Courses offered at DIME

Undergraduate Course - Bachelor of Engineering (Hons)

The Department of Industrial and Manufacturing Engineering (DIME) makes a major contribution to the Bachelor of Engineering (Honours) degree, and in particular spearheads the Industrial and Materials Engineering stream within this degree together with the Department of Metallurgy and Materials Engineering (DIME). This is a four-year interdisciplinary programme designed to meet the requirements of today's industry. By spreading the course over a period of 4 years, the technical and management skills imparted allow the graduates to be able to take up management, entrepreneurial or technically oriented jobs. The Honours graduates will be able to deal with the conceptual, methodological and technological tools used by industry and service companies in the design, production and implementation of products and processes. Due to their interdisciplinary training, they will be in an excellent position to engage in a range of Industrial R&D activities, to take up technical managerial posts and will also be eligible to embark on postgraduate degrees offered by the faculty.

Prospective students and employers can learn more about this new exciting career by visiting our website (www.um.edu.mt/eng/ime). Those interested in learning more about this career are asked to contact either Prof. Ing. Michael A. Saliba (Head DIME) or Dr Ing. John C. Betts (Head DIME) by phoning 2340 2061 or 2340 2056 respectively.

Testimonials from 4th year B.Eng. Students

Malcolm Zammit

“I look back at my time at the faculty of Engineering as a holistic experience. The rich academic formation prompts us students to improve our approach and way of thinking. Engineering is all around us and the course content managed to outline those aspects which are contributing to our daily lives. Manufacturing is a major element of the course which drives us students to contribute to this key sector of the economy through our future careers. Various industrial visits helped me further appreciate the engineering profession. The final year project on water management in sustainable manufacturing provided a number of collective learning outcomes which made me engage into critical thinking and an engineer’s contribution in ensuring sustainability. The Faculty lecturers and staff are both mentoring and supportive. Therefore, I can recommend the course as a fulfilling experience.”

Postgraduate Courses

- M.Sc. in Integrated Product Development
- M.Sc. and Ph.D. by Research

The Department of Industrial and Manufacturing Engineering in collaboration with the Faculty of Economics, Accountancy and Management (FACM) offers part-time M.Sc. in Integrated Product Development (IPD). The M.Sc. IPD is aimed for engineers or scientists, who have recently graduated in either mechanical or electrical engineering or who have already achieved experience in industry. It is intended to fortify skills and to maximise performance in the industry by integrating all aspects of product development including product function and design, product materials and manufacturing, product use and environmental impact, product marketing and costing, entrepreneurship and business management. Further details can be obtained from the course coordinator Dr Ing. Philip J. Farrugia or at www.eng.um.edu.mt/ime/dime/msc/

The department also offers the possibility for students to pursue their studies by research in a specific area of interest. Interested students are invited to contact Prof. Ing. Michael Saliba or any other academic member of staff at the department for further details.

Testimonials from Postgraduate Students

Althea Kate Borg

“The engineering course offers a holistic understanding of a wide variety of subjects. The industrial and manufacturing stream presents students with the required tools and knowledge on various industrial practices. During my last year of study, I was grateful for the opportunity to have collaborated with a prominent manufacturing company from a Global year project which provided me with a stepping stone to put into practice the theoretical aspect of the study and to familiarise myself with a wide range of manufacturing processes. Dedicated lecturing staff provides continuous guidance and support to encourage students to further their studies beyond the undergraduate level. Technical practical also assist students with the practical aspects of their work, which are enabled through investment in latest laboratory equipment. The course also prepares graduates to pursue an industrial carrier and to take on new manufacturing challenges.”

Althea Kate Borg

Joanne C. Betts (Head of Department)

“12th Annual Newsletter

Message from the Head of Department

Joanne C. