Classification and quantification of neurotransmitter mixtures using Neural Networks
- Assessing the performance of the Neural Network when changing its parameters to identify the best set of parameters for an accurate output
- Comparison of results obtained using the ideal linear case with those obtained using the real data
- Comparison of the results obtained to previous work in this field

Project Methodologies

Neural Network parameters are not fixed, but rather a methodological training has to be carried out to achieve the best parameters to address our problem.

Analysis of our problem led us to choose a multilayer feed-forward network, and to apply the Backpropagation Algorithm. The Backpropagation algorithm involves three stages; the feed forward of the input training pattern, the backpropagation of the related error, and the adjustment of the weights. The weight initialization of the nodes is the first step.

The process of carrying out the analysis was divided in three scenarios. The first scenario considers the pure case of the neurotransmitters. In this scenario the Neural Network was trained for on two different pure neurotransmitters at each time, and therefore the combinations sets: Dopamine-Serotonin, Dopamine-Norepinephrine and Serotonin-Norepinephrine were considered. Training using signals of the pure neurotransmitters was carried out, and the training data set included two the different neurotransmitters at different micro molarsconcentrations still at the pure state. Testing was carried out forby making the network to classify and quantify a test set of pure neurotransmitters for which it had been trained. The second part of the first scenario considered the training of the network using the pure neurotransmitters as before, but now the signals for testing were mixtures of the trained neurotransmitters. The Neural Network was required to classify and quantify for each signal.

For the second scenario the same training and testing procedures were carried out, however this time mixtures of the neurotransmitters were included in the training data set. Testing was first carried out for the pure signals and then for mixtures. Therefore the second scenario was to train and test for two neurotransmitters, but this time teaching the neural network how mixtures looked like.

In our brain, there is a whole list of different neurotransmitters, and Iin the third scenario the Neural Network is trained with three different neurotransmitters at different micro molars. Primarily it is required to identify and quantify the neurotransmitters in their pure state. Then it is tested for mixtures of two neurotransmitters, for which the network has been trained.

The three scenarios were first examined for the ideal linear case, by creating a dummy dataset. and It was then tested withfor the actual real signals.

Results and Achievements

The Feed-forward Neural Network using the Backpropagation Algorithm is proving to estimate good results when recognising and quantifying neurotransmitters in their pure state, both when training is carried in pairs and even when training with three signals.

The testing of the neural network for mixtures of neurotransmitters has to be finalized and compared with the results achieved using Fast Scan Cyclic Voltammetry.

References

[1] R. Webster "Neurotransmitters, Drugs and Brain Function", Wiley, West Sussex, 2001

Non-Linear Control of a Ball and Plate System

Student: Andrew Vella
Supervisor: Ing. Marvin K. Bugeja B.Eng(Hons) MIEEE

Introduction

The problem of controlling a ball over a beam has thoroughly been investigated and explored and various control methods have been applied to it. The Ball & Plate system is a two-dimensional version of the Ball & Beam. The problem is now of controlling a free moving ball on a flat, rotary surface rather than a beam.

Imagining the ball to be the end-effector of a robotic manipulator, the Ball & Plate system has four degrees of freedom. The Ball & Plate system is open loop unstable, inherently non-linear and under-actuated.

Project Objectives

- To explore different control strategies for the implementation of regulatory controllers that automatically stabilise the ball at a predefined point on the plate
- To design controllers for the implementation of servo systems that automatically track a changing reference position on the plate.
- To assess the available hardware and make alterations where deemed useful.

Project Methodologies

A variety of control methodologies were applied to tackle the tasks at hand. Since the actuators on this project are DC motors, two output variables which we want to control are the angular position of the shaft and the current in the armature windings.

Classical control methods using PID techniques were applied to control the angular positions of the motor shafts depending on the error in the position of the ball on the plate. On the other hand, state-space techniques were applied to control the torque on the motor shafts which is directly proportional to the armature current. With this technique, a linear and a non-linear controller topology were investigated and both Pole Placement and Linear Quadratic Regulator were used.

Results

The system is automatically stabilizing the ball at the reference points on the plate with minimal steady-state error and settling times of about 15 seconds using LQR and 25 seconds using PID.

Using PID techniques, the system is also tracking a circlular reference trajectory though with a steady state error.

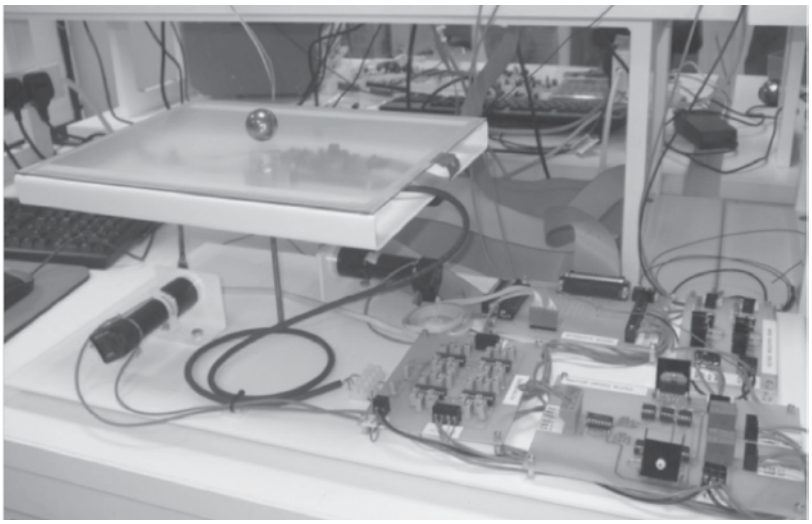


Figure 1: Original Greyscale Image

Stochastic Techniques for Modelling of Dynamic Systems

Student: Francesca Vella
Supervisor: Prof. Ing. Simon G. Fabri

Introduction

Modelling of systems and processes is an important step in the context of system analysis and design. Achieving better control and an understanding of system dynamics is of importance when studying the behaviour of a system. When interacting with a system, a theory is needed to investigate how its variables relate to one another. This relationship amongst observed signals can be defined as the model of that system [1]. One approach to modelling of systems is based upon the input-output collection of data. This data is used to fit in parameters of a model such that the error between the data and the prediction of the model is at a minimum. Very often the data is subjected to noise therefore, several techniques from stochastic theory have been proposed for this purpose. This project aims to investigate the use of stochastic techniques, including the least-squares method, the recursive least-squares method, the Kalman filter, and the stochastic negative gradient approach, for data-driven modelling of dynamic systems.

Project Objectives

The objectives of this project are:

1. An extensive survey of stochastic techniques and algorithms for data-driven system modelling;
2. Implementation and development of such algorithms;
3. Modelling of dynamics systems, namely biomedical data, using these stochastic data-driven techniques;
4. Analysis of the modelling results, testing and validation.

Project Methodologies

The methodology adopted was carried out as follows:

1. Background theory and literature review;
2. Design and Development of the algorithms using MATLAB;
3. Simulation results:
   - Comparison between the different stochastic techniques studied;
   - Analysis of the simulated results, testing and model validation.
4. Practical results:
   - Pre-processing of the biomedical data;
   - Analysis of data, testing and model validation.

Results and Achievements

Simulation results obtained show the difference between the stochastic techniques studied when using a test auto-regressive moving average (ARMA) model to estimate the parameters. The Kalman filter gives the most accurate and consistent results at different noise standard deviations. The techniques, tested on an ARMA model, were validated using the residual analysis, the F-test and the Akaike's information criterion (AIC), which is also used to determine the order of the model. The residual analysis uses autocorrelation to determine the performance of the model, but the F-test and the AIC test are still needed to validate the model. Results obtained from the F-test and the AIC show that the smallest value indicates the model and the model order, which best describes the given set of observable data. The techniques are being tested on biomedical ECG data, which is obtained from a publicly available webpage [2]. This ECG data has been pre-processed to remove any deficiencies, such as outliers, signal offsets and any trends in the data.

References

[1] Ljung L. 'System Identification, Theory for the User' Prentice Hall PTR, Upper Saddle River, New Jersey 1999.

[2] E. Keogh, J. Lin, and A. Fu. (2005). Finding the Most Unusual Time Series Subsequence: Algorithms and Applications. [Online]. Available: http://www.cs.ucr.edu/~eamonn/discords/

Idle State Classification in Motor Imagery based BCI

Christian Zammit
Supervisor: Ms. Tracey Cassar

Introduction and Background

The brain is a complex, multifunctional and dynamic system used to perform various tasks some of which known as motor tasks and include left or right hand, foot or tongue. These tasks can be either real or imaginary with their brain activity being very similar. This neuronal activity is recorded using electroencephalography (EEG) in which event-related desynchronization (ERD) and event-related synchronization (ERS) results. Using such brain activity a software or a hardware based system can be controlled. This idea is known as Brain Computer Interface (BCI).

Project Objectives

The goal of this dissertation is to detect the idle state and other motor imagery tasks. The idle state is defined as any motor imagery tasks other than one of the predefined motor imagery tasks.

Project Methodologies

An extensive literature review of the algorithms and methods used in each stage of Figure 1 was formulated while identifying the benefits and drawbacks of each method. A theoretical analysis of the chosen algorithms i.e. the Common Spatial Patterns (CSP) for feature extraction and Linear Discriminant Analysis (LDA) as classifier followed. Furthermore, in this section the effect of the chosen algorithms was demonstrated using simulated data. As the algorithm should discriminate between two predefined motor imagery tasks and the idle state, thus the CSP was amended so as to cater for this scenario. The two spatial filters that result are inputted into a two two class classifier. One two class classifier discriminates between one predefined motor imagery task and any other motor tasks while the second two class classifier distinguishes between the other predefined motor imagery task and any other motor tasks. By averaging the classifier outputs the tasks can be discriminated. Then in the next section BCI competition III Dataset IVc was analyzed to note the most discriminative frequency and following the optimal active time window was selected from the topographic plots of Figure 2.

Results and Achievements

The raw EEG data was then inputted into the algorithm with the derived parameters to classify between left hand, right foot and idle trials for the dataset mentioned previously. The results are illustrated in Figure 3. The same procedure was repeated for BCI competition IV Dataset 1a with left and right hand together with idle state and PODs of 90% were achieved. From these results the idle state classification was entirely achieved with very low computational time that makes it very attractive for online BCI systems to control some software or hardware.

Figure 1: BCI process

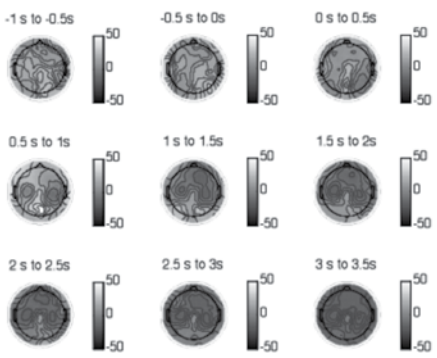


Figure 2: Topographic plots of Left Hand Motor Imagery tasks with frequency band of 12 – 14 Hz

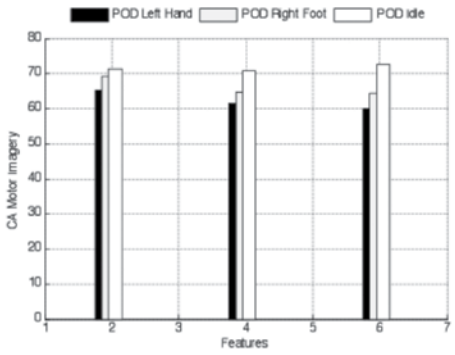


Figure 3: Probability of detection (POD) vs number of features achieved after Monte Carlo Analysis

Virtual Networked Cycling

Student: Ryan Chetcuti
Supervisor: Dr. Ing. Adrian Muscat
Co-supervisor: Dr. Ing. Saviour Zammit

Introduction

It is well known that computer games are a very engaging and motivating means of entertainment, yet they tend to promote laziness. Using gaming and its power of motivation during actual training would not only make the exercise enjoyable, but would also act as promotion for the activity.

Project Objectives

The objective of this project is to develop a system whereby a computer is used to simulate a virtual reality cycling activity, by use of an actual bicycle connected to the computer. The "virtual" bicycle would correspond in behaviour to the real one, and provide feedback to the hardware to change the amount of effort required by the user in response to the changes in the game environment (ex: uphill, wind).

Project Methodologies

The focus of the project was to develop the basic hardware and software to prove that such a system can be implemented, and that it can have the desired effects of motivation. It would then be able to be used as a tool in further research in any of the areas involved. The project required the development of:

- the hardware responsible both for input and physical output
- the software that generates the virtual reality environment
- the communication between software and hardware

The hardware, shown in Figure 1, measures the speed of the wheel and the angle of the steering, while an Eddy current disc is used to electrically vary the resistance offered to the user. A game pad is used to navigate through menus during the simulation.

The hardware is connected to a computer using a USB connection, and the software uses the readings to create a realistic movement in the simulation software. Two different graphical methods were developed for the output of the virtual environment: one using the usual 3D graphics used in computer games, as shown in Figure 2, and the other using a mixture of video and 3D.

The two systems were compared to find the merits of each system in simulating real life experiences. The software would then send a signal to the hardware to vary the resistance depending on the simulation. A system of recording and saving the performance was also introduced so that user can compete with his previous performance or with a previous user.

Results and Achievements

The resulting combination of hardware and software gives to a certain degree a good simulation of the behaviour of a bike, and can be used to develop gaming projects as well as further analysis of the effects of gaming for motivation.

Figure 1: Bicycle mounted on sensor rigs.

Figure 2: Screen capture of the simulation using 3D graphics only.

Video Compression on FPGA

Student: Keith Izzo
Supervisor: Dr. Ing. Carl J. Debono

Introduction

Real time video compression has always been a challenging problem. The requirement for very short delays between live recording and viewing on a client device, whether via the Internet, or terrestrial digital broadcasts, puts great pressure on the systems that must compress high resolution images at several frames per second. Video compression standards aim to reduce the necessary transmission data rate by compressing the video data into a more compact bitstream, with good compression often coming at a cost of high computational complexity. Having an encoder implemented in hardware rather than software may increase the performance of the system, mainly due to the potential for parallel processing of data. This can be achieved by implementing a video encoder on a Field Programmable Gate Array (FPGA).

Project Objectives

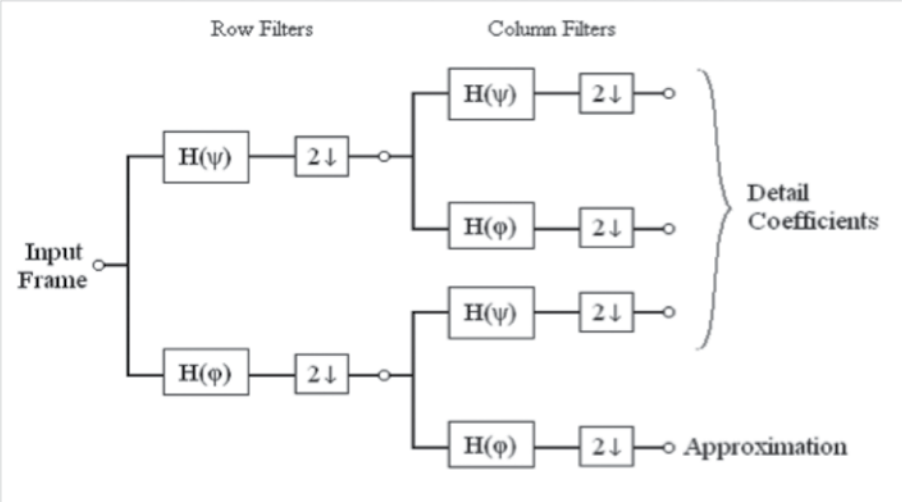
The objective of this project is to review, select and implement a video compression scheme in a FPGA.

Project Methodologies

The Fast Wavelet Transform (FWT) was selected to perform the image transformation making the resulting data suitable for compression. This is because it can be implemented as a set of hardware filters. Tests were carried out using MATLAB to simulate the FWT, and explore the effects of different quantization thresholds on the reconstructed images. Figure 1 shows the filter bank used to implement the FWT. The system was then ported to VHDL using Xilinx ISE to program the FPGA with the required hardware configuration. Simulations were carried out on each hardware block, before final assembly of the program.

References

[1] R. Gonzalez, R. Woods, Digital Image Processing, 3rd Ed, New Jersey: Prentice Hall Inc, 2008



Automatic Focusing of Digital Video Camera

Student: Jonathan Mercieca
Supervisor: Dr Ing. Carl J. Debono

Introduction

The surge in popularity of consumer video cameras is largely due to the increase in their usability, portability and affordability. One asset which has helped increase their popularity is the automation features available, which makes the camera much more user friendly. Moreover, automation makes the use of this camera more time efficient. Engineering has clearly played an important role in this process, especially when transforming the technology from analog to digital. This transformation led to the invention of some other features, such as image stabilization and electronic zooming. The features mentioned have improved a lot lately the image quality. A properly focused image or video is always presentable and pleasant to the eye.

Project Objectives

The objectives of this project are to:

- Research on various automatic focusing techniques.
- Study edge detection algorithms such as that developed by John F. Canny [1].
- Develop an automatic focusing algorithm.

Project Methodologies

The project was carried out as follows:

1. Literature survey on existing automatic focusing algorithms.
2. Selecting a technique for this project and studying the theory behind it.
3. Choosing the right software.
4. Ordering the hardware and other parts for the system.
5. Writing the source code, programming the microcontroller and interfacing both hardware and software.
6. Calibration of hardware components, designing user interface application and testing the developed algorithm.

Results and Achievements

Automatic focusing was performed on a still object infront of a plain coloured background which was placed at different distances from the camcorder. The object distance detected by the video camera was noted with both internal and implemented automatic focusing systems, for different high to low threshold ratios. Both values were very close to one another confirming that the Canny edge detector can be used for automatic focusing systems.

References

[1] J.F. Canny, "A computational approach to edge detection," IEEE Trans. Pattern Anal. Mach. Intell., vol. 8, pp. 679-698, Sept. 1986.

Figure 1: Original Greyscale Image

Figure 2: Image after Canny Edge Detection

Design and Implementation of a Handwritten Input Calculator

Student: Emmanuel Bouvett
Supervisor: Dr. Owen Casha

Introduction

Developments in the relatively young research area of Artificial Intelligence have in many occasions, provided tools which proved to be useful in solving complicated problems of which a definite solution still did not exist. One such problem is the recognition of handwritten symbols such as letters of an alphabet and mathematical digits and operators. This project aimed at implementing and integrating artificial intelligence in the design of a calculator by means of a handwritten symbol recognition algorithm. This algorithm would provide the necessary capability for the calculator to allow the user to seamlessly interface with it.

Project Objectives

The main objective of this project was to implement an embedded system which augments the user experience whilst using a calculator, by means of artificial intelligence. In order to achieve this, a completely graphical interface was setup. The project also needed to be independent of any computer in order to be portable. Research had to be conducted on the possible handwritten symbol recognition algorithms and efforts were made in order to find a reasonable compromise between the accuracy obtained and the resources consumed by the implementation.

Project Methodologies

A brief summary of the methodology adopted to develop the project is listed below in chronological order:

- Familiarisation with the hardware.
- Development of the software and circuit boards to interface with the hardware.
- Research and development of the calibration algorithm for the touch screen.
- Research and design of the handwritten symbol recognition algorithm.
- Collection of a suitable amount of samples for testing the algorithm's accuracy.
- Design the calculator algorithm and various other functions to enhance the user experience.
- Further adjustments to the system to find a better compromise between accuracy and resource consumption.

Results and Achievements

Using a graphical and a character LCD together with a touch screen, a completely graphical user interface for a calculator was developed. A system on a chip was implemented in order to control all the hardware and processes involved. This led to a compact design consuming only 36% of the slices available on the FPGA resident on the development board. The handwriting input syntax rules governing the calculator are few and hence the design managed to achieve an interface which is both natural and intuitive. The accuracy obtained from the handwritten symbol recognition is around 85%, hence making it reasonably practical.

References

[1] XILINX, (January, 2010). PicoBlaze 8-bit Embedded Microcontroller User Guide. Available: http://www.xilinx.com/support/documentation/ip_documentation/ug129.pdf

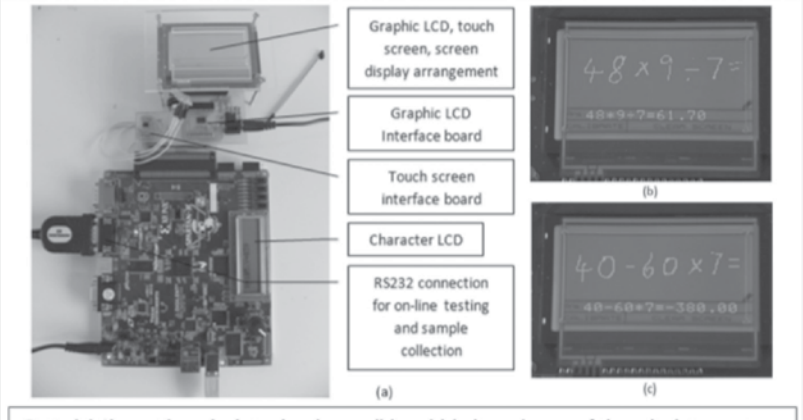


Fig 1: (a) Shows the calculator hardware; (b) and (c) show demos of the calculator system

Implementation of a speech coder

Student: Ansel Briffa
Supervisor: Dr. Ing. Edward Gatt

Introduction
Speech is one of the most effective means of transmission of information between humans. The ability to produce and acquire language is a principle feature in humans. In today's highly digitalised world, speech coding has become one important field of research as it forms one of the basic needs of telecommunications. Speech coding differs from other forms of audio coding since the speech wave is very specific when produced by the human body.

Project Objectives
Speech coding systems aim to transmit speech with the highest possible quality using the least possible channel capacity. Algorithms try to minimise the bit-rate in the digital representation of a speech signal without any loss of speech quality. Linear Predictive Coding was implemented as a speech coding scheme in this dissertation. The speech wave is divided into frames, and coefficients for each frame are obtained. At the receiver end, these parameters are used to synthesise speech by changing the excitation signal. The aim was to implement this speech coder on hardware using a Field Programmable Gate Array (FPGA). The FPGA allows prototyping of the implementation of this digital system with minimum costs. It also offers easier design iterations and is easier to correct mistakes because it can be re-programmed.

Project Methodologies
The basic principle of orthogonality is used in the linear mean-square estimation. This principle was adopted as it develops optimal filtering for linear prediction. Linear prediction relates to the Autoregressive Model. This relates to the fact that when a system outputs white noise for a given input, the inverse system produces the output from white noise. If the filter is inverted and excited by white noise the output of this filter will be a reproduction of the original sequence. The Levinson recursion was adopted in this implementation. It is a fast recursive method used to solve the necessary equations. The project was organised as following:

- A literature survey to familiarize the reader with speech production and processing
- Selecting the algorithm to implement
- Implementing and testing the algorithm through software with the use of MATLAB®
- Designing and implementing the algorithm on hardware
- Simulations on hardware were done through the use of the software ModelSim®
- Program the FPGA to test simulation results

Results and Achievements
The software implementation gave satisfactory results as the speech wave synthesised was very similar to the original signal as shown in Figure 2.

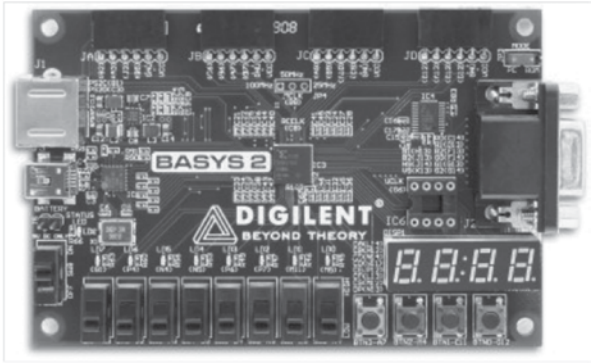


Figure 1 Basys2 FPGA Board

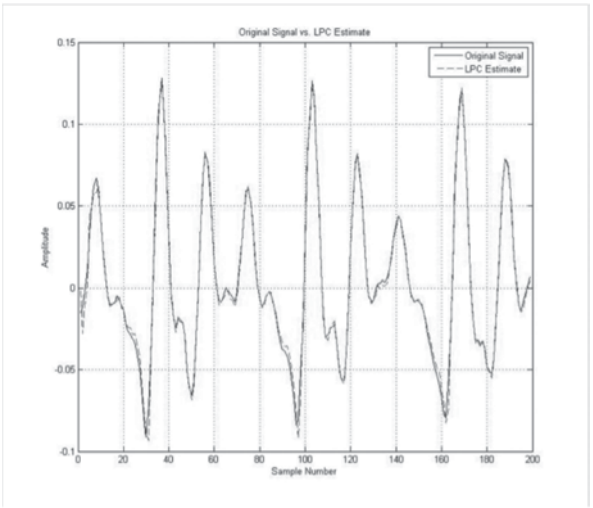


Figure 2 - Original Signal vs LPC Estimate

Microprocessor Operation Simulation – Predecoding

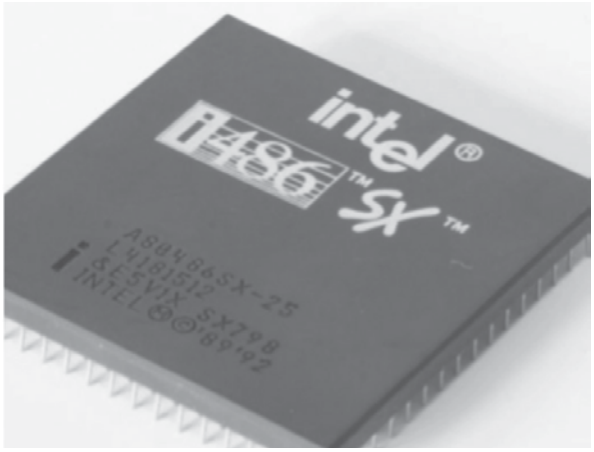
Student: Matthias Cassar
Supervisor: Prof. Ing. Paul Micallef

Introduction
The thesis consists of creating an educational tool to explain, by simulation, how the i486 processor performs the predecoding stage in a fetch-decode-execute cycle. I chose to write this thesis since being a student I find that such educational tools can prove to be very useful in one's studies. Also, I have an interest in computer architecture and the methodologies that are used in computer systems to make them run fast and efficiently.

Project Objectives
The aim is to develop a pedagogical tool showing the operation of a modern microprocessor. This is a continuation, based on the i486 processor. Last year the input part involving the cache at the initial fetch was developed. This year the next stage has to do with the instruction decoding. Using the programming language MATLAB, a simulation of the predecoding stage of the i486 processor was to be created.

Project Methodologies
It was first required to have a good understanding of the i486 processor in general. The i486 processor is one of the most common processors found in most computers. A lot of research work was required to gain a good understanding of how the processor worked. Focus was then shifted to the decoding of instructions in the processor, more importantly on the first stages of decoding, where predecoding occurs. Detail was taken to see exactly what the processor would do as regards the individual bits of any instruction. Once enough material was obtained, the simulation program could be written.

Results and Achievements
Predecoding, as the name implies, is a method by which the processor can have a quick look at the instruction to be decoded, and can tell what sort of function it performs, and if it can be executed in parallel with other instructions. If the processor was to just decode the instructions immediately, it would have to read the entire instruction to know how to execute it, but in predecoding, the processor checks only the first few bits of the instruction to know what type of function it performs and determine if its exectution time can be optimised. Hence it would be easier and faster for the i486 to execute instructions, by seeing which instructions can be decoded and executed at the same time, and which ones can't. Instructions that can be executed at the same time are allowed to make use of a system called pipelining. The decode-execute cycle has a number of individual stages. Therefore, pipelining allows one instruction to go through one stage of the cycle, while another instruction goes through a different part of the cycle, hence working on more than one instruction at a time.



The i486 processor

Instr. No.	Pipeline Stage						
1	IF	ID	EX	MEM	WB		
2		IF	ID	EX	MEM	WB	
3			IF	ID	EX	MEM	WB
4				IF	ID	EX	MEM
5					IF	ID	EX
Clock Cycle	1	2	3	4	5	6	7

Instruction Pipelining

Instruction Pipelining

Design of a 2-Axis MEMS Accelerometer

Student: Jean Marie Darmanin
Supervisor: Dr. Ivan Grech

Introduction

Accelerometers are sensors which provide an output signal according to the variation in acceleration the sensor experiences. As miniaturization started to become commercially viable Micro Electro Mechanical Systems (MEMS) started to reproduce what in the past only large and bulky sensors could do. Thus MEMS enabled the accelerometer market to infiltrate into devices where minimum size is essential. Typical applications of MEMS accelerometers are: mobile phones, since tilt can be determined by an accelerometer; hard drives; game controllers; Inertial Measurement Units (IMUs) which are units installed in vehicles, especially in unmanned or remote types; vibration analysis; and air-bag deployment units.

Project Objectives

The primary objectives of this project are:

- Familiarize with CoventorWare® 2010 software and its features;
- Design and Simulate a MEMS 2-axis capacitive sensing accelerometer;
- Carry out an assessment on the accelerometer's results;
- Further study by providing alternate designs and compare them.

Project Methodologies

Since the software used in this project was new, tutorials were performed and this gave good insight on the software such that when in the project is in designing phase software knowledge wouldn't pose a problem. The initial segment of the project consisted in gaining knowledge of how MEMS are fabricated and what types of designs are generally used for capacitive sensing accelerometers. Three different designs were drafted and implemented using the software. The first design consisted of two independent orthogonal accelerometers. The other two as illustrated in Figure 1 show a single sensing mass having two different spring topologies. The designs were then simulated systematically and compared with each other.

Results and Achievements

The theoretical and simulated results were compared and found to be comparable with each other. Correct functionality was achieved as shown in Figure 2. Also the Saber® simulator and the mathematical solvers showed similar results when an appropriate mesh was selected. The sensitivity achieved for all the three designs was comparable to commercial designs. The analogue electronic circuitry connecting the sensor to the outside world is suggested for future work thus providing a complete design.

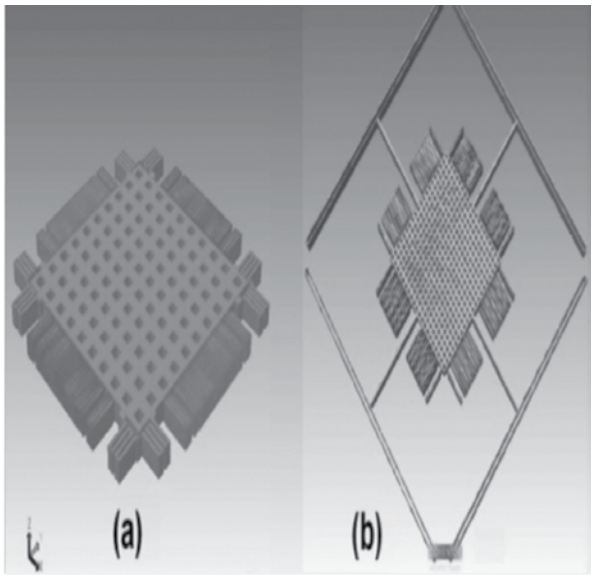


Figure 1 - (a) Serpentine Springs; (b) Folded Springs

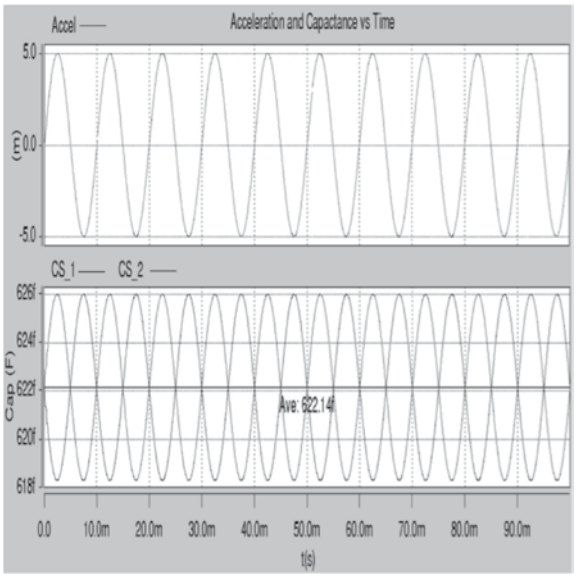


Figure 2 – Graph showing Acceleration (Top Plot) and the Capacitance (Bottom Plot)

Interface Integrated Circuit for Microsensors

Student: Maria Dimech
Supervisor: Prof. Ing. J. Micallef

Introduction

MEMs accelerometers have found major applications in automotive industry, virtual reality, consumer electronics and navigation. Integrated CMOS MEMS accelerometers have total sensing capacitance smaller than 100fFand parasitic capacitances are of this order of magnitude as well. Typical sensitivities are around 1mV/g and less than 0.4fF/g acceleration-induced capacitance change[1]. The minimum signal to be detected is usually determined by the electronic noise in the interface circuit which is typically between 100 - 1000ug/√Hz. A method of increasing the sensitivity of the overall system while keeping electronic noise to a minimum must found.

Project Objectives

The main aim of this project is to design a capacitive readout application-specific integrated circuit (ASIC) circuit that amplifies the useful signal while keeping the electronic noise to a minimum thus improving the signal to noise ratio. The method of chopper stabilization technique was chosen which significantly reduces the low frequency amplifier noise.

Project Methodologies

The work required took place in the following order:

- Literature Review:
  - The mechanical sensing principle of MEMS capacitive accelerometers.
  - Noise sources specifically electronic noise involved in readout circuits.
  - Circuit techniques used in literature to reduce noise in readout circuits specifically the effect of Chopper Stabilization Technique on low frequency electronic noise.
- Design and implementation:
  - Analysis and implementation of the circuitry involved to implement the chopper technique mainly the modulation, fully differential amplifier and the filter required, using CADENCE 5.0.41 with AMS 0.35µm CMOS kit. Refer to Figure 1.
- Evaluation of results:
  - Analysis of the obtained results, comparison to previous works and future improvements.

Results and Achievements

A chopper amplifier has been successfully implemented with an overall sensitivity of around 80mV/g and a noise floor of 474nV/√Hz at the output of the demodulator as seen in Figure 2. Presently, the noise contribution of the filter that follows is being analyzed with the aim of following the circuit with a LPF that gives good results without adding too much noise.

References

[1] Jiangfeng Wu, Gary K. Fedder, and L. Richard Carley, Fellow, IEEE "A Low-Noise Low-Offset Capacitive Sensing Amplifier for a 50-µg/√Hz Monolithic CMOS MEMS Accelerometer," IEEE Journal of solid-state circuits, vol. 39, no. 5, May 2004.

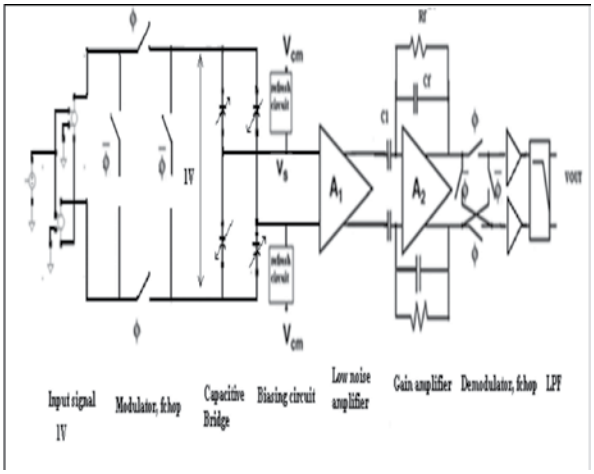


Figure 1 : Circuit implementation of the chopper stabilization technique.

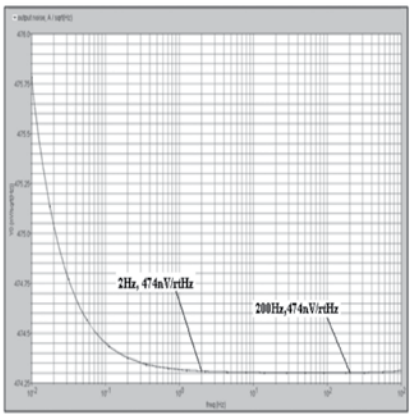


Figure 2 : Noise floor of 474nV/√Hz at the demodulator output.

Design of an FPGA Based Balancing Robot

Student: Kris Scicluna
Supervisor: Dr. Owen Casha

Introduction

Embedded system design using Field Programmable Gate Arrays (FPGAs) has become a viable solution due to the exponential increase in the number of logic entities available on a single chip. In many robot applications, hybrid processing systems consisting of both DSPs and FPGAs, are currently being used. This project used the balancing robot as a platform to test the feasibility of an embedded system designed on a standalone FPGA for control applications. The control task in the balancing robot consists of balancing a vertical structure by simply driving the wheels forward and backwards until a stable upper equilibrium point is achieved.

Project Objectives

The aim of this project was to design and implement a balancing robot structure (Fig. 1) and the necessary embedded system to perform the control task. The following VHDL entities were designed:

- Converters of Analogue to Digital Outputs to Actual Physical Values
- Clock Dividers
- Complimentary Filter
- State-space Controller
- PI Current Controller
- PWM Generator

Project Methodologies

The following is a brief summary of the methodology used in the project listed in chronological order:

- Related studies on hardware description languages and state-space theory.
- Research on existing inverted pendulum systems, balancing robots and complimentary filters.
- Design and simulations in MATLAB.
- Design of the balancing robot structure in AutoCAD.
- Design and simulations of the FPGA based embedded system in Modelsim.
- Electronic circuit design in particular the implementation of H-Bridge, current sensor, accelerometer/gyro boards.

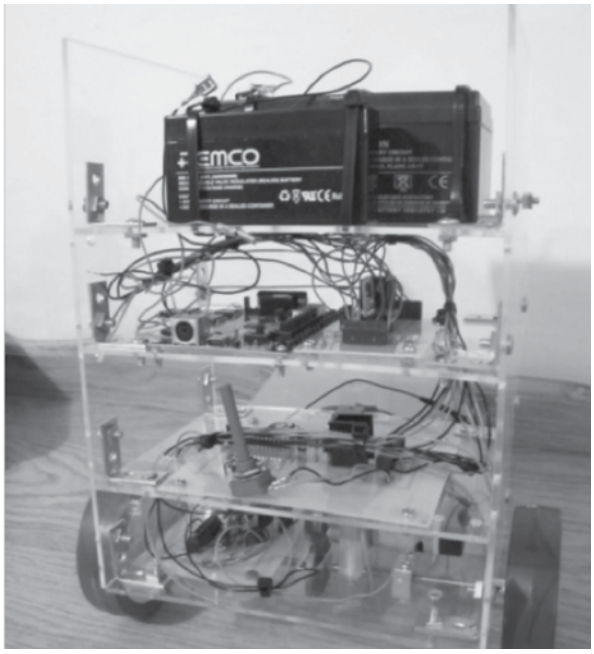


Fig. 1 – Balancing Robot

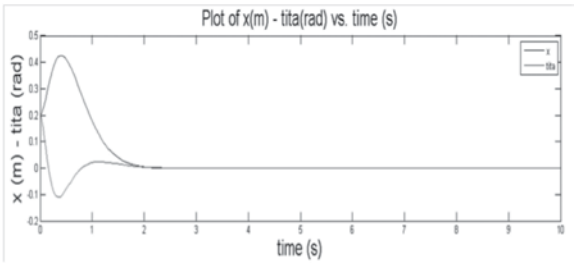


Fig. 2 – Plots of x(m) and θ (rad) - time (s)

Results and Achievements

The MATLAB simulations related to the design of the complimentary filter and state-space controller (Fig. 2) yielded the desired results. When the MATLAB results were compared to the VHDL simulations in Modelsim the errors involved in the rounding of binary numbers were considered to be negligible. Hence the emulated systems were working as expected.

Mechanical Engineering Stream

Improving Material Flow in an Electronics Assembly Process

Student: Shaun Abdilla
Supervisor: Dr. Ing. Conrad Pace

Introduction
Batch Production is currently utilized at ProMinent Fluid Controls for the through-hole assembly part of printed circuit board production and as a result a significant amount of material handling creates too much Work-in-Process.

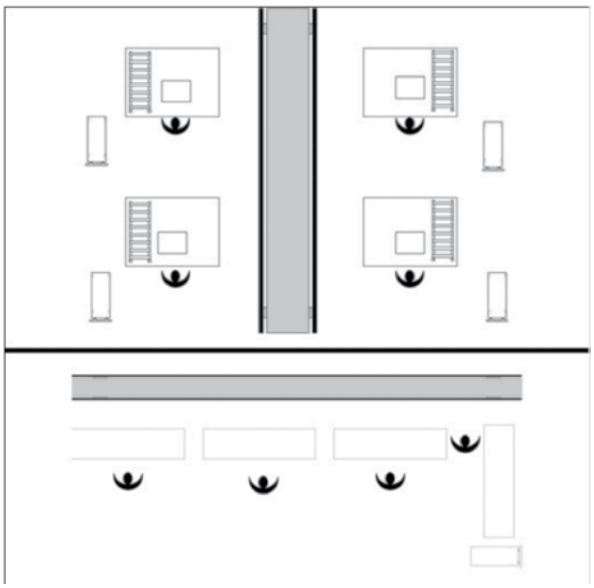
Project Objectives
The project aims to reduce as much as possible work-in-process and material handling, keeping in mind a lean mentality and implementing one-piece-flow as part of a production line layout to eliminate the 7 types of waste according to Lean methodologies.

Project Methodologies
The project sought to identify the main types of waste occurring in the process and consequently aimed to establish a lean production flow system based on the elimination of said waste and the subsequent formulation of a flow production-based system which could cater for all product families:

- Literature review of lean methodologies and tools, different types and characteristics of production layouts, and process evaluation methods and tools with some in-depth analysis into Quality tools. Attention was given to outlining the basic ideas behind the origins of Lean ideologies in order to transmit the correct mindset to be kept while studying the process and to know which processes are wasteful to the system.
- General analysis of production process in effect on-site, followed by a study of process with recognition of non-value-adding activities in current process and other wasteful activities
- Drawing up of current Value Stream Map and future target Value Stream Map in order to target the waste to be eliminated.
- Time study/work study of process using video and standard timing techniques in order to obtain a true, accurate value of the time required for each step of the process.
- Pareto analysis to determine the 80%-demand boards on which to focus for line production
- Formulation of line production system using time study values, followed by station design dependent on line balancing.

Results and Achievements
From the study it resulted that a significant amount of material handling could be removed by rearranging the line and assigning particular jobs to each assembly operator instead of proceeding with batch production, and efficiency could be increased.

Also, the increase in demand of every product could be met with a flexible flow production system, allowing time for the lower-demand products to still be produced using batch production, and significantly increasing the efficiency of material preparation.



Design for Manufacture of a One Touch Damped Opening Compact

Student: Alan James Attard Kingswell
Supervisor: Dr. Ing. Jonathan C. Borg

Introduction

This project concerns the re-design of a novel, one-touch, damped opening make-up compact manufactured by Toly Ltd. that suffers from technical issues that limit distribution options. These issues are the reason why the solution cannot currently be manufactured in Malta as Toly Ltd. would like to achieve.

Project Objectives

The main objectives were to improve manufacturability and functionality of the current solution whilst reducing cost. Achieving these objectives implied focusing on the automatic and damped (slow opening) hinge mechanism, that proved to be the source of the problems following a manufacturability and functionality analysis of the current solution.

Project Methodologies

The project followed a standard engineering design. Several design tools and methodologies throughout design process such as market research, product design specification and quality functional deployment in the early phase of design and other tools such as rapid prototyping and 3D modelling were used in the later stages.

A solution was chosen by generating several alternative concepts listed on a morphological chart, and using a complex selection process to narrow down the choices based on numerous factors related to manufacturability and functionality. The selected solution makes use of standard rubber o-rings to generate frictional resistance, rather than silicone grease as in the current solution, thus eliminating the costly handling and application of fluid materials. After brainstorming, sketching and concept selection, a rapid prototype was developed using state of the art University equipment. 3D models were created in modelling software and a 3D printer used to create the components (fig. 1). Such techniques are novel in product design; and the project proved the usefulness of the technique as it provides several benefits over traditional modelling techniques. Once the concept was modelled and optimized to reduce the number or O-rings and improve repeatability, the solution was evaluated with respect to the initial objectives to allow for simpler injection moulding, mass manufacture and failure effects, hence the term design for manufacture. These changes were implemented in 3D animations (fig. 2).

Results and Achievements

A viable, low cost solution was found that has the added benefit of being designed with mass manufacture and simplicity in mind. Preliminary user evaluation is positive, however further testing and optimization in the form of future research will reduce size, improve durability and improve the chances for multiple applications making use of small friction dampers for hinges instead of viscous fluid based solutions that are costly, difficult to manufacture and temperature dependant. Such applications could include the automotive and consumer electronics industries.

Figure 1 - Physical Prototype

Figure 2 - 3D Models

Simulation of Compressive Moulding Using Abaqus FEA

Student: Christopher Bianco
Supervisor: Dr. Ing. Arif Rochman

Introduction

It is a complex and time-consuming process to manufacture polymer products starting from the product and mould design through to the pre-processing and process optimisation as well as product characterisation. The time and effort can be reduced significantly using computer simulation. The product and mould can be designed and optimised effectively by means of simulation so that their design time can be reduced. In addition, the expensive pre-processing which is usually trial and error experiment will not take very long and significant amount of material anymore, since the optimum process parameters can be determined by the simulation of the process.

Project Objectives

The aim of this project was to simulate compressive moulding processes using a finite element analysis software Abaqus FEA. In particular, this work concentrated on the modelling and simulation of thermo flow forming, a new method developed for the manufacturing of thin-walled polymeric micro components by Dr. Ing. A. Rochman in his Ph.D. studies [1].

Project Methodologies

A model suitable for the simulation of a compressive process using Abaqus/CAE was built and based on Rochman's experimental studies to create a suitable part using thermo flow forming. The prototype part which was to be produced by simulation is shown in Figure 1 and had to be formed from a ring-shaped preform having an outer diameter of 8mm and the same through hole of 2mm. Since the aim of this simulation was to mould a part similar to the prototype part which was produced experimentally, the same geometrical features of the prototype part had to be produced from the same preform by Abaqus/CAE. The materials which were tested included PTFE, PEEK and PPS. These highly viscous thermoplastic polymers were selected as the materials for simulation since experimental analysis with these materials was already carried out and hence it was possible to compare experimental with simulation results.

Results and Achievements

Initial simulation results matched the geometrical features of the part obtained experimentally and hence confirmed the feasibility of the process using the simulation model which was designed. The compressive process was then optimized to try and achieve the same part thickness as was obtained experimentally. However, in trying to achieve this, limits imposed by the mesh were discovered and impeded the analysis from progressing to the desired levels. The final results achieved corresponded to a maximum part thickness being 73% of the experimental results as shown in Figure 2. Comparisons were made between experimental and simulation results for the resulting force needed to form the material. Simulations were also performed to highlight the importance of applying good meshing techniques to achieve better results.

References

[1] A.Rochman, "Development of a novel method for manufacturing thin-walled polymeric micro-components," Queen's University of Belfast, UK, 2009.

[2] A.Rochman, "Development of a novel method for manufacturing thin-walled polymeric micro-components," Queen's University of Belfast, UK, 2009, p. 57.

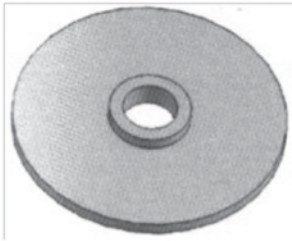


Figure 1: Prototype part with basic geometry [2]

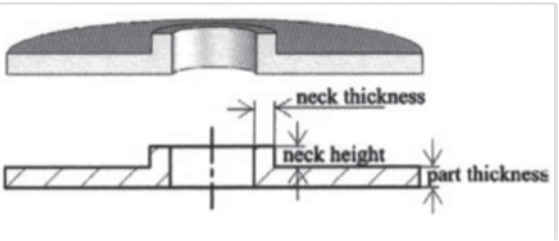


Figure 2: Final part with stress distribution

Towards Sketch-Based Virtual Prototyping of a Factory

Student: Stephanie Borg
Supervisor: Dr. Ing. Philip Farrugia
Co-supervisor:[Ing. Emmanuel Francalanza

Introduction

When organizations need to design or modify a manufacturing system layout, the procedure adopted is that first ideas for a layout are sketched on paper. These are then modeled manually in a CAD software, where from there the layout can be visualized in 3D and modified as desired. This method is quite time consuming and not so straight forward especially when sketches have to be built in 3D models using computer software. These factors prolong the actual construction of the layout and initialization of production, therefore puts the company in a disadvantage.

Project Objectives

This project's aim it to continue the development and improvement of an already existing prototype tool which was developed to shorten the design stage of a factory planning layout by combining the benefits of sketching with 3D CAD modeling. This is done by generating a 3D CAD model directly from paper-based sketching.

Project Methodologies

- A literature review: to identify the importance of sketching in the design process; to identify the existing factory layout software and their strengths and weaknesses; to identify existing prototypes which use computer aided sketching linked with 3D modeling; and to identify the limitations of the already existing tool with directly links paper-based sketches with 3D modeling of a factory layout [1].
- A Framework Architecture that supports a paper-based sketch as an input, importation of the model into a 3D modeling supporting software for modifications, and outputs a virtual 3D factory layout of the final model using augmented reality. with the process being completely automatic.
- Conduction of a survey to collect a number of sketches representing a number of manufacturing process, to train and test the neural network, which is used for automatic symbol recognition;
- Development of a proof-of-concept tool to automatically recognize the symbols on the sketch;
- Development means to automatically import models in a 3D software and put them in the right location;
- Implementation and evaluation of the whole system.

Results and Achievements

The result achieved is a proof-of-concept tool which automatically recognizes paper-based sketches and converts it into a 3D model into a software supporting 3D modeling, giving the user the possibility to modify the layout. Finally this layout can be better visualized using augmented reality.

References

[1] G.Attard, "Facrory Planning Through Sketch-Based 3D Modelling," in Department of Industrial and Manufacturing Engineering, University of Malta, 2010.

Production Concepts for Efficient Manufacture of Vertical Wind Turbine Blades

Student: Lawrence Luke Chetcuti
Supervisor: Dr. Arif Rochman
Co-Supervisor: Ing. Ryan Xuereb

Introduction

Fossil fuels are presently the main source of energy used to produce electricity which pollutes our atmosphere leading to global warming. Alternative natural resources are being researched and a potential alternative is to produce electricity by harvesting wind power. Large countries have a certain abundance of open space and thus can afford land on which large Horizontal Axis Wind Turbines (HAWT) can be built. For a small island like Malta, land is very limited and thus a different approach is required. Vertical Axis Wind Turbines (VAWT) are excellent for urban areas and seem a promising alternative to contribute towards electricity generation.

Project Objectives

Wind turbines are too expensive to produce which can lead to a negative return on investment. This project aims to find alternative materials and processes which may solve this problem and make mass production of small wind turbines possible.

Project Methodologies

- First a study on VAWTs was carried out to understand better the shape of the required blade.
- A study on the current state of the art of turbine blade manufacturing was done to understand better the presented problem and to have a base point with which to compare when an alternative process is proposed.
- A material selection exercise helped determine a better alternative material for the blade and what manufacturing technique to use.
- A conceptual design of the blade which simplifies fabrication and reduces processing time was created.
- Alternative processes were considered and the one with the shortest processing time was given preference.

Results and Achievements

A thermoplastic matrix composite was chosen as an alternative material. The proposed process is thus a thermoforming process called matched die moulding were the sheet of plastic can be heated up, formed and then trimmed. This process was much faster when compared to current state of the art manufacturing techniques and could be fully automated which greatly lowers the cost of the blade.

Figure 1 VAWT conceptual design showing an unassembled blade.

"Design for Manufacture" Of an Applicator System for Use by the Cosmetic Industry

Introduction

Product design is becoming increasingly important in today's society. One of the main reasons behind this being, that customers are demanding a wider range of products, which could lead to shorter product life cycles. As a result, improving manufacturability is becoming an important goal for product design. This eventually leads to the use of high-quality, low-cost materials and methods.

Project Objectives

This project does not focus solely on the design of the device and means of improvement, but there is further analysis with respect to its functionality and manufacturability. This project focuses on the importance of 'Design for Manufacture' of a mascara device for the cosmetic industry. The aim of this project was to address functionality and manufacturability issues related to a mascara applicator device, in an attempt to come up with the best possible solution to address these requirements.

Project Methodologies

The project identifies different techniques how to tackle the problem at hand. The method, which was used to identify a possible solution was:

- To analyze current solutions as well as gather information to possibly come up with alternative improved concepts (existing PDS, QFD, Morphological Chart and solution evaluations from previous work was found beneficial to come up with the improved concepts).
- The next step was to come up with several promising design concepts to possibly improve current mascara applicators.
- This was followed by a market research of the possible solutions. This was carried out to analyze what the customers and manufacturer really want out of such product. Eventually, the most potential solution was chosen. The chosen concept was then altered according to the Design for Manufacturing with special attention to Design for Injection Moulding, since the main manufacturing method, which was going to be used was Injection Moulding.
- Simulation using Mould Flow Simulator® was then carried out, and a final altered solution was finalized. A prototype of this final solution was manufactured using Rapid Prototyping.

Results and Achievements

The aim of this project was to address functionality and manufacturability issues related to a mascara applicator system, in an attempt to make it easier for the customers to use and design a product, which can be easily manufactured. By performing a full analysis into the functionality and manufacturability of the current solution and the best concept was selected and evaluated. This final solution achieved a number of the initial objectives, hence it was concluded that it was the optimum solution.

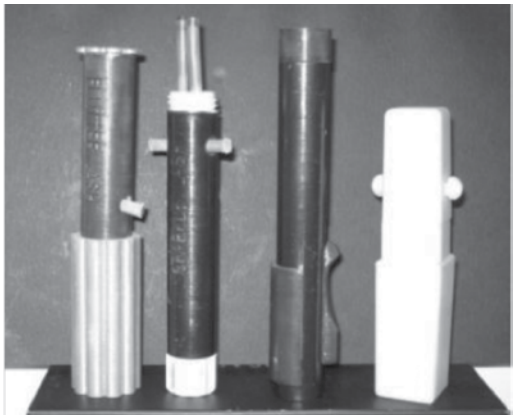


Figure 1: Featuring all prototypes: First Concept, Second Concept, Third Concept, and Final Solution (From Left to Right)

Figure 2: Final Solution

Design of a Portable Water Purification System

Student: Lawrence Farrugia
Supervisor: Dr. Ing. C. Pace

Introduction

The aim of this project was to design a mobile water treatment system, which has the capability of converting water originating from a surface freshwater body such as a lake or a river, into a potable form. One potential application of the system is to provide an emergency supply of potable water in the aftermath of natural disasters.

Project Objectives

The objectives of this engineering project are :

- To perform a comprehensive review of the issues related to the contamination of water, and the relevant technologies which are currently employed in the treatment of water
- Utilize engineering design methodologies, in order to develop and address the various aspects of the system under consideration.
- Generate a CAD model, illustrating the principles applied within the design, and provide a final evaluation of the system.

Project Methodologies

One of the major issues encountered during the development of the system, was the significant variation in the contamination of various freshwater bodies. The implication is that a unique system cannot provide effective treatment for the diverse variety of contaminants present in these surface freshwater bodies.

In order to address this problem, the system has been designed in a modular fashion. This means that the system is composed of a number sub-systems, called modules. These modules are practically the building blocks of the system, and can be used in order to build a wide variety of system configurations. In this way it is possible for the system to fulfil the specific requirements defined by the type of contaminants present in each different water source. Two of the possible system configurations are illustrated in Figure 1 and Figure 2.

Results and Achievements

The project resulted in the design of number of modules which can be used to generate a number of different system configurations. The system has the ability to cater for the demand of 300 persons, with each person receiving 3.5 litres of potable water every

Figure 1 and Figure 2.

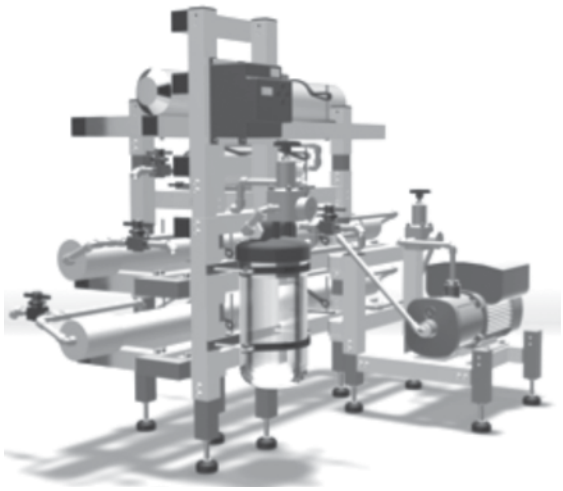


Figure 2.

Towards Emotion-Driven Industrial Design

Student: Kyra Pollacco
Supervisor: Dr. Ing. P.J. Farrugia

Introduction

Short product life cycles, cost pressures, over-capacity of mass-produce products and an equal level of quality and functionality have resulted in intense competition, where only one of seven product ideas make it to the designated market [1]. Consequently a user centred product development approach has become a major growth driver within companies which seek to move up the value chain and meet market demands [2]. The inseparability of emotions and human nature implies that emotions are an imperative element in product-user relationships and play a major role in the user's evaluation of a product to meet their needs [3]. The indispensability of delivering user emotional satisfaction has led to a new field in product design: Design for emotion, DFe.

Project Objectives

Integration of emotional needs into product design was traditionally carried out intuitively by designers; this system was subjective and ineffective. An increase in interest in designing for emotion led to the development of formal methodology. Analysis of the state of the art tools establishes a gap in active assistance, where the tool predicts a lack of emotional value in the design and suggests or applies modifications in the initial stages of the product development cycle.

- Identification and testing of how product form features elicit emotions on stakeholders.
- Develop a database relating emotions to product design elements.
- Develop a framework supporting real-time guidance to a team of designers to enhance the emotional value of a product at the primary stages of design.
- Implement and test a proof-of concept tool based on the framework developed.
- Evaluate the underlying principle of the tool from a practical point of view, in a team-based design activity

Project Methodologies

A set of guidelines relating stakeholders' characteristics, product form features and their impact on the product users' emotions were drawn from a statistical analysis of three hundred eighty three questionnaire responses. Symmetry, high length: width ratio and curvature all were associated with emotions elicited this proved that designing for emotion through the manipulation of form features is a valid hypothesis. The prototype tool analyses splines, giving the average curvature and a logarithmic curvature histogram which defines how aesthetically beautiful a curve is.

Results and Achievements

The framework developed supports real-time guidance and although still in development stage the tool aims at supporting the designer or team of designers in his/her conceptual design through guidelines to manipulate the sketch in order to enhance the product's emotional value.

References

[1] M. Abramovici and S. Schulte, "Optimising Customer Satisfaction by Integrating the Customer's Voice into Product Development," in Proceedings of the 16th International Conference on Engineering Design (ICED07), Paris, France, 2007, pp. 801-802.
[2] B. Song, et al., "A Framework for an Intelligent Design-support System Based on Product Lifecycle Data.," PLM: Going beyond product development and delivery, 2006.
[3] D. A. Norman, Emotional Design: why we love (or hate) everyday things. New York: Basic Books, 2005.

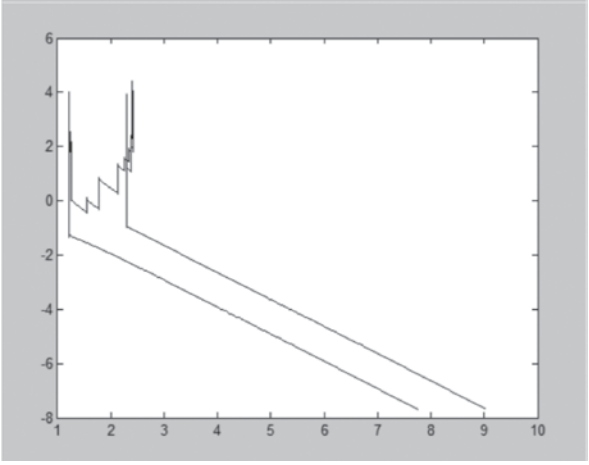


Figure 1: Logarithmic Curvature Histogram of a Non Log Aesthetic Curve

Investigating the Potential of Aesthetic Laser Marking in the Toy Manufacturing Industry

Student: Luke Said
Supervisor:Ing. Pierre Vella;
Co-Supervisor: Ing. Emmanuel Francalanza

Introduction
A principal motivating factor behind this project is the environmental friendliness of laser marking. This is due to the fact that it does not generate any waste. Furthermore it is fast, flexible and also cheaper than conventional pad printing.

Project Objectives
This project is sponsored by Playmobil Malta Ltd. This company already has a laser marking process; a 'dark on light' mark on grey Ethylene Vinyl Acetate. The first objective was therefore to analyze and optimize this particular process hence determining the most effective parameters and their respective optimum values. The next objective was to investigate the laser marking of a different material; and what colours are possible. Apart from these two industrial objectives; academic objectives were also involved, which included the identification of the chemical reactions taking place, and the scientific explanation behind each process parameter.

Project Methodologies
This project identifies the critical factors that affect the colour and quality of a laser mark. The materials in question were Ethylene Vinyl Acetate (EVA); which is used for the current laser marking process, and Acrylonitrile Butadiene Styrene (ABS); which was the selected due to the fact that a number of products of Playmobil Malta Ltd. are made by this product. A laser marking additive by the name of Micabs A®208 was obtained for the latter. The Design of Experiments approach was used for this project. This is a very effective tool for both optimization of a process and also the determination of the effects of each process parameter- or factor as they are referred to in this methodology. The following steps were taken;

- Literature review of the current available technologies of laser marking and the physical mechanism behind them.
- Design of experiments;
- Planning experiments: Defining the problem; identifying the factors, selecting the response variable.
- Designing and conducting the experiments.
- Conclusions: Confirming predicted results and recommendations.

Results and Achievements
The most significant process parameters were determined and they had their predicted effects. Hence the optimization of the current laser marking process was successful. The darkest possible mark was achieved on EVA. A 'moss grey' colour was achieved on white ABS and a 'golden' colour was achieved on Natural ABS.

Figure 1: Grey EVA

Figure 2: White ABS

Figure 3: Natural ABS

A Robust Process Analysis and Optimization for Electron Beam Melting (EBM)

Student: Christian Spiteri
Supervisor: Dr. A. Rochman
Co-supervisor: Ing. P. Vella, Ing. J. P. Borg

Introduction

Electron Beam Melting (EBM) is the epitome of Rapid Manufacturing (RM) and Rapid Tooling (RT) techniques. The machine uses an electron beam that is guided by a 3D CAD model to melt layer upon layer of powder which upon cooling solidifies and forms the specified physical part. The very high scanning speeds of the electron gun coupled with material purification due to processing in a vacuum give EBM the edge over its RT and RM counterparts [1].

Project Objectives

RT and RM techniques have a much shorter history than systems aimed for prototyping and this is confirmed by the development stage of these fields [2]. EBM is no exception and the project aims at extending the exposure of this particular technology. The Department of Industrial and Manufacturing Engineering has invested in an ARCAM S12 EBM machine and from initial test runs, some defects have been singled out. These were used as the starting point to find possible routes of investigation which ultimately lead to analysis and possibly optimization of the process.

Project Methodologies

Two experiments were devised in order to investigate the effect on final part quality of two distinct stages during part building. The first experiment dealt with the pre-processing phase which determines the part orientation during the build and whether or not to include support structures. This investigation was preceded by a preliminary analysis that pre-conditioned the part geometry to a hollow cone shape as shown in Figure [1]. A hypothesis predicted that problematic heat transfer was causing the defects and the cone shape was ideal to test different heat paths during the experiment performed. The second test analysed machine parameters during the actual physical build. The machine has an extensive list of parameters. However, due to resources constraints, the research had to be limited to investigating three factors. After viewing literature, it was decided to work with beam speed, beam current and the gun's focus offset. A specific part was designed separately for this experiment and it included features that allow for a more widespread analysis.

Results and Achievements

Both experiments proved to be effective in achieving the required goals. The first experiment verified that the preferred orientation during part building is the one that permits the easiest heat flow through the already solidified part volume underneath. On the contrary, the effect of the support structures was less evident since the defects persisted when these were included. Even though less obvious, the second part of the project rendered results that were previously unexplored. The effect of different parameters was evident and Figure [2] depicts a clear example. A compromise value for the beam's focus offset was determined and it was discovered that beam speed was also exerting its influence on the samples' characteristics.

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[2] Hopkinson A., Hague R.J.M., Dickens P.M. 'Rapid Manufacturing' Wiley, Wiltshire, 2006.

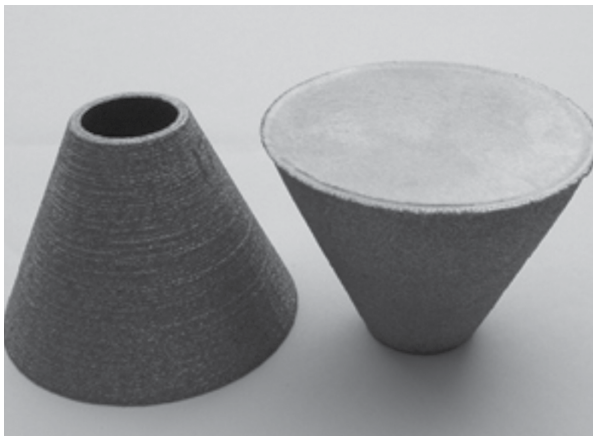


Figure [1]: Opposite orientations of samples from the first experiment

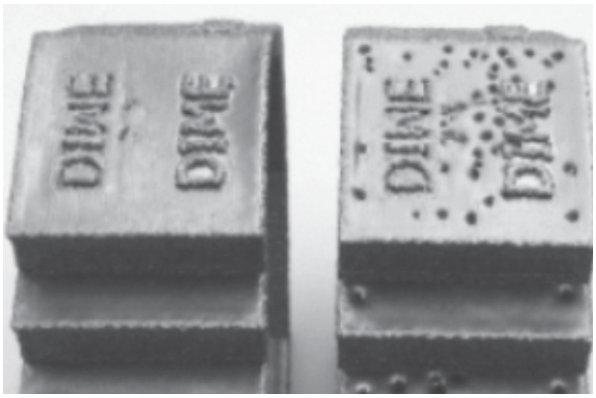


Figure [2]: Different Quality from Different Parameters

Environmental Quality in Factory Design

Student: Karl Zahra
Supervisor: Mr. E. Francalanza

Introduction

The considerable increase in emissions of Greenhouse Gases (GHG) from industry in recent years has highlighted the need to design factories which operate in an environmentally friendly manner. Key decisions taken at the factory design stage impact the environmental performance of a factory. This has been supported by the introduction of the ISO 14000 standards. However, a framework to support the factory designer is also necessary.

Project Objectives

The implementation of a framework will lead to an environmentally sustainable factory design as well as being able to provide proactive support by proposing ways by which the carbon footprint may be reduced. The project objectives were both academic and industrial, with the industrial objectives accomplished together with Econetique Limited, a member of FxB Group of Companies Limited.

The principal academic objectives set were:

- To develop a means by which manufacturing engineers can be supported during the factory design stage to reduce the carbon footprint of a factory
- To identify the technical requirements for a framework which enables the modelling and simulation of a factory layout from an environmental perspective
- To develop and test a proof-of-concept model based on these requirements
- The industrial objectives set were:
- To investigate the effectiveness of the proposed framework and tool by means of an in-depth case study at FxB Limited.

Project Methodologies

A framework for supporting the factory designer was developed as shown in figure 1.

Based on ISO 14000 standards, the boundaries and aspects of the system to be included in the analysis were defined. Once identified, a methodology for proportioning the carbon footprint produced by the lighting and ventilation systems to each component of a particular product produced was developed. This was also done for the transportation of the raw materials required from suppliers. The carbon footprint of each process required to produce a component was measured, based on the duration of each process and the power rating of the machine used. The addition of these aspects led to the calculation of the carbon footprint of each component, as well as the ability to identify areas of the factory which are the major contributors to carbon emissions. An evaluation of the framework developed was then carried out by applying the software tool designed to implement the framework on the shop floor at FxB Limited by means of an in-depth case study.

Results and Achievements

The results obtained from the case study served to underline the importance of such a support tool for the factory designer. By analysing the carbon footprint produced in the manufacture of a particular product, results, such as the aspects that contribute the largest amount of carbon footprint when manufacturing a particular product, were identified.

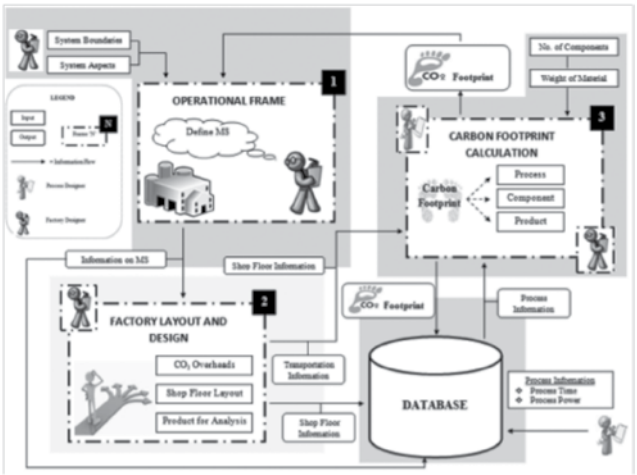


Figure 1: Developed Framework for Environmental Quality in Factory Design

Manufacturing of Embossing Mould for Rapid Hot Embossing of Microfluidic Device

Student: Mario Zammit
Supervisor: Dr. Ing. Arif Rochman
Co-supervisor: Ing. Pierre Vella

Introduction

Hot embossing is a replication process of a pattern into a softened polymer substrate by raising the temperature above its glass transition temperature. Due to the high replication accuracy, hot embossing is mostly used to manufacture fluidic and optical devices with micro features, for example micro channels and micro chambers. However, the most severe disadvantage of hot embossing is the long cycle time which is mostly associated with the electrical heating of the mould and its subsequent cooling for each cycle. In addition to this, the embossing and de-embossing time is relatively long so that a cycle time of 40 minutes is not rare.

Project Objectives

The aim of the project is to design and to manufacture embossing moulds which can reduce significantly the cycle time. The mould should be made from electrically conductive material so that it can be heated rapidly using an induction heating system. The micro features should be designed so that they can be embossed and de-embossed easily and rapidly to reduce the embossing and de-embossing time.

Project Methodologies

The microfluidic device and other related parts for the embossing process were designed. A material selection exercise was performed to determine the most suitable material for the embossing mould to be heated by an induction heating system. Mu metal resulted to be the optimum material. However Uddeholm Stavax AISI 420 was used, because it was readily available. After analyzing possible machining methods, three processes were chosen. Two methods involved the use of a milling machine and a micro EDM. The other had its features directly micro milled. The three moulds are listed with their respective machining process.

- Mould A, machined by micro EDM from hardened AISI 420
- Mould B, machined from soft annealed AISI420 by micro EDM then hardened
- Mould C, by micro milling of soft annealed AISI420 then hardened

The electrode material used was copper. Since the EDM involves a clearance between the workpiece and the electrode, the obtained average spark gap (clearance) was calculated and used for the EDM process.

After EDMing the first mould, the copper electrode was tested for any possible dimensional changes. The average spark gap was again determined and used for machining the second mould.

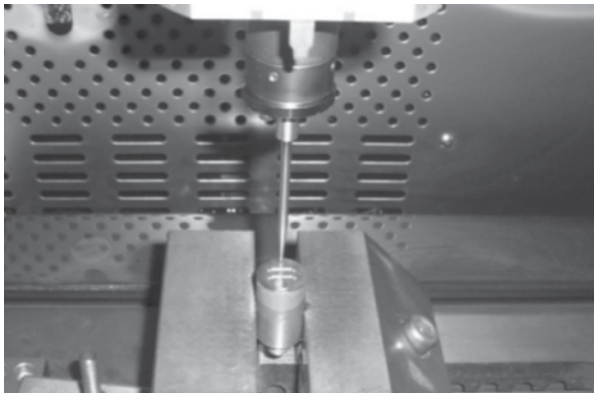


Figure 1: Using probe to measure depth

The parameters used for micro milling were similar to those specified by Uddeholm Stavax machining parameters. But the spindle speed required for milling the micro features could not be attained by the available machine and so it was carried out at a lower speed.

An experimental hot embossing process was set up to produce samples of the PMMA microfluidic device at different temperatures.

Results and Achievements

It was observed machining by spark erosion was very time consuming when compared to milling. The EDM produced the best surface finish, however higher dimensional accuracy was obtained by micro milling.

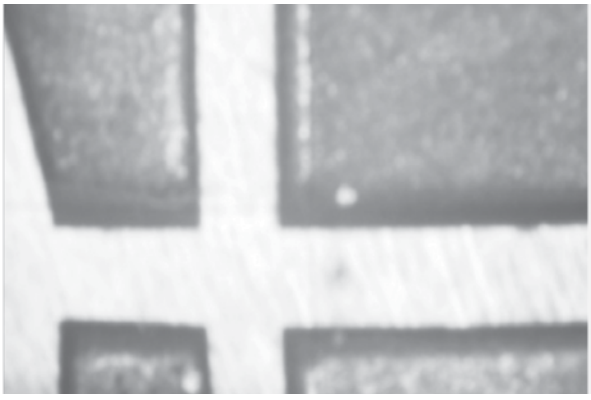


Figure 2: Micro features machined by EDM

The PMMA samples were analysed to determine the optimum hot embossing temperature.

Fatigue Life Calculation for Spot Welded Structures

Student: Charmaine Maria Agius
Supervisor: Dr. Ing. Martin Muscat

Introduction

Resistance spot welding is widely used in mass production industries to join sheet metal parts together. This technique is used especially in manufacturing automobile body parts and domestic appliances. Some advantages of this process are high volume production of components and reproducibility and high quality of welds.

Spot welded structures have to be designed for static loading. More importantly their fatigue life needs to be estimated, since these welds suffer from fatigue failure when subjected to cyclic loads. Also, the fatigue failure load of the spot weld is smaller than the static load imposed on the spot weld at static failure. Fatigue life prediction of resistance spot welded structures is very important at the development stage, as the component's properties, such as durability, strength and stiffness, can be optimized before testing the first prototype. Fatigue life prediction is quite important in an automobile body due to the number of spot welds used in its fabrication. Spot weld failure can eventually lead to car body fatigue failures.

Project Objectives

- Review of the design, structure and analysis of typical spot welded joints, including fatigue analysis, so as to get a sound background on the subject.
- Construction of several spot welded joints, which are tested in tensile-shear mode, as in Figure 1.
- Use of the finite element software ANSYS® to build several models of the selected spot welded structure.
- Fatigue life calculation of the selected spot welded structure using the models built in ANSYS®.

Project Methodologies

The project uses finite element analysis (FEA) to determine the structural stresses and stress intensity factors in a spot welded joint. These are then used to calculate the fatigue life of the spot welded structure. The following steps were carried out during the implementation of the project:

- A literature review regarding:
  - The design, construction and analysis of typical spot welded joints
  - The different stress analysis approaches used to predict the fatigue life of spot welded structures
  - The finite element models currently available in the literature that are used to predict the fatigue life of spot welded joints.
- Construction of several spot welded joints, which were tested in tensile-shear mode.
- Development of several models using ANSYS® to study the stress distribution in the joints. The results were also compared with those obtained from experiment.
- Determination of the structural stresses and stress intensity factors at the spot weld using the models built in ANSYS®. These are then used to calculate the fatigue life of the spot welded joints.

Results and Achievements

This study shows that the experimental static loading results show the same trends as the results of the models built in ANSYS®. This proves that FE modelling is a very useful technique for the design of spot welded joints. This is also true since FE modelling enables the calculation of the fatigue life of the spot welded structure, as shown in the study. The fatigue life can be calculated in several ways, depending on the approach that the designer decides to take.

Figure 1 – A spot welded structure being tested in tensile-shear mode using the tensile testing machine

An Analytical Investigation of Gas Turbine Performance in the Aerospace Field

Student: Damian Agius
Supervisor: Professor Ing. Robert Ghirlando

Introduction

Gas turbines constitute the vast majority of commercial aircraft powerplants. Their wide-spread use, combined with the vast array of different application requirements, has invariably lead to the development of a myriad of different engine configurations. This vast potential for design choices means that being able to cheaply investigate the performance of engine designs through the use of computer software is invaluable.

Project Objectives

The project aims at developing a flexible and generic computer model of gas turbine aero-engines. This model should be able to simulate a number of engine configurations as they are subjected to different inputs. Due to their widespread use, the project will concentrate on developing a model for turbofan and subsequently turbojet engines (the basis of the turbofan is the turbojet).

Project Methodologies

To achieve the required flexibility and generic attributes a modular methodology, which mirrors the structure of real gas turbines, was adopted. The different components, or modules, necessary to build up a turbofan were thus modelled. The validity of the individual programmed modules was then verified by comparing their outputs to those from 3rd party software or the relevant equations programmed into Microsoft Excel.

This then allows for the user to join up these modules in such a way as to replicate a particular engine design. This method was well suited to Mathwork's Matlab Simulink environment; as a consequence this software was selected for the purposes of carrying out the required modelling and simulations.

Figure [1] shows a real General Electric CF6-80C2B1 turbofan engine mounted on a on the Boeing 747-400 wide-body jet; Figure [2] shows its virtual counterpart as it appears in Simulink.

Results and Achievements

The model of the aforementioned engine was tested to varying inputs of altitude, forward velocity and air temperature. Some of these results were then compared to the real engine's performance data, as given by its certification documentation, to confirm the model's accuracy. The effects of the varying inputs and that of changing the Bypass Ratio were then investigated as a means of determining the resulting performance trends for different engine designs. A brief runway requirements calculation was also carried out. This served as further model verification and as a means of highlighting the effects of atmospheric conditions on aircraft take-off performance.

Figure 1 – Photo Copyright Tim de Groot

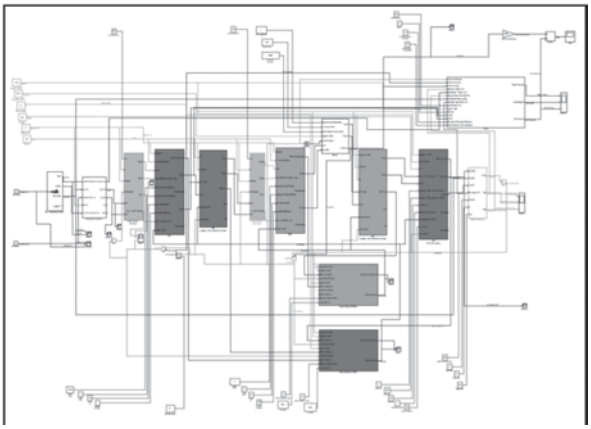


Figure 2 – Screenshot from Simulink

Development of a Simplified Computer Model for Floating Offshore Wind Turbines

Student: Sean Agius
Supervisor: Mr. Daniel Micallef

Introduction
The potential of offshore wind energy is enormous, by far exceeding that on land. However, until recently, research of floating offshore wind turbine systems had been only exploratory. The development of tools for modelling a wind turbine structure on a dynamically active support, which is affected by wind and wave, is crucial for analyzing and improving conceptual designs. This tool could also be used to ensure that future offshore wind turbines are cost effective, high performance with structural and dynamic reliability and integrity.

Project Objectives
This project's objective was to develop a tool to calculate the dynamic response of an offshore wind turbine. A simplified mathematical model to carry out time-domain simulations, analyze and predict the coupled response of a floating wind turbine structure was implemented in a computer program called FLOWTS. From the numerous concepts of floating wind turbines, including spar-buoys and barges, the Tension Leg Platform (TLP) was considered in the current model.

Project Methodologies
The model finds the structure response by determining:

- The affect of wind forces on the rotor, using the Blade Element Momentum Theory,
- Wind forces generated on the tower, using the wind power law and the effect of the wake on the tower,
- Forces on hull, spokes and mooring lines due to sea currents and waves.

These forces are coupled together with the Mass, Damping, and Stiffness of the system in the equations of motion. Also, by how these interact with each other they influence and update the structure's position during a timed simulation.

Results and Achievements
The software model was verified by running a series of simulations with different values of time step, tolerance and discrete elements using different solvers. The software model was also tested with parameters supplied from a physical TLP wind turbine model tested in a wave tank. From these tests it was concluded that, given the right parameters, FLOWTS is able to produce the expected results.

Optimization of the Wasteserv Incinerator

Student: Matteo Aquilina
Supervisor: Prof. Dr Ing. Robert Ghirlando

Introduction
Wasteserv (a company that treats various streams of waste) operates an incinerator at Marsa (the only one in the Maltese islands). This project was proposed by this same company to improve the incinerator's current operation and help to exceed the specified standards set by EU directives. Such standards are there to safeguard the public and the environment. Hence this project's application is to make the incinerator more environmentally friendly.

Project Objectives
This project was proposed so as to improve the current way in which this incinerator operates. One of the observed problems is that currently this incinerator has to shut down every four weeks for a period of five days to conduct maintenance. Also the heat used for the incineration process is wasted (lost to atmosphere). Thus this project aimed to reduce both the shutdown periods and to make better use of this heat energy.

Project Methodologies
The plant was analysed and areas which were creating problems for the normal operation of the plant were identified. After investigating the cause of the observed problems solutions were provided. Shutdowns were occurring due to clogging of the secondary combustion chamber (SCC) and boiler. The SCC was clogging due to the presence of dust in the gases and the boiler due to solidification of specific gases upon cooling. These had be cleaned and thus a shutdown period ensued where workers enter and manually clean the units (refer to figure 1).

SCC clogging was reduced by changing the position of the blower and including an inverted U section at the entry. Clogging of the boiler was reduced by installing a radiation boiler between the SCC and the boiler. Heat transfer in the radiation boiler was analaysed through the application of heat transfer equations and theories. This analysis helped to verify the operating conditions and that these would eventually result in a benefit for the plant. A brief analysis was also conducted as to how the heat energy produced from the incineration process should be utilised. It was decided that this energy should be used to heat water to be used in the adjacent abattoir and the same plant, while any excess energy should be used to sterilize the organic waste to be incinerated.

Results and Achievements
The change in the blower's position gave positive results (shut down frequency reduced by about 25% of original value). However due to restriction in the allocated time the other solutions could not be tried out. However the inverted U section can be approximated to the introduction of baffles which are known to be effective in such cases [1, pg 791]. It is predicted that the radiation boiler will not stop all clogging in the boiler however it should reduce this scaling resulting in longer operating periods between shutdowns.

References
[1] Michael D. LaGrega, Philip L. Buckingham, Jeffrey C. Evans and Environmental Resources Management, 'Hazardous waste management' McGraw-Hill, Singapore, 2001.

Figure 1: worker cleaning boiler during shut down

Design, Construction and Testing of a Prototype Tennis Ball Pitching Machine

Student: Damian Baldacchino
Supervisor: Dr. Ing. Pierluigi Mollicone

Introduction

At Zebbug Tennis Training Club (project sponsor), training is carried on a coach to single player basis; thus only a single player can be coach trained at a time, although four tennis courts are available. The aim of this project is to build a prototype tennis ball throwing machine capable of simulating most of the tennis shots generally used in tennis, in order to allow the training player to practice and improve his techniques in dealing with shots, normally generated by his opponent or coach. The machine will therefore allow more than one training session at the same time, with the club making more efficient use of the time and courts available.

Project Objectives

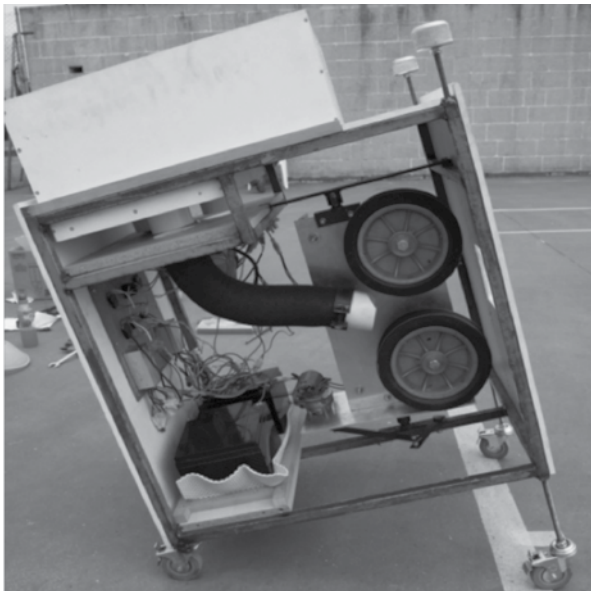
- Review of existing ball pitching machines on the market
- Preliminary and detailed design
- Construction of a prototype
- Testing of the prototype
- Performance evaluation of the prototype including recommendations for improved design.

Project Methodologies

- Analysis of tennis ball projectile motion including ball spin, drag and lift effects, in Matlab Software.
- Design and dynamic analysis of a counter rotating wheels pitching system, inputted in Matlab software to determine the wheel Torque - Speed characteristics and their effect on ball pitching, including ball spin effects, wheel gap analysis and ball - wheel interface slipping effects.
- Design and Kinematic Relative Motion Analysis of a mechanical linkage system producing oscillatory motion of the pitching system. System was analysed in Working Model software.
- Design and Analysis of a Manual Ball Launching Angle Adjustability Power Screw System and an Automated Ball Feeding Mechanism.
- Detailed design and construction of all prototype mechanical and electrical systems.
- On court testing, improvements and analysis of prototype.

Results and Achievements

The pitching system is capable of simulating 6 out of the 7 main shot types in tennis, within experimental error limits (not designed to simulate serve). The oscillation system allows random throwing of balls across the court width between the singles court sidelines, covering most of the court width. The ball feeder carousel mechanism is capable of feeding an average of 194 balls out of 200 (machine ball capacity) in a single run, with no jams. The ball launching angle adjustability system is comfortable to use and effective, however adjustment is too fine and system is slow. Larger pitch power screws would allow faster angle adjustability. Amongst important results determined are the fact that wheels having a high moment of inertia produce low torque and speed fluctuations because of the flywheel effect, a linear relationship exists between wheel gap size and ball range, permanent magnet D.C motors offer a great degree of speed control suitable for such machines, and higher friction coefficient wheels are advantageous, in that, due to their lower slip, closer wheel gaps can be used and higher ranges obtained, at lower wheel angular velocities.



Performance Measurements On Model Floating Wind Turbines

Student: David Bonnici
Supervisor: Dr. Ing. Tonio Sant

Introduction

Wind power energy is not a technology of the last decades. It is more like a "rediscovery of a long tradition of wind power. [1]" The drive towards renewable energy and because of the lack of land is shifting the wind turbines from onshore to offshore, that is installing wind turbines at sea. In deep waters of about 60m, it will be more viable to install wind turbines on floating structures. The implementation of such structures at sea requires understanding the complexities involved in the interaction of the aerodynamic and hydrodynamic loadings acting simultaneously on such structures.

Project Objectives

The objective of this project was to design and construct an instrumented laboratory-scale floating wind turbine, and observe its dynamic behaviour under different controlled operating conditions. The model was tested under the combined action of hydrodynamic aerodynamic and inertia forces. The concept used for the floating structure was a tension leg platform (TLP).

Project Methodologies

The project aimed to study and analyse the dynamics, aerodynamics and the effects of hydrodynamic loadings on the power coefficient of the two tested turbines. The following steps were taken in the project.

- Literature review of the current technologies of offshore wind turbines, and the dynamics involved in such structures.
- Theoretical analysis of a wind turbine having a dynamic foundation. The blade element theory was used in order to analyse the effects of aerodynamic damping and dynamic stall. Also an estimation of the hydrodynamic loadings was taken using the Morrison's equation and linear wave theory.
- Design of the buoyant platform structure, consisting of a cylindrical hull which was assembled in the wave generator while the wind turbine was assembled in a low speed straight through wind tunnel which laid over the tank generator.
- Testing of the model with wave and wind loadings. Two different wind turbines were tested in the experiments.

Results and Achievements

The wind turbines were tested under fixed wind speeds, while the rotor tip speed ratio and water wave frequency and amplitude were varied. Only one-dimensional deep water wave conditions were tested. The measured characteristic curves for the power coefficient versus tip speed for both turbines subjected to wave loading were found to be considerably different than those obtained when the floating structure was rigidly fixed. The peak power coefficients were lower within the optimal and high tip speed ratio ranges. On the other hand minimal deviations were observed at low tip speed ratios. A statistical uncertainty analysis on the measurements was undertaken, taking the generator energy losses into account. The peak accelerations and velocities of the oscillating floating system over different rotor tip speed ratios and wave conditions were derived from the position measurements. This study has revealed the importance of investigating in depth the influence of the floater motion on the aerodynamic peak power coefficient of wind turbines.

References

[1] E.Hau, "Wind turbines", Fundamentals, Technologies, Application, Economics, 2nded, Germany, Springer, 2006.

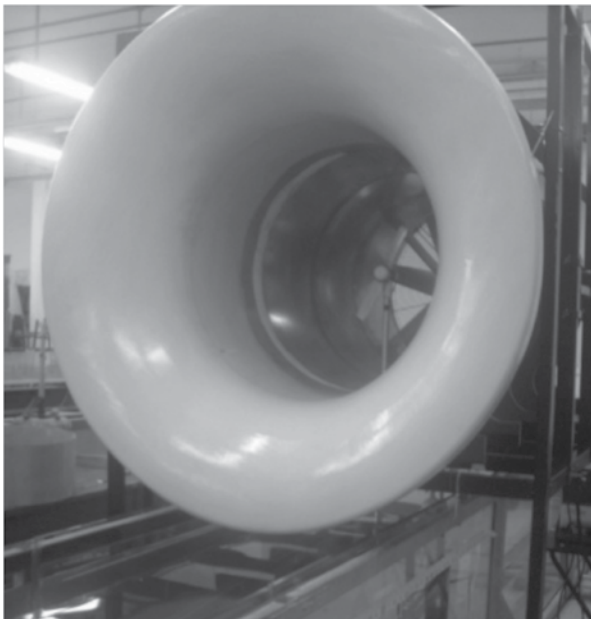


Figure 1- Model floating wind turbine assembled in water tank and wind tunnel

Design, Construction and Testing of a Multi-Bladed Wind Turbine Rotor

Student: Albert Borg
Supervisor: Dr. Ing. Tonio Sant

Introduction

Due to the continuous rise in the cost of fossil fuels, there is a major need to develop technologies that rely on clean and renewable sources of energy to generate electricity. Thus, for this scope to be reached, the basis of this thesis is, to reuse the Chicago windmills found in several places on the island to be utilised to generate electricity, by replacing their rotor with a more aerodynamically efficient rotor which consists of nine blades so that it more resembles to the traditional ones. This project is funded by the Ministry of Resources and Rural Affairs.

Project Objectives

- To review literature, in order to better understand the theory behind wind turbines and to become familiar with glass fibre composites,
- Design the blades and the rotor hub,
- Manufacturing the blades using Glass Reinforced Plastic,
- Testing the blades and finally assembling the rotor.

Project Methodologies

The nine bladed rotor was designed with a tip radius of 1.7 metres. After, the blades were designed, they were tested theoretically using a computer program to predict the rotor performance.

The blade has to be highly aerodynamic efficient, low in weight and high in strength. Thus, it was divided into four different sections in order to meet with the desired specifications. The division of each section is shown in figure 1.

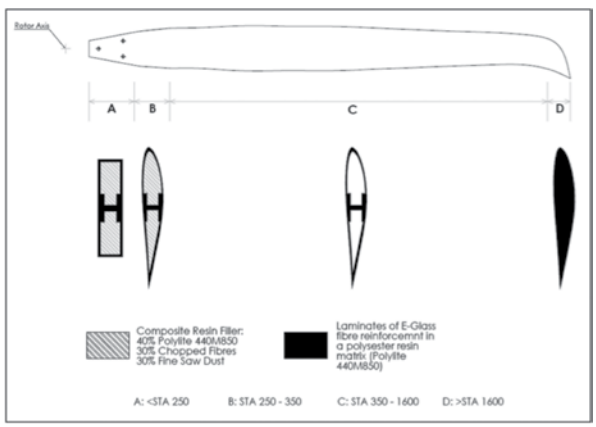


Figure 1: The different sections of the blade.

The blade was manufactured in two halves with the rib in the middle. The height of the rib was obtained by constructing half of the height on the upper and lower half respectively. Then everything was bonded together at the edges and at the centre between the upper and lower part of the rib. The rotor hub was made using two parallel steel disks and attached to the structure using four high tensile bolts.

In order to make the blades, a plug was manufactured. The plug, which was made from wood was formed with the aerodynamic profile needed to be present in the blades. From this plug, the moulds were constructed by using GRP. It was divided in two halves the upper and lower half. Once the moulds were constructed, the nine blades were made. A static load test was made on each blade to check if they have the required strength.

The rotor was assembled and statically balanced in order to reduce the possibility of any vibrations. The final result could be seen in figure 2.

Results and Achievements

The nine-bladed rotor was successfully constructed. There is always room for improvement. First of all, the mass of the blades. If possible the mass of each blade could be made much less in order to obtain a lighter rotor which then thinner materials can be used for the tower. Another improvement would be to make a variable pitch hub. This has an advantage over a fixed pitch, because the blades can be rotated according to the wind speed, thus, maximising the power output.

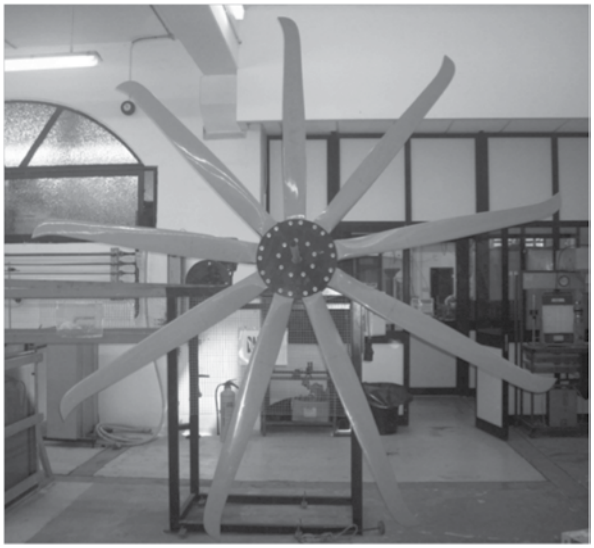


Figure 2: The finished rotor.

Design & Construction of a Hydraulic Bulging Apparatus for Sheet Metal Plates

Student: Christiana G. Borg
Supervisor: Dr.Claire De Marco

Introduction

Industries such as automotive involve the processes of forming sheet metal. As such material is ductile; it can be subjected to large strains before it fractures. Studying the mechanical behaviour and limiting strain values for forming and fracture is of primary importance so that the latter can be avoided. A test that provides data up to the fracture point is the Hydraulic Bulging Test. This test allows sheet material to be formed and fractured under various strain loading conditions. Hydraulic fluid pressure is used to deform the sheet material. The sheet is placed below a die, for example, with a circular aperture and is rigidly clamped. The sheet bulges out forming a shape of a dome when fluid pressure is applied on the other side of the sheet. The sheet plastically deforms to a point where the ultimate strength is exceeded, followed by necking and eventually fracturing.

Project Objectives

- Designing the hydraulic bulging apparatus for testing sheet material
- Building of the apparatus which forms and fractures sheet material by hydraulic fluid pressure
- Determining the fracture and forming limit diagrams of Al-1050 aluminium sheet of thickness 0.8mm

Project Methodologies

The task involved in this project was conducted as follows:

- Literature review in the area of sheet material formability and the various tests used to characterize the forming behaviour of sheet material
- Theoretical analysis of hydraulic bulging of a circular dome
- Design of the apparatus taking into consideration the significant needs required for example including the confined o-ring seal to prevent hydraulic oil leakages and bolt strength calculations
- Building and testing the apparatus
- Determining the mechanical properties and formability parameters of Al-1050 sheet material
- Acquisition of Forming Limit Curve and Fracture Forming Limit Diagram of Al-1050 sheet material

Results and Achievements

Experiments are carried out to study the formability of Al-1050 sheet material using the hydraulic bulging apparatus. No leakages of the hydraulic oil were observed during testing. An 8mm diameter bright mild steel round bar that was placed in the apparatus prevented any drawing in of the sheet material in the aperture during testing. The control of the metal flow is achieved. Forming Limit Curve and Fracture Forming Limit Diagram are plotted representing the formability of the sheet material as they show the forming and fracture limit strains. This diagram gives valuable insights into the mechanics of forming operations as it determines the safe, necking and failure regions of the sheet material.

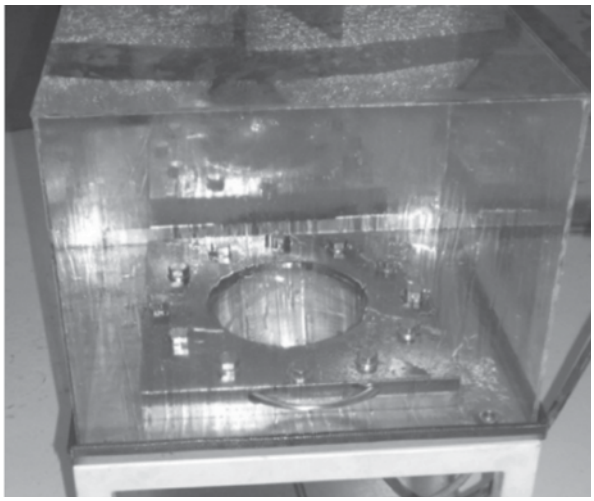


Figure 1: Hydraulic Bulging Apparatus

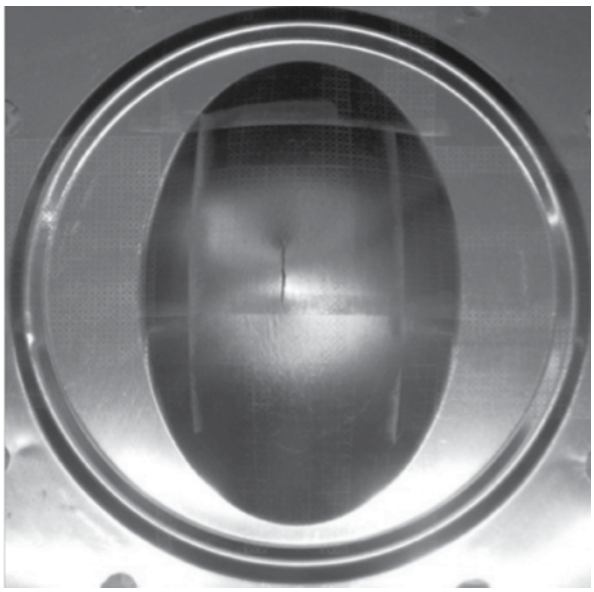


Figure 2: Elliptical bulged specimen

Analysis of stress-strain distribution within the sternum after median sternotomy (foam model)

Student: Ivan Bugeja
Supervisor: Dr. Ing. Zdenka Sant

Introduction
During intrathoracic surgeries the median sternotomy procedure is followed, which involves a vertical incision in the midsagittal plane of the sternum (breastbone) and suturing back together after surgery is finished. Mechanical instabilities in this area may lead to serious medical complications and thus the need of improved closure techniques arises. Sternum foam and computer based models are used for researching as a substitute to cadaveric bone.

Project Objectives
The geometry of a computer based solid model was obtained from a sternum foam model [1] and modified in order to simulate a sternum foam model after a median sternotomy procedure. With the use of Finite Element Analysis, an approximate numerical technique, the stress-strain distribution in the model is to be computed.

Project Methodologies
The sternum geometric model was bisected using Rhinoceros 3D, a modelling tool software, then imported to ANSYS, a finite element package software, where volumes were generated and three suture ring models were added in the first, third and fifth gap between two rib couples. Material properties were assigned to the sternum and sutures models as foam and steel respectively. Contact elements were created between the sternum halves' touching surfaces, and between the sutures and the sternum body. The sternum was thus pulled apart laterally by a total distance of 0.5mm.

Results and Achievements
Observations from the graphical solution of the model deformation and von Mises stress distribution (Fig.1), show the region between the three sutures has an average separation between the two sternum halves of approximately 0.2mm. However this separation increases drastically at the superior and inferior ends reaching maximum separations of 1.075mm and 1.085mm respectively. The distribution of most stress concentrations occur along the contact regions between the sternum body and the sutures giving a maximum stress value in the sternum foam model of 20.5MPa. The stresses generated in the sutures reached maxima of 88.6MPa, 70.8MPa, and 150.7MPa for the superior, central and inferior sutures respectively.

From the separation contour observed, one can deduce that in the region between the three sutures, the separation is well below 0.5mm, the maximum bone separation for bone healing to be possible, while at the superior and inferior ends the separation is greater than 0.5mm thus bone healing is no longer possible. One can thus deduce that if this were a real life situation, such a deflection would probably cause sternal dehiscence, implying that such a suture technique would not be suitable for the patient and must be improved. Improvements include adding sutures between the second and fourth gap between rib couples to distribute stresses more evenly and introducing sutures through the manubrium and between the sixth ribs and the false ribs' cartilaginous joints to reduce the separation found at these areas.

References
[1] Jeffrey Cilia, "Analysis of Stress-Strain Distribution within the Sternum (Foam Model)", B.Eng Dissertation, University of Malta, Malta, 2010

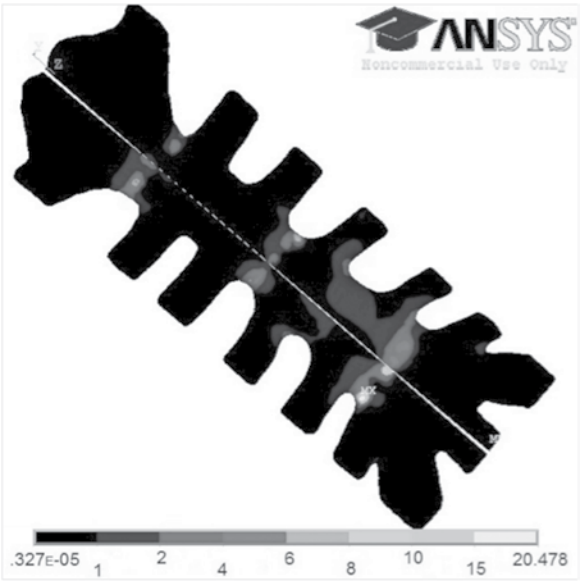


Figure 1: Von Mises stress distribution on Sternum (MPa)

Design and Construction of a Dynamometer Test Bed for Internal Combustion Engine Testing

Student: Terence Bugeja
Supervisor: Dr. Ing. Mario Farrugia

Introduction

Engine testing has been and still is one of the most exciting and challenging operations to a mechanical engineer. Vehicle engines are perhaps the most popular type of internal combustion (IC) engines tested in laboratories, although this is not always the case - jet, helicopter and construction machinery engines, amongst others, could also be adapted for this type of testing. The testing of IC engines requires a test cell or test bed, complete with all the necessary hardware and systems, also including all auxiliary apparatus. Engine testing and modification is carried out on both new and used engines, such as for improving the ignition timing or for fault inspection on readily installed engines in vehicles.

Project Objectives

The main objectives of this project were the following:

- Learning about the different types of systems and hardware, including all the auxiliary equipment used in engine testing.
- Design and construction of hardware and all necessary machining needed for the building of the dynamometer test bed.
- Testing the functionality of all the systems of the test bed.

Project Methodologies

The project identifies all the necessary hardware and systems to carry out engine testing by the use of a water brake dynamometer. The following steps were followed during the implementation of the project:

- Literature review about the different types of dynamometers and about the different systems available for the minimization of exhaust pollution from IC engines.
- Planning and Design and of all hardware construction and systems which needed to be machined and/or welded, using Autodesk Inventor.
- Construction of the designed hardware and systems needed for the operation of the engine and water brake dynamometer.
- Coupling of engine and dynamometer, using all necessary steps for the correct alignment.
- Exhaust system design and construction.
- Software setup and mechanical and electrical connections required for testing of the engine.
- Commissioning and engine steady state testing.

Results and Achievements

From testing analysis of the test bed, it was concluded that all systems, including all auxiliary apparatus, were operating in the correct manner. The modernization of the test bed when compared to older systems, allowed for a number of engineering innovations, such as the speed pick-up system installed with the dynamometer shaft, and the water flow restriction when the dynamometer tends to operate as a pump. Tests carried out during engine operation ensured the facility of the system to maintain a steady state and also the ability of engine speed variation with automatic setting of water flow into the dynamometer.

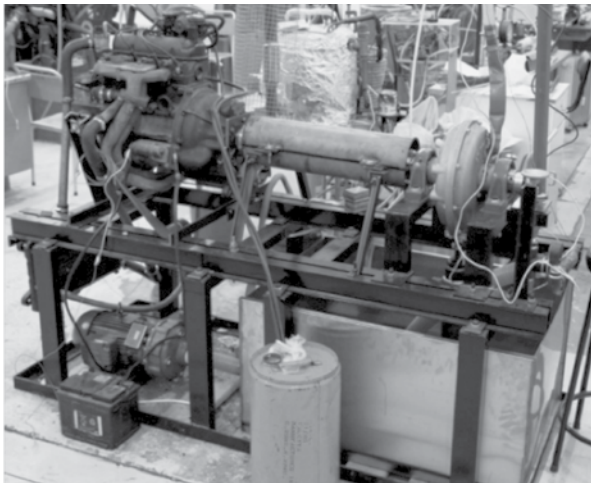


Figure 1: Engine dynamometer test bed

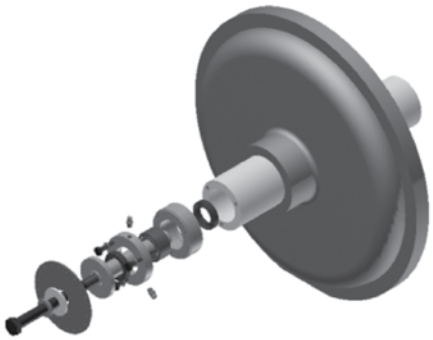


Figure 2: Exploded view of the speed pick-up design with Autodesk Inventor

Design and Construction of a Wooden Hull Boat

Student: Ryan Mark Cachia
Supervisor: Dr. Claire De Marco
Co-supervisor: Prof. Carmel Pule

Introduction

Boats have always been important for man especially for those living on an island like Malta. The use of boats ranges from work purposes to leisure. Each country has its own variations of construction method in the creation of unique boats. With the introduction of new adhesives new methods have been introduced which make it easier for those not having boat building skills to actually build a boat.

In our case the boat to be constructed is 3.9m (twelve and a half feet) in length.

Project Objectives

The main objectives of this project are to:

- Design a boat that meets the requirements.
- Build the actual designed boat.
- Test the boat
- Develop hull characteristics and properties

Project Methodologies

The following steps were carried out during the development of this project:

- Information was gathered on the different types of hull that exist and on the different methods of construction which can be adopted.
- Identification of the best hull type and construction method to orient the design according to the chosen method of construction.
- A set of lines plans were drawn by hand and then a 3D model was generated to obtain more detailed lines plans of the boat to be built.
- Construction of the actual boat, as seen in Figure 1.
- Modelling the actual boat by software to obtain theoretical characteristics and the actual lines plans, as shown in Figure 2.
- Testing the boat to obtain experimental hull characteristics.
- Comparison of these characteristics with theoretical ones.

Results and Achievements

When the boat was tested it achieved good results. The boat managed to achieve a top speed of 6.7kts with 5 persons on it, which is in the range of the achieved speeds by similar hull type boats. The boat's mass was found to be that of 130kg. Moreover, theoretical values and experimental values were very similar. Some characteristics which were compared were: resistance at different speeds, the displacement of the boat at various draughts and the GZ curve.

Figure 1 - The actual boat built

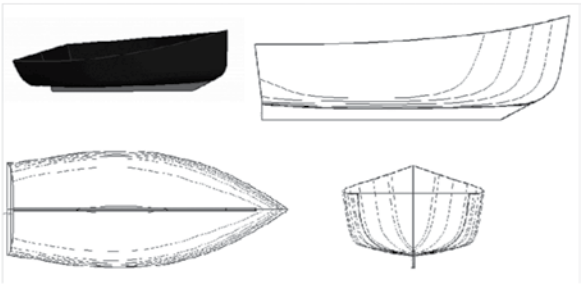


Figure 2 - 3D model and lines plans of the actual boat

Investigation of Common Rail Diesel Engine

Student: Stephen Camilleri
Supervisor: Dr. Ing Mario Farrugia

Introduction

The common rail injection system with electronic controls is being promoted as the future standard in fuel injection systems for diesel engines. Among the advantages claimed with respect to the common rail concept are injection rate shaping, variable timing and duration of the injection, in addition to variable injection pressure, enabling high injection pressure even at low engine loads.

Project Objectives

The objective of this dissertation was to build a software model of a Common Rail Diesel engine based on a Peugeot HDi 1.9 litre. The engine simulation software was then used to analyse the effect that different fuel injection parameters have on the engine performance.

Project Methodologies

- Learn the operating principle of common rail diesel engines
- Familiarize with the use of engine simulation software (WAVE 8.2 Build 15), and simulation techniques
- Experimental test on the Peugeot HDi to gather data in order to calibrate the engine simulation model
- Use the engine simulation model to understand the effects of different fuel injection parameters on the performance of the engine

Results and Achievements

From the analysis on the main injection timing, it transpired that the ideal timing of the main injection lies between twelve to ten degrees before top dead centre for the maximum break engine torque and for reduced CO and HC emissions. However the NO2 emissions are at their lowest values beyond five degrees before top dead centre.

Figure 1 depicts a typical 3-D plot produced by WAVE engine simulation software. The plot illustrates the effect of the main injection timing on the Break Engine Torque at various Engine Speeds.

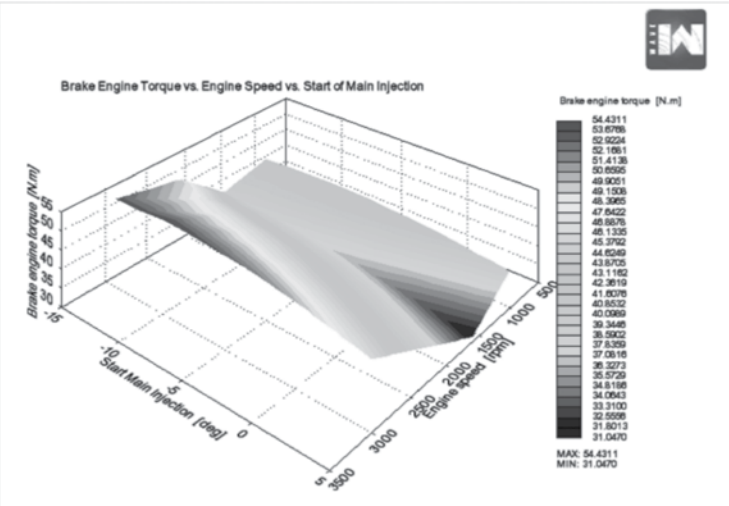


Figure 1: Variations in the Break Engine Torque at Different Engine Speeds and Main Injection Timing

Finite Element Analysis and Experimental Validation of a Formula SAE Car Chassis

Student: Mark Cini
Supervisor: Dr. Ing. Pierluigi Mollicone

Introduction

The aspiration of a race car engineer is to continuously improve the design of the car. As one of the major components of the car, the chassis' design carries a big role in the car's performance. To appreciate the importance of a well designed chassis it is first necessary to examine the kind of conditions it is likely to meet on the road. The major loading situations which the chassis will experience are bending and torsion. However, if a chassis is well designed to handle torsional loads, bending forces won't be an issue. [1]

There are many simulation software available that help with the design of the chassis, saving both time and money. However, despite the fact that computer-aided engineering has made major advances in simulating engineering applications accurately it is still important to do experimental validation of the model to have confidence in the results achieved.

The University of Malta participated once, in the 2007 Italian edition of the Formula SAE competition.

Project Objectives

The individual goals of the project hence are:

- Create FEA models of the 2007 Formula SAE car chassis and carry out a study on each model.
- Build a test rig to carry out torsional rigidity experiments to validate results obtained from the finite element studies.
- Analyse results of the different models and design an improved chassis using the most suitable model.

Project Methodologies

Computer-aided engineering software is essential for the design of a competitive Formula SAE chassis. It allows the designer flexibility to go through a number of design iterations for a fraction of the cost. One such software is ANSYS which is capable of performing stress analysis, amongst other types of analysis based on the finite element method. Two models were created and analysed; a beam-element model and a solid-element model.

To validate the torsional stiffness determined through finite element analysis, a physical test was carried out on the chassis. In order to be able to get good qualitative experimental data from the test, a test rig has to be built to mimic exactly the same boundary conditions modelled by the finite element simulation.

Results and Achievements

The experimental test showed that the stiffness of the frame is equal to 1050 ± 15 Nm/degree. This represents a 25% variation from the beam-element model and a 6% variation from the solid-element model. Since the solid-element model shows only a small variation, this result gives confidence that improvements made on the solid model to improve the chassis stiffness will translate to real improvements on the racing car.

References

[1] W. B. Riley and A. R. George, "Design, Analysis and Testing of a Formula SAE Car Chassis," in Motorsports Engineering Conference & Exhibition, Indianapolis, Indiana, 2002.

Figure 1: University of Malta race car

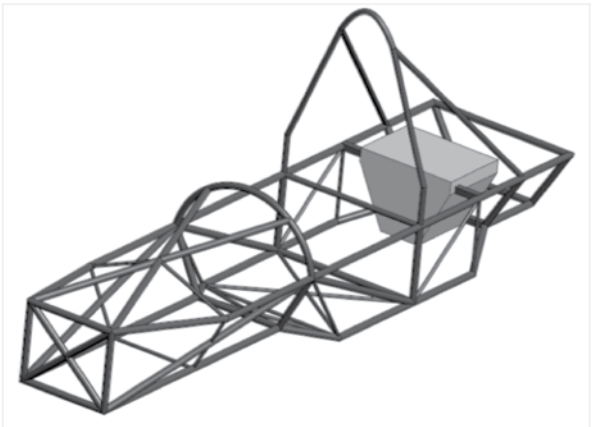


Figure 2: CAD model of frame

Design and Construction of a Fibreglass Planing Craft

Student: Jeremy Cortis
Supervisor: Dr. Claire De Marco

Introduction

Over the past 50 years, the boatbuilding has taken a new way with the replacement of wood with fibreglass which speeds up the manufacturing process and ensures repeatable results. In addition, the planing type of marine crafts are the ultimate design in the modern boatbuilding industry since they can travel at high speeds and offer a comfortable ride for recreational purposes.

Project Objectives

The aim of this project was to design and build a planing craft made from fibreglass. The boat was designed for two people, at a design speed of 20 knots.

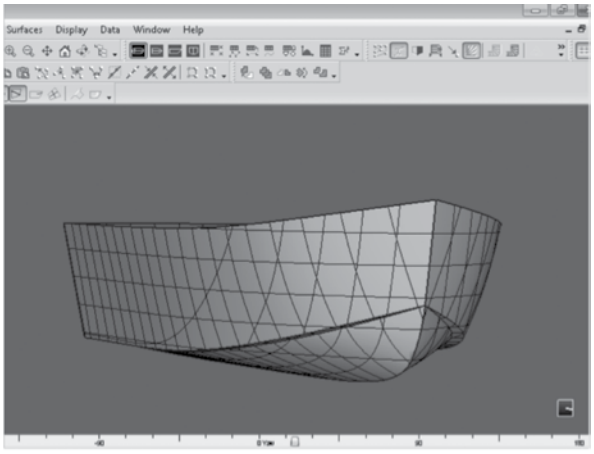
Project Methodologies

A review was made outlining the main differences between the displacement and the planing type of boat hulls. A planing hull is designed to reach high speeds due to being supported entirely by hydrodynamic forces, not by buoyancy forces as in displacement hulls. A planing hull was therefore designed for the required needs using a naval architecture software called Maxsurf v15.0. Linesplans were output into a CAD program and a female mould was designed and built directly from wood. The required thickness of fibreglass was calculated and the mould was laid with fibreglass using the normal hand layup procedure as used in the industry, to produce the main hull. Reinforcements were then added along the boat to stiffen the hull and the interior seats were installed, made of wood. The boat was designed with watertight compartments and a double bottom so that it was made unsinkable in the event of capsizing. The weight and centre of gravity of the final boat were measured and the required horsepower for a speed of 20 knots with two persons on board was calculated to be 10.4hp. A 9.9hp motor was bought and the boat was tested with 1 person and 2 persons respectively and the speed reached was determined. Stability and resistance tests were also made.

Results and Achievements

The maximum speed achieved was 20 knots with 1 person on board, and 18.6 knots with 2 persons. The boat was also towed to measure the resistance offered when its still in the displacement regime. Stability tests were also carried out to determine the position of the boat's vertical center of gravity and metacentric height, which is a measurement of the boat's stability.

The boat can reach higher speeds with the same power if fitted with trim tabs at the back to control the trim angle at which the boat travels through the water. The overall expectations were reached since the desgined planing craft reached the required and calculated speeds and achieved good overall performance.



Conversion of the Chicago Type Wind Pump to Generate Electricity – The Structural Aspect

Student: Adrian Farrugia
Supervisor: Dr. Martin Muscat

Introduction

The introduction of the electric water pump replaced the conventional windmill with the majority ending up as heritage that form part of the natural country view. The Ministry for Resources and Rural Affairs financed the University of Malta to design and build a prototype to convert the top part of the conventional windmill.

Project Objectives

The main objectives of this project were to;

- replicate an existing tower design and model it on Finite Element Analysis (FEA) software in order to read the optimum stresses;
- design and model a mast connection on top of the tower on FEA software to verify that all stresses will be below the critical stress;
- build a full scale tower and top mast connection;
- design and build a full scale yawing system on which to mount the nacelle with the top mast;
- design and build a full scale nacelle which incorporates rotor mounting, bearings, generator, mechanical breaking and tail vane mounting; and
- design and build a full scale tail vane.

Project Methodologies

Finite element analyses were carried out for the whole structure, including several top mast connection designs, to verify that maximum stress was always smaller then the allowable stress. Having achieved the optimum design based on minimal stresses and ease of fabrication, a 12.5 metre tower was constructed in a horizontal position shown in figure 1. The top part of the tower was then disassembled and placed in an upside down position to facilitate the top mast fabrication.

The nacelle and yaw system designs were initially drawn using Autodesk Inventor in order to obtain the necessary measurements for the components to be machined as shown in figure 2. The necessary designs needed to construct the nacelle included rotor mounting, turbine rotor bearings, generator mountings as well as yaw shaft and tail vane mountings. The yaw system designs consisted of a yaw shaft, nacelle mounting, bearing housings and a commutator for the electrical supply.

The tail vane of this prototype wind turbine is faithful in design and shape to the original in order to keep the same appearance of the old windmill. The tail unit consisted of two components, the tail boom and the tail vane. Furthermore, with the use of an actuator mounted on the nacelle frame the rotor could be brought parallel to the wind direction to bring the turbine out of action when severe weather conditions are expected or for maintenance purposes.

The furling concept was adopted to have a mechanical control mechanism that will furl the rotor at varying wind speeds at any time.

Results and Achievements

A fully functional small wind turbine prototype was achieved by assembling a full scale tower together with the main components being the nacelle, tail vane and top mast connection which will be subjected to further testing.

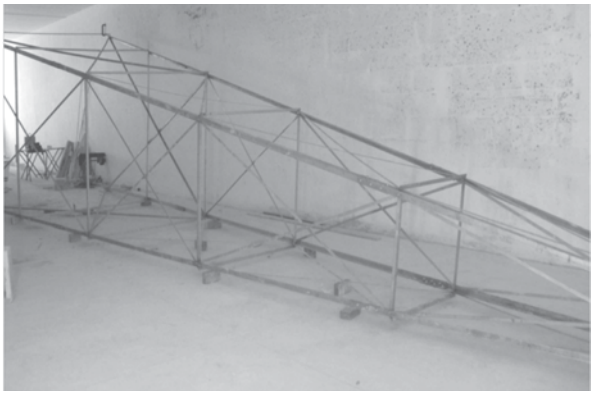


Figure 1: Final tower structure

Figure 2: Nacelle and Yaw system

Design and Development of an Automatic Two-Axis Distortion Measurement Machine

Student: Daniela Galea
Supervisor: Dr. Ing. Duncan Camilleri

Introduction

Structures and assemblies are usually constructed of multiple parts joined together by fusion welding. However, welding is plagued with inherent residual stresses and distortion. Consequently, the dimensional tolerances and stability of the finished products are drastically affected. The resultant welding-induced distortion and residual stresses must be taken into consideration to a great extent during the design process. These are a consequence of the thermal stresses resulting from the non-uniform temperature distribution during welding, followed by plastic deformations/non-elastic strains. Although, these cannot be completely eliminated, several methods can be obtained to reduce them. Choosing the best design and fabrication process for a particular assembly, involves a thorough analysis of how much and what kind of distortion is present in the welded parts. Although this analysis can be efficiently obtained through computational strategies, experimental tests of realistic nature should be performed to validate it.

Project Objectives

The objective of this study is to design and develop an automated measuring technique capable of quantifying the out-of-plane residual deformation, developed due to welding. An automatic two-axis distortion measurement machine, which will be fitted on an experimental semi-automated welding rig, was developed and commissioned. Repeatability of test-results is achieved through control and programming using Labview. The machine is capable of measuring distortion of butt welded flat plates having a maximum length of one meter.

Project Methodologies

The project identifies the measurement of the out-of-plane residual deformation of the welded plates, by using a laser sensor system. The following steps were carried out during the implementation of the project:

- Literature Review of the types of distortion which can be present after welding, as well as, the different techniques which can be used to quantify this distortion experimentally;
- Design and construction of the automatic two-axis distortion measurement machine;
- Testing of the machine for positional error; and
- Providing repeatability of test-results.

Results and Achievements

An important result in this particular project is that the laser sensor records displacements at the specified intervals. This positional error, which is still in progress, can be tested by placing small blocks on the plate and along the scan path, at the particular intervals where the laser is set to take the measurements. The laser is then set to start the scan path. The recorded results by the laser during the scanning, show whether the laser has detected the blocks or not, which means whether the measurements are recorded at the right time or not.

Optimisation of an Existing Material Recovery Facility

Student: Frank Gauci
Supervisor: Prof. Robert Ghirlando

Introduction
WasteServ Malta Ltd. is responsible for the organization, management and operation of the treatment and disposal of solid and hazardous waste. WasteServ Material Recovery Facility (MRF) accepts materials which are discarded by society, whether they are source separated or mixed, and then separates them, processes them and stores them for later use as raw materials for remanufacturing by other companies.

Project Objectives
The aim of the project is to optimize the operation of the WasteServ Material Recovery Facility situated at Sant`Antnin in Marsascala. The main function of the MRF is to increase the quantity of recyclables it processes while it makes the highest revenue from the selling of these recyclables. It can also process waste which can then be used as a fuel source for the production of energy. Recycling can have many advantages namely to help protecting the Earth, help in saving energy, reduce pollution and global warming, reduce waste going to the land-fill and finally save money.

Project Methodologies
In the study, an overview of the main European legislation on waste was consulted. Hence the targets that Malta had to abide to were noted. Data about waste collection in the Maltese Islands coming from bring-in sites, civic amenity centres and Recyclable Tuesdays scheme (Grey Bag) was gathered and studied. Then the operation costs of both the collection and sorting of waste was analysed. The operation of the sorting plant was analysed by the use of flowcharts and process layout. The process layout of the existing sorting plant is shown in figure 1. Four tests were carried out. The first test was carried out on waste composition coming from the grey bag. The second test was on the stoppages of the conveyors while the sorting of waste was going on. The third test was a study on residue composition. The residues are the leftovers of the waste after the sorting had taken place. Lastly, a pilot run of a two stream co-mingled collection programme was carried out in the locality of Hamrun.

Results and Achievements
From the research and tests it was concluded that the existing plant was not originally designed for sorting waste coming from a single co-mingled collection programme (Grey Bag). Its main aim was to sort materials coming from bring-in sites, civic amenity sites, commercial and industrial sectors. Therefore it is proposed that the existing plant should be used to sort only the latter types of waste as was originally intended while making some alteration on conveyor timing. In addition, a smaller sorting plant should be built to automatically sort the waste that is coming from the single stream co-mingled grey bag. The proposed layout is shown in figure 2. The costs for the equipment and engineering work for setting up the new plant was analysed.

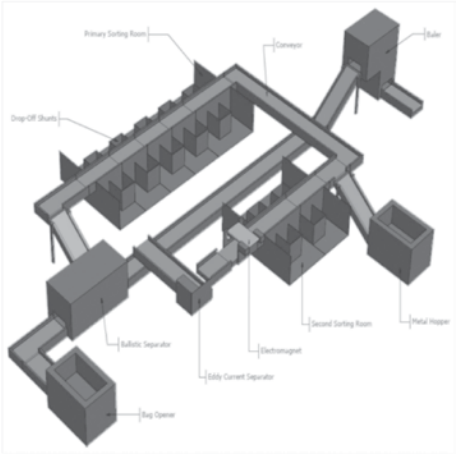


Figure 1: Existing Sorting Plant

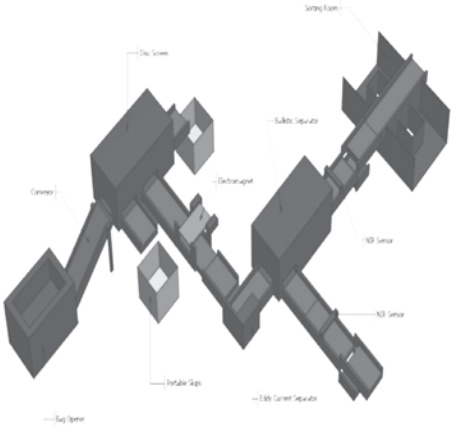


Figure 2: Proposed New Sorting Plant

Investigation of a Multihulled Vessel

Student: Andrea M Grech
Supervisor: Dr Claire Demarco

Introduction

A vessel which is composed of more than one hull is called a multihull. Various instances throughout history show that multihull vessels have been used for fishing, transport, military and other important purposes[1]. This is due to the larger work plane area present on top of the hulls keeping them together, the superior transverse stability and lower resistance at high speeds.

Project Objectives

- To investigate different multihull configurations;
- To select the optimum configuration that would satisfy both stability and resistance characteristics;
- To design and construct a model of a multihull vessel; and
- To perform resistance tests on the model.

Project Methodologies

After carrying out a profound analysis on resistance and stability theory, the individual hulls that make up the trimaran were designed using Maxsurf (FormSys application software) (see Figure 1). A model was subsequently built on the design obtained (hereafter referred to as 'the physical model'). The optimum positioning of the hulls was then determined by conducting several simulations on Hullspeed (FormSys application software), using slender body theory from which the ideal set up was identified with respect to resistance. In order to be able to compare with the results obtained from computer simulations, tests were carried out on the physical model.

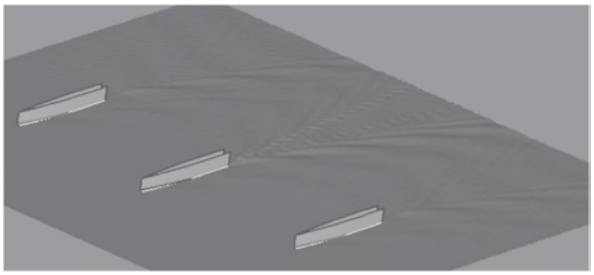


Figure 1 - Wave pattern of one of the configurations of the trimaran.

In total, four parameters were varied:

a) separation – the transverse distance between a pair of hulls (0.60m to 0.88m in 5 steps);
b) stagger – the longitudinal distance between a pair of hulls (-0.32m to 0.32m in 5 steps);
c) draft - the height below the water-line (0.016m to 0.028m 3 steps); and
d) velocity (0 to 15 knots).

Further analysis was carried out by increasing the separation for a given draft in increments of 0.07m in order to determine the position at which the hulls may be considered independent of one another. Tests were then performed in calm open water to investigate the resistance analysis on the physical model. Hydromax (FormSys application software) was used in determining the ideal hull layout according to stability characteristics (in accordance with the 2000 High Speed Craft Code).

Results and Achievements

From the results obtained, a number of items were noted. An increase in draft results in an increase in resistance, due to multihull vessels being very sensitive to much larger wetted surface areas. The highest level of resistance was noted to occur when all the three hulls were collinear [that is without any stagger]. A staggered layout provides less resistance at high speeds for the same separation. A positive or negative stagger however results in an identical resistance-velocity curve[2]. The wave patterns produced by the vessel at high speeds demonstrated that the bow waves were not being produced, resulting in an increase in efficiency. A series of curves were then plotted to analyse the effect of stagger, separation and draft on stability. By increasing the stagger or separation, a much stiffer vessel can be produced capable of sustaining larger loads with a very low angle of heel.

[1] V. Dubrovsky and A. Lyakhovitsky, Multi-Hull Ships: Backbone, 2001.
[2] A. Migali, et al., "Experimental Study on the efficiency of Trimaran Configuration for High-Speed very large Ships," presented at the FAST 2001, Southampton, UK, 2001.

Use of Heat Pipes/Thermosyphons in Solar Desalination

Student: Norbert Grech
Supervisor: Professor Ing. R. Ghirlando
Co-Supervisor: Ing. P. Refalo

Introduction

Water scarcity is one of the main problems to be faced by the Earth's population in the twenty first century. Although water is abundant on our planet with 75% of the total surface area, only 0.25% of the planet's water is easy to retrieve, and good for drinking. Thus with the ongoing increase in fuel prices and the need for sustainable development, it was imperative to develop means to use clean alternative sources of energy such as the sun's radiation to produce fresh water. A device which was invented to harness the sun's energy to generate fresh water was the solar desalination unit also known as solar still. In this study the heat pipe/thermosyphon will be used to try and increase the output rate of condensation in the solar still.

Project Objectives

The main aim of this project is to investigate the technical feasibility of using heat pipes/thermosyphons for heat recovery within solar desalination units to increase the output rate of condensation.

Project Methodologies

The method was to use a heat pipe/thermosyphon in the ceiling of a cascaded solar still so that the condensate formed on the lower part of the device, transferred its latent heat energy in it. Through the operation of the heat pipe/thermosyphon this energy would then be transferred from the higher part of the device to the water surrounding it. This was done to recover the energy released from the condensate, which in normal cases is lost, and so use it to heat more rapidly the water present in the upper chamber of the desalination unit.

To accomplish this:

- An analytical model of the system had to be constructed.
- Design of the heat pipes/thermosyphons was done using the data from the analytical model.
- Different heat pipes/thermosyphons were built to be tested in different conditions.
- A testing rig for the heat pipes/thermosyphons was designed by Autodesk Inventor and then manufactured.
- Various experiments were performed to establish the effectiveness of the device in this system.

Results & Achievements

From the data obtained in the experiments, for each thermosyphon tested the water present in the upper chamber rarely exceeded that of the thermosyphons saturation temperature. This may be attributed to the continuous change in the variable parameters because of an increase in temperatures. Hence the operation of the thermosyphon in this setting will not be as effective as when it is used for its normal application when it dissipates energy in a heat sink where the temperature is kept constant.

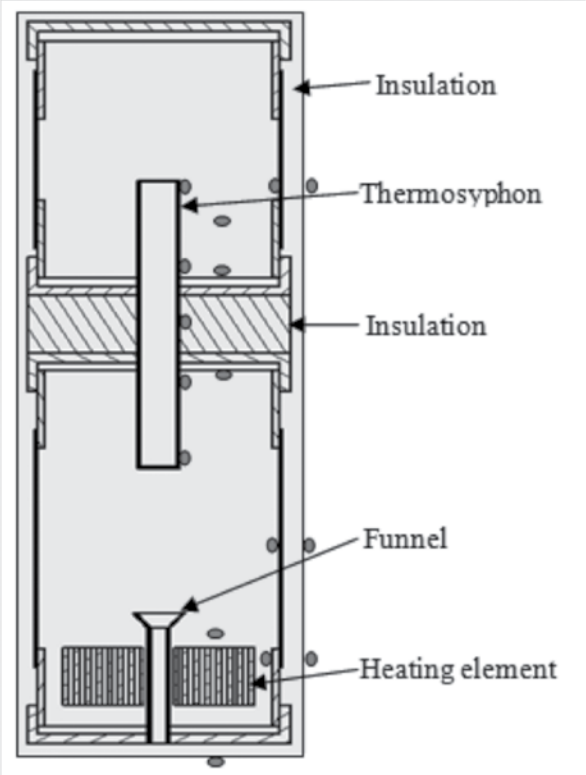


Figure 1: Design of testing rig.
• *thermocouple*

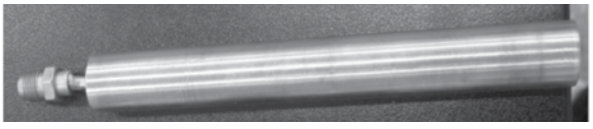


Figure 2: Thermosyphon

Design and Construction of a Groundwater Heat Pump

Student: Ronald Mangion
Supervisor: Dr.Ing.Mario Farrugia

Introduction

Statistically, in Malta, the electrical power generated reaches the maximum in three particular months; January, July and August. These coincide with the minimum and the maximum ambient temperatures respectively. One of the main reasons for this high electrical generation may be due to the increased energy demand for heating and cooling purposes. Thus, one way to reduce energy consumption in this field is by using more energy efficient heat pump systems. The efficiency for such a system can be increased by utilizing a constant temperature source/sink rather than having a source/sink temperature dependent on the outside air temperature, as for the conventional air source systems. A constant temperature source/sink is achieved by using the relatively uniform temperature of Earth which is the operating principle of a geothermal heat pump system.

Project Objectives

The objectives of this project were:

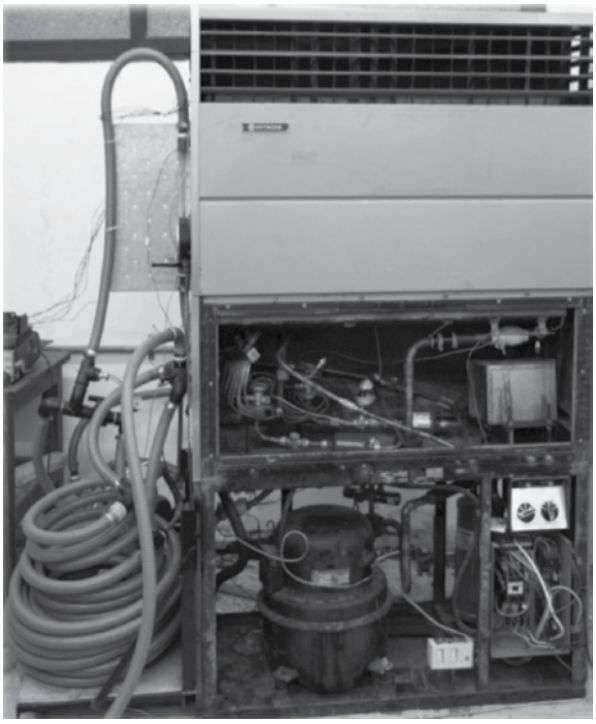
- To design and construct an actual groundwater heat pump system using well water, including both the refrigeration and water circuits and also a double pipe water-to-refrigerant heat exchanger to serve as the Earth connection;
- To analyse the system performance at different flow and piping arrangements of the designed heat exchange and compare with literature;
- To determine the heat dissipation from the well water to the ground.

Project Methodologies

The refrigeration circuit was based on the vapour compression cycle. It consisted of the fundamental components; the compressor, the expansion device (TXV), the designed water cooled condenser and an air finned evaporator. The other necessary components were the reversing valve, check valves, sight glasses and filter driers, apart from the instrumentation apparatus. The designed condenser consisted of two double pipe heat exchangers, which were connected in parallel. The inner copper pipe had an external diameter of 0.01588m while the outer plastic pipe had an internal diameter of 0.03m, each double pipe heat exchanger had a total length of 15m. Regarding the water circuit, it consisted of a submersible pump and 80m of 0.035m (inner) diameter plastic pipe, which were installed after the decision on the flow and piping arrangement of the heat exchanger.

Results and Achievements

The Coefficient of performance (COP) for both heating and cooling mode was plotted against a ratio of water flow per kW of heating capacity. By these charts the flow and piping arrangement of the heat exchanger were determined based on the best obtained performance. The use of such charts is helpful for the design of other heat pumps with different heating capacity. This is because, by the knowledge of the heating capacity and the desired COP, the water flow rate, and hence the water pump, can be determined.



Fatigue life prediction of welded wind turbine support structures

Student: Mark Micallef
Supervisor: Dr. Ing. Martin Muscat

Introduction

Fatigue is an accumulative damage process on a material due to repeated, alternating loads. What makes this damage process interesting but at the same time dangerous, is that the loads applied may well be below the ultimate strength of the material but failure would still occur. This is so because the damage is accumulated cycle after cycle until finally a rapid fracture occurs.

Offshore wind turbines support structures have to withstand random, alternating loads created mostly by sea waves and wind currents during its lifetime without failing. Having good knowledge about this fatigue phenomenon and how to perform the design check against this type of failure is of paramount importance to safe design of wind turbine support structures.

Project objectives

- Make study of fatigue and the different existing fatigue-life prediction methods.
- Study and explain the fatigue assessment procedures available in the Offshore Standard DNV-OS-J101.
- Conduct fatigue assessments using the finite element software Ansys.

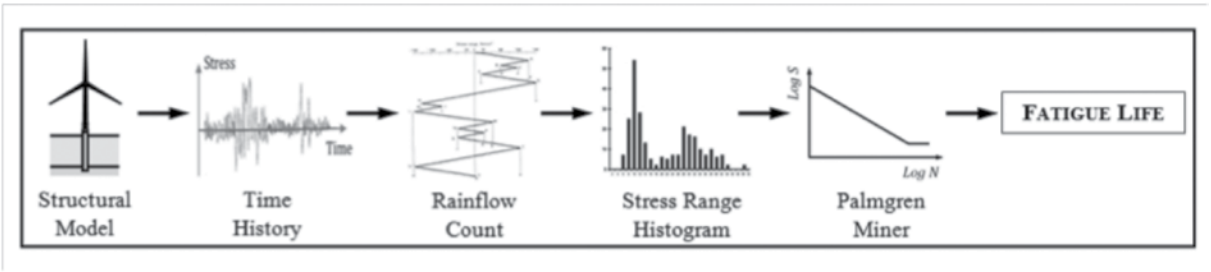
Project methodologies

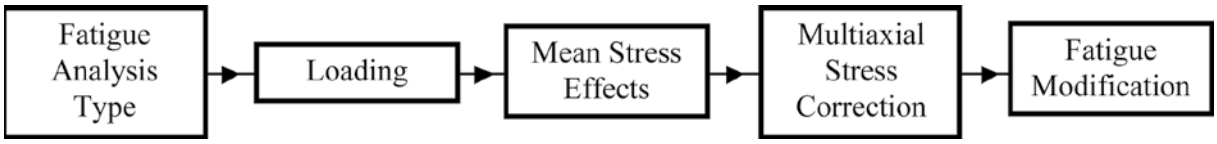
General procedure for fatigue life calculation using Palmgren-Miner Rule (Analytical):

When using the finite element software Ansys, these are the common decisions for fatigue analysis:

Results and achievements

By conducting a fatigue assessment in the early stages of a design, one would ensure a more safe design of the structure that is not over engineered.





Weight Bearing Device

Student: Melanie Muscat
Supervisor: Dr. Ing. Zdenka Sant

Introduction

Arthritic problems associated with obesity would be ameliorated if the person is allowed to exercise without placing any pressure on the inflamed joint. This relieves the person from pain and gives him that confidence to lose weight without further deterioration of joints.

Project Objectives

The objective behind this thesis is to design a weight bearing device which transfers the excess weight the torso places on the joints in the lower limb, while walking, through an exoskeleton structure. A quick release mechanism must also be devised to accommodate for sitting.

Project Methodologies

In order to devise a proper mechanism to transmit the excess weight borne by the joints, a force analysis of the ground reaction forces must first be investigated.

A participant of average weight and height volunteered to walk on a force plate where the participant's ground reaction force (GRF) values were made available through the Vicon Nexus software and MLSviewer. In order to calculate the magnitude of excess force an obese individual endures, the GRF values were transformed to produce graphs as a percentage of the body weight and gait cycle as demonstrated in Figure 1.

A resultant of the two forces illustrated in Figure 1 was calculated to be produced in the sagittal plane. The forces transferred from the resultant of the GRF through the lower limb joints were then analysed and computed to reveal the magnitude of force borne by the joints.

Results and Achievements

Once the forces in the lower limb have been analysed, it was possible to devise a mechanism which bears any excess weight an individual must carry.

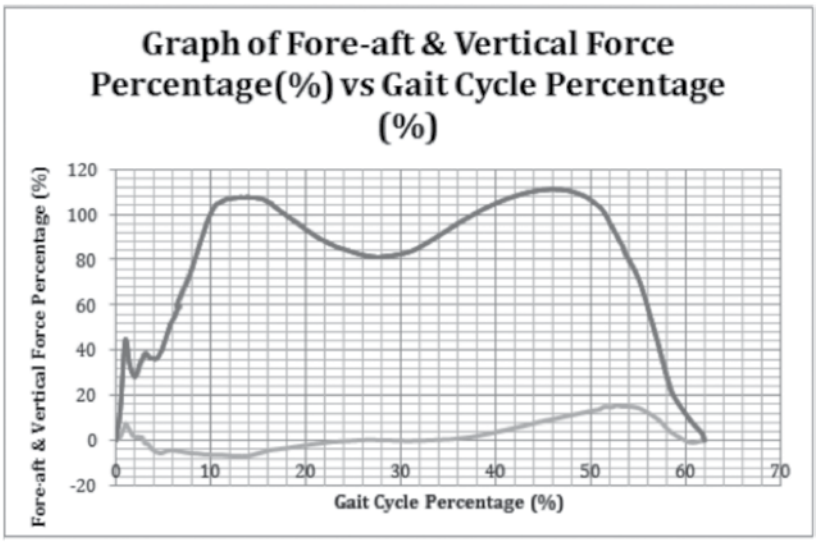


Figure 1: Graph of Fore-aft (bottom line) and Vertical (top line) Force Percentage against Gait Cycle %

Testing of a Hot-Wire Anemometer in a Low-Speed Straight-Through Wind Tunnel

Student: Joseph Schembri
Supervisor: Dr. Ing. Tonio Sant

Introduction

Wind Tunnels are used in order to test the aerodynamics of models of. A hot-wire anemometer is one system used to measure flow velocities within the wind tunnel: by heating a thin wire, and manipulating the data from its rate of cooling. The hot-wire permits a high spatial resolution, and a high frequency response, which enables the measurement of Turbulence Intensity in the flow.

Project Objectives

- Design and Construct a traversing system for the hot-wire anemometer;
- Test the operation and calibrate the anemometer;
- Measure the flow velocities with and without a Shear Flow Generator in the Square Section Wind Tunnel. Compare theses results with those obtained by other methods.

Project Methodologies

After studying the requirements needed for the traverse system, the necessary parts were manufactured (Figure [1]) and hence assembled. The traverse is able to move along the x-y-z axis, and rotate the probe about its axis.

The anemometer gives a reading in terms of voltage, but what is really needed is the velocity. Hence it needed to be calibrated. This means that the voltage reading was related to the velocity.

Then the Wind Tunnel per se was tested (Figure [2]). Velocity readings at various points were taken, in order to be able to verify the uniformity of the flow in the tunnel.

Once this was completed, a Shear Flow Generator was placed in the tunnel. The aim of this generator is to mimic the effect of wind flowing over the land. Thus, the hot-wire was used to measure the different velocities due to the Shear Flow Generator [1].

The hot-wire is capable of recording an impressive number of readings per second. In this project, "only" 10 readings/second were recorded. With this large number of frequent readings, the turbulence intensity in the flow was measured too. (Turbulence is the fluctuations in an air flow.) Finally, the flow was tested to check if the flow was straight.

Results and Achievements

The results of the velocity of the Shear Flow Generator were in agreement with those using other systems, however the calculation of Turbulence Intensity was a very important Improvement. As expected, the major turbulence was found near the edges of the tunnel and where there were sharp changes in geometry.

A very interesting result is the that flow was not completely straight when the Shear Flow Generator was tested. In fact some components of the flow were found to go in the vertical and horizontal directions.

References

[1} D. Baldacchino, "An Investigation of the Aerodynamics of Wind Turbines in Shear Flow," University of Malta, 2010.

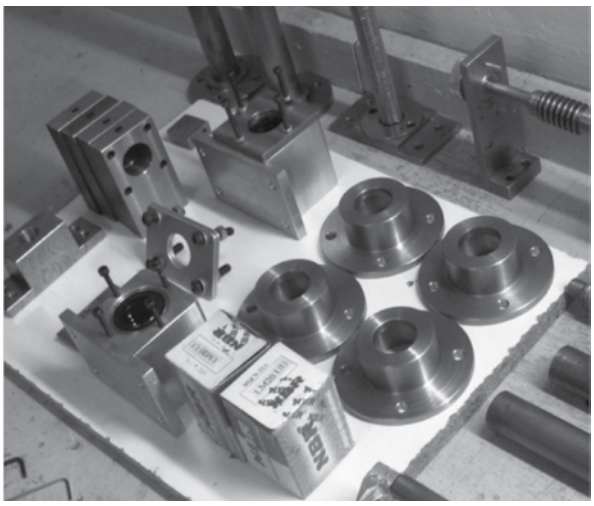


Figure 1: Manufactured Parts for the Traverse System

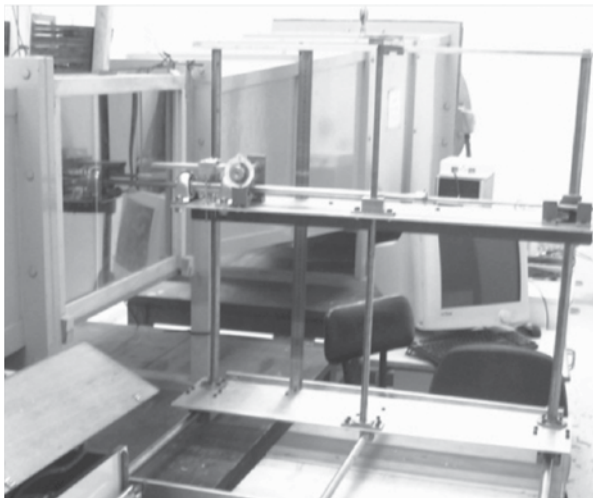


Figure 2: Set-up ready to make the testing

Design and Development of an Experimental Semi-Automated Welding Rig

Student: Sarah Sultana
Supervisor: Dr. Ing Duncan Camilleri

Introduction

Residual stresses and distortions are two major concerns in welded structures. Various techniques are used to mitigate residual stresses and distortions. These tools are best utilized with the aid of numerical models which aid in designing the best welding process. The semi-automatic welding rig uses Metal Inert Gas (MIG) welding technology for automatic welding of flat plates. The distortions are measured using a laser sensor and the results are then compared to distortion predictions obtained by computational models. These results can then be used to create and improve methods which aid in reducing the distortions and residual stresses; and also to improve the accuracy of numerical models in predicting distortions and residual stresses.

Project Objectives

The main purpose of the design and development of a semi-automatic welding rig is, to provide an experimental set-up where welding tests can be performed. The rig is to be capable of welding automatically various assemblies in a linear manner using MIG welding, while subjecting the plates to pre- or post-heating. The welding speed can be varied from one process to another, but is kept constant for a particular test. The control system should enable repeatability of the test-results required.

Project Methodologies

The project identifies various design tools and machining processes which were used in the design and construction of the structure. The following steps were carried out during the implementation of the project:

- Literature Review were different distortion and residual stresses mitigating process and modelling techniques were discussed
- Design and construction of the experimental semi-automatic welding rig;
- Testing of the functionality and repeatability of the welding rig; and
- Evaluation of the performance of the welding rig

Results and Achievements

The design and construction of the machine were completed and the machine is capable of performing the intended tasks. Some tests were carried out using different parameters, observing a change in distortion from one process to the other. Repeatability of the results for similar welding processes was satisfactorily achieved.

Investigation of variable expansion device in air conditioning

Student: Eric Vella
Supervisor: Dr. Ing. Mario Farrugia

Introduction

Air conditioning systems constitute a large portion of the consumption of energy due to their wide range of application. [1] Inverters are usually used to control the speed of compressors in order to enhance the system's energy conservation ability. [2] Inverters are coupled with expansion devices which control the flow rate of the refrigerant in order to match the varying conditions. [3]

In 2010, Vassallo [4] carried out testing on an inverter driven air conditioning unit having a fixed orifice expansion device in order to determine its ability at varying conditions. From the analysis of the results, it was determined that inverter systems offer improved energy saving capabilities at partial loading.

Project Objectives

Modify the test setup used by Vassallo [4] to include a variable orifice expansion device instead of the fixed orifice capillary tube. Perform testing on the setup and compare the performance of the variable expansion device to the capillary tube at various specified set points. Manufacture of a flowmeter and modification of another in order to be able to obtain a measurement of the refrigerant flow rate.

Project Methodologies

The following steps were carried out for the implementation of the project:

- Derivation and analysis of the working principles of two types of flowmeters.
- Design and construction of a variable area flowmeter and modification of the measuring range of the pressure differential flowmeter.
- Modification of Vassallo's [4] setup to incorporate the variable expansion device.
- Controlling the electronic expansion device via the combination of a LabView program and an electronic circuit.
- Varying the opening area of the expansion device and conducting testing at the same set points specified by Vassallo [4].

Results and Achievements

Graphs of Coefficient of Performance (COP) against area of opening of the expansion device were plotted. Two main trends were identified. At high ambient temperatures, the variable expansion device obtained the same performance as the capillary tube. At low ambient temperatures and relatively high heat loads the variable expansion device performed better than the capillary tube. Other graphs were also plotted which compared more parameters with the opening area of the variable expansion device.

References

Journals:

[1] I. Y. Chen et al., "A Comparative Study between a Constant-Speed Air-Conditioner and a Variable-Speed Air-Conditioner," ASHRAE Transactions, vol. 115, pp. 326-332, Jan. 2009.
[2] H. Nasution and M. N. W. Hassan, "Potential Electricity Savings by Variable Speed Control of Compressor for Air Conditioning Systems," HNICEM International Conference, pp. 1-7, Mar. 2005.
[3] Y. C. Park et al., "Performance Analysis on a Multi-Type Inverter Air Conditioner," Energy Conversion and Management, vol. 42, pp. 1607-1621, 2001.

Dissertation:

[4] O. Vassallo, "Investigation on a Commercial Inverter Air Conditioner using Manual Speed Control," B.Eng. (Hons.), Mechanical Engineering, University of Malta, Msida, 2010.

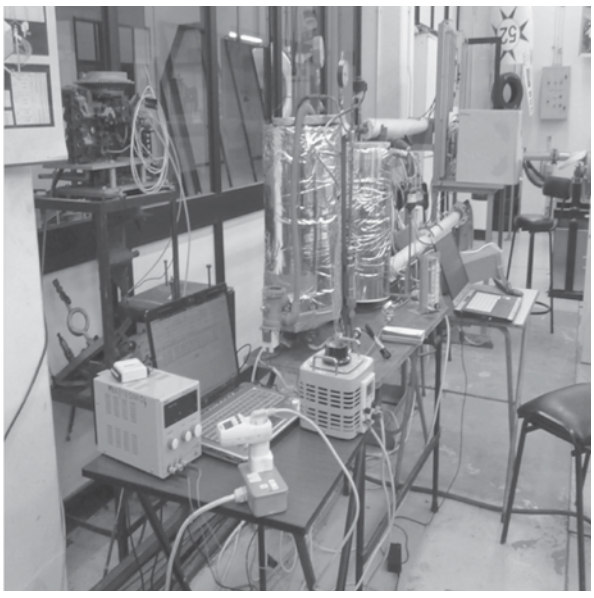


Figure 1 - Complete Experimental Setup

Corrosion and Fatigue in the Artificial Cardiac Pacing System

Student: Lisa Abela
Supervisor: Dr. Joseph Buhagiar

Introduction

The common treatment for patients suffering from bradycardia (when the heart beats less than 60 times a minute)[1], is to undergo an operation whereby a pacemaker is implanted. This consists of the pacemaker/ pulse generator itself together with a pacing lead whose function is to transmit the pulse to the heart providing stimulation. Problems encountered with such a system are those of (a) lead dislodgement; (b) insulation failure (such as subclavian crush); and (c) conductor failure[2].

Project Objectives

The main objectives of the project included material characterisation techniques for (a) the pacemaker housing and (b) for the pacing lead. Two jigs were designed for testing conductor integrity and insulation integrity. The pacemaker housing was examined for corrosion susceptibility, making use of diverse pacemakers including a pacemaker which was thought to have corrosion products.

Project Methodologies

For the corrosion susceptibility of the pacemaker housing, the titanium housing was cut up into the required sample size and mounted onto the corrosion tester. Open circuit potential and cyclic polarization tests were carried out. The inner and outer surfaces of three different pacemaker housings having different surface finishes were tested.

In examining the conductor and the insulator integrity of the pacing lead, the samples were prepared by exposing the conductors from the protective insulation. Separate samples were required for the different tests which were mounted on the respective jigs to carry out the tests, during which readings of resistance were taken. Three different pacing leads were tested in each case.

Results and Achievements

After carrying out EDX (Energy-dispersive X-ray spectroscopy, a process used to determine the chemical composition of a material), and XRD (X-ray diffraction, a process used to yield the atomic structure of materials) tests, it resulted that the pacemaker housing is made from titanium. All three pacemaker samples provided the same result. After characterizing the surface of the pacemaker which was thought to have corrosion products, it was concluded that the surface was coated with deposits including calcium and phosphorus, clearly meaning that the bodily deposits remained attached to the surface after explantation. This deposit layer on the surface of the pacemaker is outlined in Figure 1.

The results of the corrosion testing showed that up to 1.5V, currents remained low and hence no pitting corrosion occurred. Some samples however showed the formation of metastable pits (pits that initiate and grow for a limited period prior to repassivation), whilst all samples exhibited oxygen evolution at 1.5V.

The use of the suture sleeve (the protective cover on the insulation of the pacing lead used for implantation purposes) to secure the lead and prevent lead dislodgement showed that an increase in load of 20N could be withstood when compared to the loading that would occur directly on the insulation. The test results showed that until the pacing lead remain undamaged, the resistance between the reference electrode and the lead conductor remained constant. Once the suture (the material used for making stitches to hold human tissue together) cut the insulation, the resistance reading was the total of the NaCl solution and that of the conductor.

References

[[1] D. M. Anderson, Dorland's Illustrated Medical Dictionary, 30 ed. USA: Saunders, 2003.
[2] S. A. M. Said, et al., "Possible Complications of Subclavian Crush Syndrome," Netherlands Heart Journal, vol. 13, p. 6, March 2005 2005.

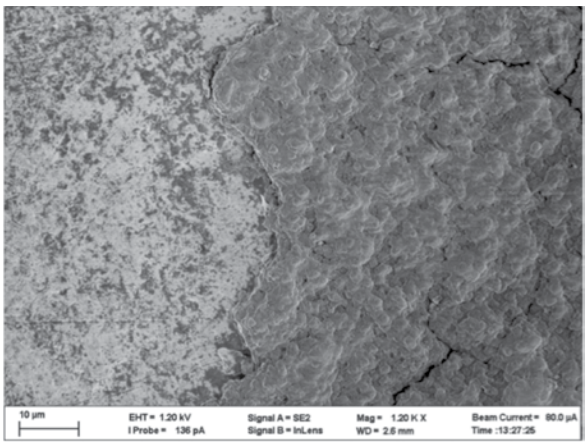


Figure 1 - Pacemaker capsule with deposits

Mechanical and Fatigue Properties of Surface-Modified ADI A Preliminary Analysis

Student: Joseph Axiak
Supervisor: Ing. Ann Zammit

Introduction

Austempered Ductile Iron (ADI) has emerged amongst engineering materials by offering remarkable qualities. Its potential is activated with the use of meticulously controlled heat treatments and an array of surface altering techniques. Shot Peening is a technique which involves the bombardment of the material surface with spherical shots. Upon impingement, the surface is plastically deformed causing a residual compressive stress on the surface, significantly improving fatigue properties. Laser Surface Hardening is a technique which involves the irradiation of a laser beam onto the material surface, raising its temperature and quenching through its own bulk. This allows for suitable hardening transformations, causing residual compressive stresses improving bending fatigue properties.

This study, which will be performed using optimal parameters achieved from former research, aims to study the effects on the bending fatigue properties achieved by implementing both techniques on ADI.

Project Objectives

This thesis is part of a larger project being carried out within the Department of Metallurgy and Materials Engineering. The aim is to investigate the effects of shot peening and laser hardening on the mechanical and fatigue properties of ADI, using appropriate characterisation and testing procedures.

Project Methodologies

- Review existing literature on austempered ductile iron, shot peening, laser hardening and fatigue testing.
- Fabricate specimens for heat-treatment and perform the required surface preparation.
- Shot peen a number of specimens and perform fatigue testing on rotating bending fatigue testers, obtaining the appropriate S-N curves.
- Determine optimal parameters for successful laser hardening of ADI, based on the characterisation of the specimens.
- Perform characterisation and analysis of specimens before and after fatigue testing using optical microscopy, surface profilometry and hardness analysis.

Results and Achievements

When ductile iron is austenitized at 900oC for 2 hours and austempered at 360oC for a further 1 hour, the result is a microstructure having a matrix of acicular ferrite suspended in austenite with graphite nodules spread across the matrix. It also results in a 23.5% increase in hardness.

Shot peening greatly improves the fatigue properties of ADI, with a 40% increase in the fatigue caused by martensite formation at the plastically deformed surface.

Successful laser spot hardening for ADI has been achieved with a spot diameter of 1.2mm and a depth of approximately 300µm when performing laser hardening at 630 Watts, with the nozzle 13mm above the sample. Laser hardening produced a greater than 100% increase in surface hardness values for ADI, due to transformation to martensite at the treated surface.

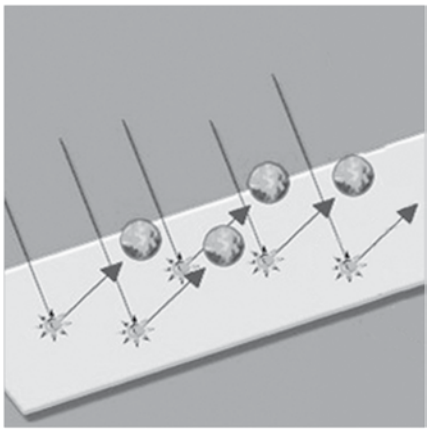


Figure 1 - Shot peening technology

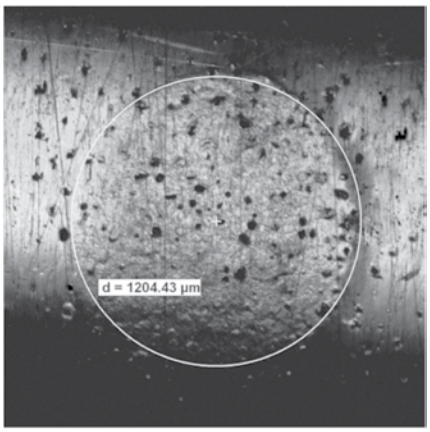


Figure 2 - Spot of laser hardening

Thermal Imaging of Limestone used as a Building Material

Student: Jean-Marc Bonello
Supervisor: Dr. Ing. John C. Betts

Introduction

Globigerina limestone characterises the traditional Maltese urban environment and has been used in the local construction for millennia due to its ideal properties for this application. Despite the extensive use surveying and inspection techniques exploited improvement in technology and are not benefitting from modern techniques that have been successfully applied to other materials for years.

Thermal imaging (or thermography) is one of these techniques that is used widely in the building and conservation industry. Using Infra Red (IR) wavelengths on the electromagnetic spectrum emitted from surface, thermal imagers can instantly measure the temperature of the said surface without the need of any contact or damage. One of these applications is the detection of moisture presence and movement within a building envelope. This study aims to evaluate the potential feasibility of using thermal imaging for building surveying in the Maltese context with a special focus on moisture detection.

Project Objectives

It was required to establish preliminary parameters under laboratory conditions for optimal imaging of globigerina limestone. Benchmark images of control samples of stone in the "as quarried" state and after exposure to moisture were to be taken to document any effect on temperature. Subsequently attempts to detect areas of moisture not visually evident due to their thermal signature were to be made. The effectiveness of thermography was also compared to commercially available moisture meters that are widely used in the industry.

Project Methodologies

- Review of literature concerning the applications of thermal imaging in the construction industry
- Procurement and cutting of stone samples to facilitate handling
- Establishing imaging parameters and conduct benchmark imaging to analyse the effect of moisture presence has on temperature
- Introduce moisture by exterior exposure, destructive (drilling holes in samples) and non-destructive (apply damp sponges on the surface) techniques and take thermal images to try to identify the presence of moisture with no visible evidence
- Conduct an active thermography process by applying a radiant heat source to samples to investigate the effectiveness of this process
- Carry out experiments to obtain better understanding regarding physical characteristics of the stone being used to better understand results obtained through thermography. These included measurement of porosity, heat flux and water transport rates and relations between percentage moisture and surface temperature.
- Compare results obtained with readings taken from a digital moisture meter.

Results and Achievements

From the results obtained during the investigation, one can see that thermography on globigerina limestone for moisture detection is possible with a good success rate and the data obtained is much more useful and accurate when compared to commercially available moisture meters. Moisture was characterised by a The depth at which useful results were obtained was limited to 40mm beneath the surface. Further tests would have to be conducted to evaluate its effectiveness on site under different environmental conditions as well as to determine financial viability to undertake on a commercial scale.

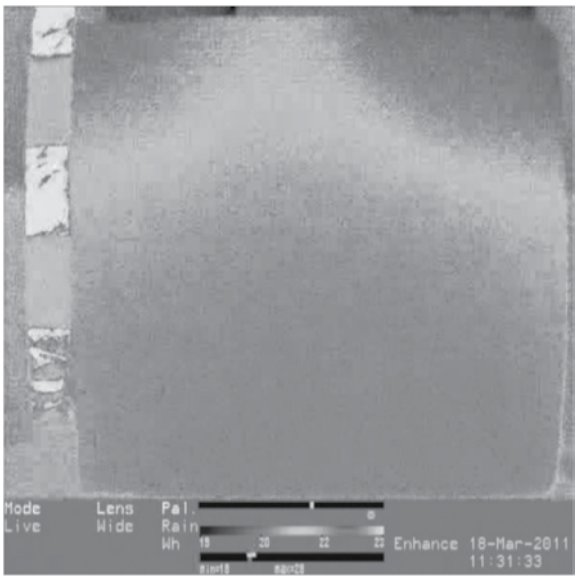


Figure 1 Typical thermograph showing areas of lower temperature (top corners) where moisture is present

Degradation of Paper Due to Ink

Student: Malcolm Caligari Conti
Supervisor: Dr. Ing. Stephen Abela

Introduction
This dissertation focuses on the degradation of paper (especially cotton paper) due to Iron gall ink. The main areas being tackled within this context are: the composition of ancient inks, the replication of ancient inks by modern methods, the degradation of paper in different environments and the analysis of modern techniques which are being used to halt the degradation.

Project Objectives
The objective of this thesis is to describe the effects of Iron gall ink on cellulose based paper, as regards to the corrosion process, and to analyse methods of slowing down the degradation.

Project Methodologies
The main techniques used to characterise the degradation, and the main composition are X-ray fluorescence, X-ray diffraction, Electron dispersive spectroscopy and scanning electron microscopy. Although these modern methods initially may seem to be an overkill, the structure being dealt with in this thesis is very complex. It is effectively the structure of a very complicated polymer with polymer chains having bulky groups throughout, and which also forms a semi crystalline structure when produced. The ink itself is composed of tens of elements (formed into compounds) all produced from natural sources. Therefore both substances, the ink itself and the substrate are complex. In this context these techniques therefore become an integral part of any investigation taking place on these substances.

Results and Achievements
X-ray fluorescence techniques were used to check the authenticity of iron gall inks being manufactured with modern materials following older recipes. The results of the XRF method for the liquid inks were compared to the solid (dry) inks on an aged document, which was analysed using a scanning electron microscope, fitted with an electron dispersive x-ray spectroscopy sensor. The results produced by this technique were encouraging, and an interrelationship between the samples was achieved. This therefore proved that the further investigations with inks on the reproduced inks on modern paper for artificial ageing would give the correct results. i.e. That the next experiments would in fact be a reflection of the true degradation of paper due to Iron Gall ink.
X-ray Diffraction (XRD) techniques have shown that when ageing a sample under different conditions of relative humidity, and with the sample having different inks applied to the surface, the change in crystallinity is different for each condition. One could observe the expected rise in crystallinity (due to the relatively high decay of the amorphous content of the cellulose structure).

XRD techniques have also shown, Figure 1, that an antioxidant treatment method, used for treatment of aged documents, and which was highly recommended by Incor (A European funded project on ink degradation), also has its drawbacks. XRD analysis shows that if the antioxidant treatment is applied with a very high concentration of antioxidant, it may well lead to the degradation of the paper beneath the ink. Therefore while preserving the ink, the antioxidant would be destroying the paper beneath it.

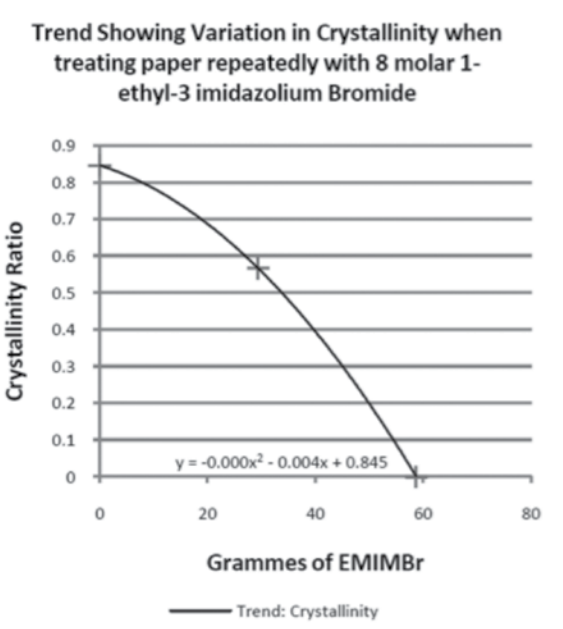


Figure 1

The Controlled Erosion of Limestone

Student: Clarence Camilleri
Supervisor: Dr Ing. John C. Betts

Introduction
One of the most popular cleaning techniques employed on limestone masonry buildings is dry air-abrasive blasting. This cleaning method is considered as a fast and cheap way to clean a large facade but it tends to extensively erode the limestone surface. Hence it is important to investigate the process parameters of this technique, their effects to the material loss, the surface roughness induced and the change in colour of the stone.

Project Objectives
To investigate the erosion of Globigerina limestone under a controlled environment by varying the air pressure, exposure time of the stone to the abrasive jet, the angle and stand-off distance of the blasting gun with respect to the stone surface and two types of abrasives. Identifying and measuring the surface roughness of the stone without impairing any damage.

Project Methodologies
Abrasive blasting experiments were carried out on 54 Globigerina limestone specimens at nine different combinations of parameters. Using the Taguchi method it was possible to reduce the number of different combinations from 81 to 9 having four parameters (air pressure, exposure time of the abrasive jet on the stone, angle and stand-off distance of the blasting gun with respect to the stone surface) with three levels. A motorised jig was used to maintain constant traverse velocity during the erosion process. Two different types of abrasives were investigated: Bianco Carrara milled marble powder widely used locally, and grounded walnut shells as shown in Fig 1 which are more popular in the USA. The mass loss per unit Area, change in lightness and colour of the surface of the stone were measured (using a spectrophotometer) and analysed using statistical analysis software to obtain the strength of correlation between the variables, their contribution to the total variance and level of significance.

The surface roughness was also measured from the surface impressions of the stone made from silicone rubber as shown in Fig 2. Stylus profilometry was employed to measure the average surface roughness of the marble powder eroded specimens and microscopy with image processing was used for the walnut shells eroded samples. Comparative photography was also used to confirm the results obtained.

Results and Achievements
Finally it was concluded that the stand-off distance was the only variable that had a relation with all dependent variables for the walnut shell experiments whilst time and angle were more influential for the marble powder experiments. Since the walnut powder had an irregular shape the change in angle did not resulted into a significant change in mass loss. Hence this technique should be further analysed with regular shaped grounded walnut shells particles to confirm their effect on limestone. Also from the results it can be concluded that at an angle of 50° the surface roughness induced and the mass loss were at a minimum for both types of abrasives.

Figure 1 Grounded Walnut shells

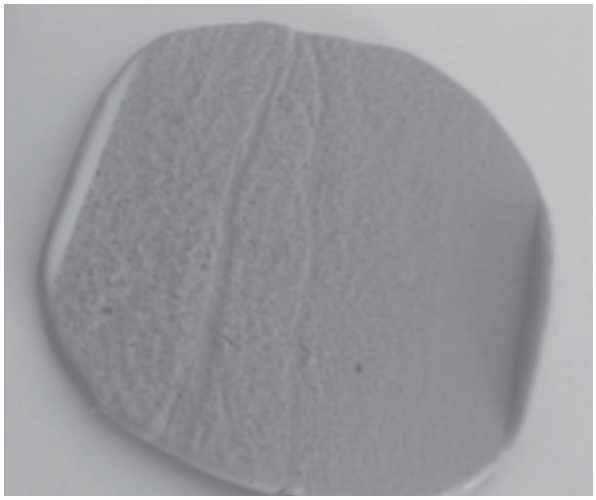


Figure 2 Silicone Surface impression

Investigating the active corrosion mechanisms in an industrial central heating system

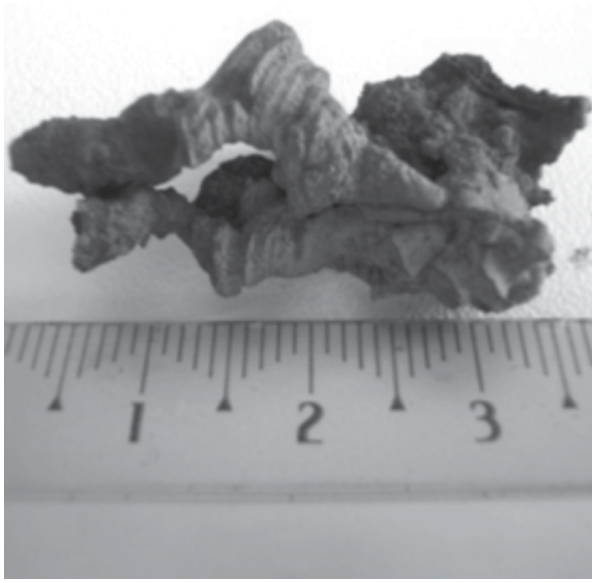
Student: Jordan Yves Cutajar
Supervisor: Dr. Ing. Stephen Abela

Introduction
This dissertation focuses on the investigation of a hot water generation plant, situated at the Radisson Blu Resort & Spa Golden Sands Malta and its related corrosion problem. This plant was chosen because it has a common design structure and entails corrosion problems that can easily be related to other equipment in industry. This plant endured severe corrosion and degradation of various components that required replacement in order to keep uninterrupted operation.

Project Objectives
The main objective of this investigation is to analyze the mechanisms of corrosion which cause the destruction and failure of the equipment. Such research will help to locate the sources of corrosion and suggest suitable practices and techniques to mitigate and inhibit such occurrences. This will reduce the maintenance cost which directly broadens the profit margin of this particular establishment.

Project Methodologies
A coherent investigation was adopted in order to determine the critical parts within the plant. First, the potential differences of all the parts in the system were measured with a reference electrode. This was followed by a series of tests carried out on the electrolyte and two gray cast iron non-return valves which were retrieved from the system. The valves were opened, sectioned and inspected under a stereo microscope and a confocal microscope. Potential/pH diagrams where utilized indicate whether the related metallurgical components are susceptible to corrosion.

Results and Achievements
The investigation revealed that the active mechanisms were Biological corrosion and Tuberculation induced by the incorrect water treatment method used. Mechanisms like Crevice and Galvanic corrosion were active due to incorrect design. Correct control of the alkalinity would keep the pH and the ORP levels stable and thus, the oxidizer will fully function as a sanitizer and inhibit biological growth and tuberculation. A protective anode (zinc) should be installed in the system together with an inline filter that will hinder the ingress of debris into the plant and inhibit crevice and galvanic corrosion.



Design and Manufacture of a Reciprocating Tribo-Corrosion Tester

Student: Aaron Farrugia
Supervisor: Dr. B. Mallia
Co-supervisor: Dr. J. Buhagiar

Introduction

Tribo-Corrosion or Corrosion-Wear is a duplex mode of materials degradation which is the interaction between mechanical wear and corrosion processes. Tribo-Corrosion is observed in components which operate in these two environments which include parts in the transportation, marine, chemical, mining, food, textile, biomedical and electronics industries. The resistance of a material to tribo-corrosion is tested using dedicated equipment since the material lost in this type of degradation is larger than the addition of each individual process.

Project Objectives

The aim of this project was to design, build and test the tribo-corrosion tester. The main project objectives included:

- Creating a detailed design of the tribo-corrosion tester
- Selecting the materials for the components of the tester
- Manufacturing the tribo-corrosion tester
- Interfacing the tester with a data acquisition system
- Testing the tribo-corrosion tester

Project Methodologies

A review of the literature on the tribo-corrosion of materials was conducted. The design of the tribo-corrosion tester was divided into three parts: Concept, Embodiment and Detail.

In the Concept part, different design concepts were proposed and the requirements needed by the tester were identified In the Embodiment part, the calculations required to design the tester and the materials needed to build the tester were identified. The calculations included the motor power required, bending of counter-face holder and required diameter of pulleys. The materials selection was made using material selection techniques such as materials selection charts and materials weighted ranking methods. The Detail part was made up of the detailed drawings using Autodesk Inventor™. Manufacturing of the tester was done using workshop tools and a conventional lathe and milling machine equipped with a digital readout for precision work.

The load cell used to measure the frictional force between the counter-face material and test specimen was interfaced to a data acquisition system using a National Instruments™ DAQ card connected to a computer. A Labview™ program was built to acquire the signals from the load cell in order to plot the necessary graphs. Testing of the tester was implemented by running a tribo-corrosion test on a stainless steel LVM specimen against a sapphire counter-face in a ringer's solution.

Results and Achievements

The tribo-corrosion tester was successfully built and tested. The running of the machine was satisfactorily since vibrations were minimal. Results from the testing performed were matched with those of other researchers and were found to be correct. An improvement on the horizontal arm was made by inserting two brass plates which minimises the looseness in the arm.

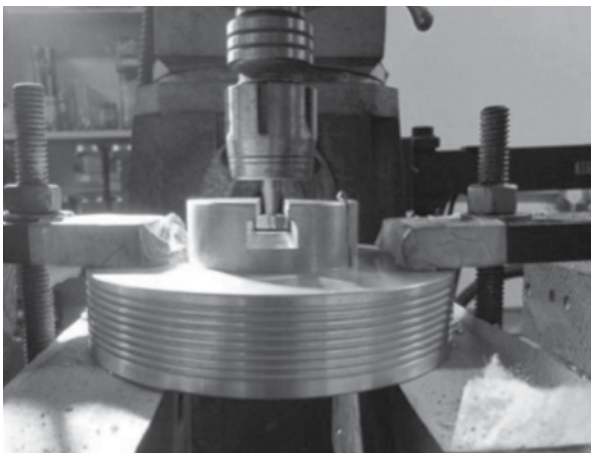


Figure 1 – Manufacturing the crank by a T-slot cutter

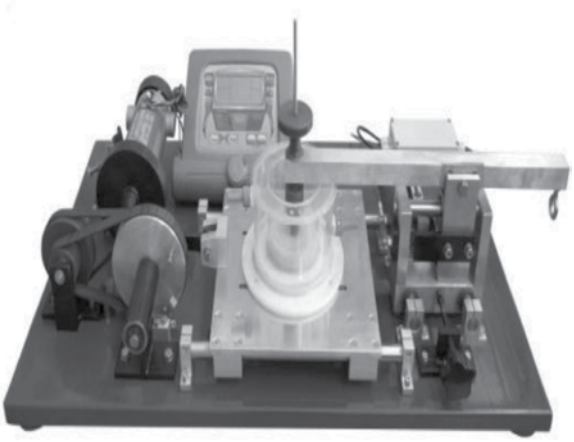


Figure 2 – The manufactured tribo-corrosion tester

Corrosion Testing of Kolsterised® Biomedical Ni-Free Stainless Steel

Student: Dennis Formosa
Supervisor: Dr. J. Buhagiar

Introduction

Biomedical surgical implants are ever evolving, searching for new, cheaper and better performing materials to use. Ni-free stainless steel seems to be ideal due to good corrosion resistance and biocompatible. However surface hardness as with other stainless steel is an issue making material susceptible to wear.

Project Objectives

The aim of the study is to test for crevice, pitting and intergranular corrosion of the Ni-free material before and after Kolsterising®. Also as a control material I used AISI 304 material upon the same treatment and testing were performed.

Project Methodologies

My project involved creation of all my samples, in 2 different shapes and sizes because of the standard practices requirements. I followed 3 different ASTM standard practices to conduct my corrosion testing on the materials; F 746, G 48, A 262. The first one included electrochemical potentiodynamic and critical pitting potential techniques where I will find the potential when the passive barrier stainless steel rely on is broken and pits, such as Figure 1 start to form. My adaptation of second one simulates a metallic surface under stagnant solution and a controlled area of crevice by help of a crevice washer. The third one includes submerging samples in a boiling solution of copper sulphate and sulphuric acid which will induce intergranular corrosion. Also extraction techniques and various characterisation techniques were used to help understand what is happening by the treatment and corrosion processes.

The above picture shows a cross section of common corrosion on stainless steel called pitting which upon first look seems just like a pinhole on the surface (surface is just right to letter A) however just beneath the surface manifestations of reactions and corrosion happen without the user not noticing. The above material is treated AISI 304. The test performed was a 72-hour immersion test of the treated metal in a stagnant fluid containing halide ions in a very similar manner as found in a human being.

Results and Achievements

The results showed that the treatment improved significantly AISI 304 material's corrosion resistance like crevice corrosion however due to the high inclusion (like MnS) content, the pitting still occurred with high frequency because of the lack of the chrome oxide layer that is responsible for the good corrosion resistance of stainless steel. The Ni-free material showed to be highly corrosion resistant before and after treatment. The conditions and parameters of the tests were not harsh enough to induce any appreciable corrosion on it, before and after treatment. However the intergranular test A262 showed weight lost from the Ni-free and AISI 304 material after treatment, this could have to do with the fact that after treatment, the material surface will experience high compressive stresses in it. Hence preferential slip planes will slide accordingly to ease it off. This new stepped surface will include newly exposed material surface on the edges of the steps, which allegedly have thin chrome oxide layer and pits happened there during the test.

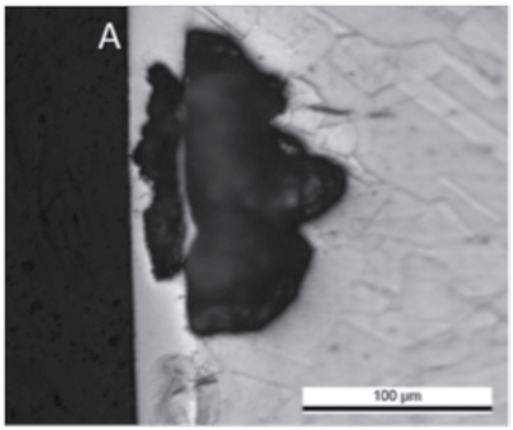


Figure 1 – Pit on treated metallic surface AISI 304

Properties of pure tricalcium silicate for use in MTA as a replacement for industrial Portland cement

Student: Luke Formosa
Supervisor: Dr. Josette Camilleri
Co-supervisor: Dr. Bertram Mallia

Introduction

Portland cement with a 4:1 addition of bismuth oxide is marketed as "mineral trioxide aggregate" (MTA) and is used mainly as a dental material [ ]. Portland cement is used as a binder in concrete and is manufactured from chalk, limestone and clay by clinkering at very high temperatures and grinding together with gypsum. Toxic heavy metals such as arsenic, lead and chromium [ ] can be incorporated into the Portland cement from impurities in the raw materials or fuels used in the production process [ ]. This is of concern because MTA will be in contact with hard and soft tissues within the mouth.

The main constituent of Portland cement is tricalcium silicate [1]. Replacing the Portland cement in MTA with pure tricalcium silicate would allow better control over the exact constitution, the impurities and the heavy metal inclusions present in the final product, as well as imparting other advantages such as a faster setting time [ ].

Project Objectives

The aim of this project was to investigate the chemical and physical properties of an MTA-like material prepared using tricalcium silicate and bismuth oxide, and to compare them to Portland cement with bismuth oxide used as MTA.

Project Methodologies

Compressive strength was evaluated by producing cylindrical specimens and loading them in a compressive strength testing machine. The compressive strength is equal to the maximum force the specimen could withstand before fracturing, divided by the cylinder's cross-sectional area. Dimensional stability during the first 24 hours after setting was determined by using linear variable differential transformers (LVDTs) to continuously measure the length of a freshly cast cement specimen, and a datalogger to record the LVDT readings at 15 minute intervals.

Setting time was determined using an indentation test. A batch of cement was mixed and placed into a mould. A stopwatch was started and a weighted needle was lowered onto its surface at regular intervals. The cement is considered to have set when the needle does not leave a complete indentation on the cement's surface.

Radiopacity was measured by taking digital radiographs (X-rays) of the specimens next to an aluminium step-wedge (with each step being 3mm thicker than the previous one). The radiopacity of the cement samples was then determined (in terms of the thickness of aluminium required to block the same amount of x-rays) by drawing up a calibration curve from the colour of the aluminium steps on the radiograph and the apparent colour of the cement samples.

pH was measured by incubating the samples for 28 days and using a handheld pH meter to measure their pH at 7 day intervals. Leachate analysis was carried out by X-ray fluorescence (XRF).

The microstructure of the cement after immersion in water or physiological solution was observed using a scanning electron microscope (SEM) and the main phases present in the hydrated cements were investigated using X-ray diffraction analysis (XRD).

Results and Achievements

The results indicate that the novel tricalcium-silicate based material has comparable radiopacity, compressive strength, pH, quantity of leached elements and dimensional stability to Portland-cement based MTA. Its setting time was found to be advantageously shorter. SEM images indicated a comparable surface morphology. Thus this dissertation has concluded that the novel material is a viable candidate for replacing MTA from a physical and chemical perspective.

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Investigation of the Susceptibility of Corrosion of Steel Reinforcement in Glass-Replaced Concrete Structures

Student: Justin Sammut
Supervisor: Dr. Ing. S. Abela
Co-supervisor: Dr. J. Camilleri

Introduction

The increased awareness of our impact on Earth's fragile environment has led to a growing emphasis on the utilization of waste materials and by-products in construction materials. These practices provide a partial solution to environmental and ecological problems, and an opportunity to develop new, and sometimes better materials. The use of these materials may improve the mechanical and aging properties of mortar and concrete, which often is difficult to achieve using ordinary Portland cement alone, apart from several other indirect benefits. This study deals with the use of crushed waste glass powder (100 – 600 μm) as 40% by volume cement replacement.

Project Objectives

- Casting of reinforced concrete control and glass-concrete specimens.
- Prepare specimens for testing chloride ion penetration.
- Prepare specimens to determine the alkalinity of control and glass-concrete specimens.
- Investigate the corrosion potential of steel reinforcement in glass replaced concrete exposed to different weathering conditions.

Project Methodologies

- A literature review was compiled to understand better the utilization of glass in concrete structures.
- Perform X-ray diffraction (XRD) and Energy

Dispersive X-ray Fluorescence (EDXRF) analysis on un-hydrated Portland cement and glass fines, and also on the hardened Portland cement paste and Portland cement replaced with 40% waste glass to study their phase analysis and their chemical composition respectively.

- Investigate the alkalinity of control and glass-concrete by measuring the pH value of the leachate of concrete specimens, using a pH meter.
- Investigate the corrosion potential of steel reinforcement in control and glass-replaced concrete in different weathering conditions, by means of a half-cell (Figure 1).
- Compare the cohesion strength between the concrete and the reinforcing rebar of the control and glass-replaced concrete when exposed to different weathering conditions by means of a pull-out test.
- Investigate the chloride ion penetration chemically, electrochemically and also by gravimetric analysis.

Results and Achievements

Glass-concrete was more permeable than the control, i.e. it had less resistance to chloride ions, and its corrosion potential was significantly higher than the control when exposed to wet/dry cycling in salt and acidic solutions. However, glass-concrete showed higher potential values (less negative, thus less corrosion potential) than control concrete when not exposed to chloride ions and acidic environments.

Figure 1

Ceramic reinforced AISI410 laser clads for severe tribological environments

Student: Etienne Spiteri
Supervisor: Dr. Bertram Mallia
Co-supervisor: Mr. Maurizio Fenech

Introduction

Martensitic stainless steels are used widely in the production of tools, engineering components and plactic injection moulds. The latter are exposed to molten plastic, many times containing abrasive particles and possibly aggressive chemicals, flowing at high pressures, temperatures and velocities and therefore materials with high wear and corrosion resistance are required. Other tools are subjected to both impact and wear and as such require a good combination of toughness and wear resistance.

An improvement in the production of such components and many other tools would be the localized tailoring of properties on certain critical areas selectively by laser cladding to increase tribological performance.

Project Objectives

The aim of this project is to study the feasibility of using ceramic reinforced AISI410 stainless steel laser cladding to modify the properties of key areas in tool components.

More specifically, the aim of this project is to investigate the effect of ceramic reinforced AISI410 stainless steel powder cladding on the properties and tribological response of key areas in tool components.

Project Methodologies

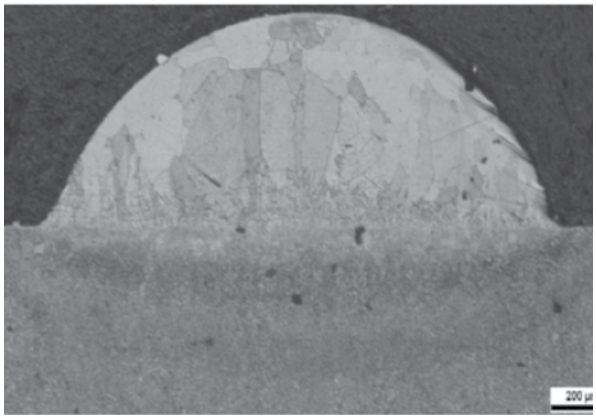
Three different kinds of samples were prepared. The first were rectangular sections on which two separate, single clad tracks were produced, these provided the opportunity to undertake hardness profiles on the clads and to study the cross section of the welds under the microscope, where weld defects such as excessive substrate dilution or poor penetration would be revealed. Multiple tracks with a 20% overlay were produced on rectangular sections having the same dimensions to study the effects of multiple runs and for X-ray diffraction characterization. Finally circular sections were cladded in a continuous manner, again using a 20% overlay, to be later used for wear testing.

Results and Achievements

The quality of the clads was very good for the samples with a Cr3C2 content lower than 6%, substrate melting was low while a sound metallurgical bond between clad layer and substrate was achieved. For a Cr3C2 content of 6% and higher some macro porosity started to appear in the clad layer, with the amount of porosity increasing with increasing Cr3C2 content.

Micro hardness tests were made, micro hardness values varied from 45 to 56 HRC, the hardness increased with increasing Cr3C2 content.

Pin on disc wear tests were carried out on all the samples. The modified AISI420 substrate showed very good tribological characteristics with minimum weight loss and no signs of gross plastic deformation under the load. The wear resisting properties of the clads improved with increasing Cr3C2 content up to a value of 6% chrome carbide content. The samples with 9% Cr3C2 content showed signs of deteriorating performance and lost more weight after the test than those with lower chrome carbide content.



DLC based coatings for biomedical stainless steel

Student: Marvic Vassallo
Supervisor: Dr. Bertram Mallia
Co-supervisor: Dr. Joseph Buhagiar

Introduction

In the biomedical field, artificial implants have been used successfully for many years. Cases of failure are still encountered especially in artificial joints, with the main cause for failure being loosening of the implant due to osteolysis, normally caused by wear particles. There is an increasing interest in prolonging the lifetime of these implants through the use of more wear resistant materials or coatings such as amorphous diamond like carbon (DLC) coatings [1]. These coatings are characterised by high hardness and strength, high wear resistance, low coefficient of friction, adequate biocompatibility and high corrosion resistance [1].

Project Objectives

The main aims of this project were to evaluate the microstructure, properties, scratch resistance and corrosion response of commercially available DLC based coated biomedical stainless steel.

Project Methodologies

- Literature review of DLC structure and properties and their current use in biomedical applications.
- DLC based coatings and CrN coatings were supplied by Hauzer Techno Coating BV (The Netherlands).
- Microstructure evaluation using scanning electron microscope (SEM) as shown in fig 1 and X-Radiation Diffraction (XRD).
- Nano scratch testing with a diamond indenter.
- Mechanical properties evaluation using the nano tester.
- Electrochemical corrosion study in simulated body fluid.

Results and Achievements

Characterisation and scratch analysis of Cr+W-C:H, Cr+W-C:H+DLC, Cr+W-C:H+Si-DLC and CrN was carried out. Cr+W-C:H and Cr+W-C:H+DLC had similar tribological characteristics. When comparing them to the conventional CrN coating, they had lower hardness values but displayed higher resistance to the onset of cracking during scratch testing. The addition of Si in the Cr+W-C:H+Si-DLC resulted in higher hardness when compared to the three other coatings but was the first to crack during scratch testing. For the DLC based coatings, the harder the coating the lower the load at which the onset of cracking takes place. From the electrochemical corrosion testing that was conducted an improvement in electrochemical corrosion properties of the 316 LVM substrate can be observed by the application of CrN and DLC based coatings.

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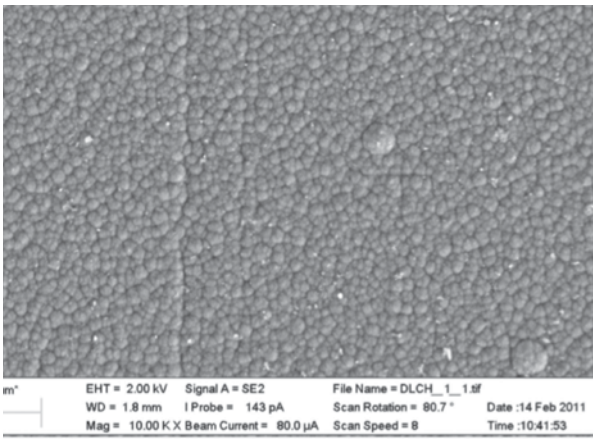

Fig. 1 SEM image showing the surface topography of Cr+W-C:H+DLC.

An Initial Study of the Mechanical and Wear Properties of Surface-Treated ADI

Student: Mark Joseph Zerafa
Supervisor: Ing. Ann Zammit

Introduction

Cast irons are generally known for their brittleness, excellent machinability and castability, and resistance for compressive stresses. Austempered Ductile Iron (ADI) provides the ductility, toughness, fatigue strength and elongation which are lacking in most cast irons. The wide range of properties possessed by ADI attracted many engineering applications; some of such applications demanded the characteristics of a tough core and a wear resistant surface. A harder surface is usually beneficial to increase the wear resistance of a component, as higher forces will be needed to induce shear and wear of material, thus surface engineering processes on ADI such as laser hardening and shot peening can be applied. Laser hardening is a surface engineering process by which selective hardening takes place by inducing rapid heating via electromagnetic waves. Shot peening, another surface engineering process, involves the impingement of spherical shot material on the surface.

Project Objectives

The aim of this project is to study the mechanical and wear properties of untreated and shot peened ADI on a pin-on-disk setup according to the ASTM G99-05 [1]. Also to determine the optimal parameters for laser surface hardening of the ADI specimens.

Project Methodologies

- A literature review was compiled on ADI, laser surface treatment, shot peening and wear mechanisms.
- Machine and heat treat pins and disks.
- Shot peen ADI pins in order to form a cold worked surface layer which creates a work hardened, compressively stressed layer in the surface of the specimen.
- Laser harden the specimens using different laser parameters to obtain a higher level of hardness.
- Analyse laser hardened specimens.
- Carry out dry sliding wear tests using two nominal applied pressures.
- Analyse worn surfaces after wear test using optical microscopy.

Results and Achievements

Laser parameters were varied in order to achieve hardening. Variation of both height and beam power yielded different microstructures and hardness measurements. Microstructures ranged from minute hardening to full melting. Clear laser spots, as shown in figure 1, were found to produce the best compromise between hardness and minimum melting.

Analysis of the two different nominal applied pressures revealed different behaviour of the ADI under different loads. The wear tracks of the ADI pins, were characterised by shallow wear scars and grooves throughout the specimens. Graphite nodules were spread on the surface, which presumably acted as a thin lubricant which reduced the wear rate. Material deformation led to material removal, which took place via different modes, such as ploughing and wedge formation.

On the other hand, the high load regime was characterized by the formation of a white layer. Figure 2 shows the white layer on the surface, which is different than the bulk microstructure. The formation of this white layer is due to the large deformations and also the quenching which takes place due to the high temperature fluctuations involved when surfaces comes instantaneously into contact with atmosphere.

References

[1] ASTM, "Standard Test Method for Wear Testing with a Pin-on-Disk Apparatus,G99 – 05 (Reapproved 2010)." s.l. : ASTM, 2010.

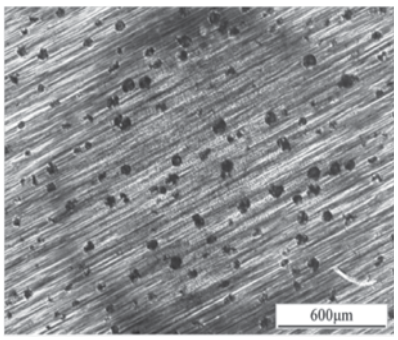

Figure 1: Clear laser hardened spot

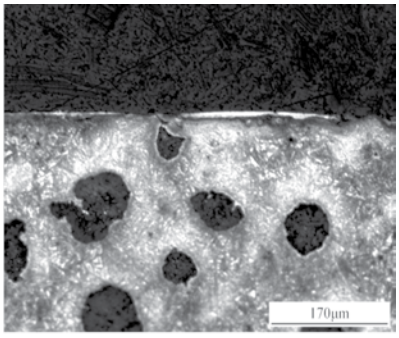

Figure 2: Microstructure of sectioned ADI wear tested pin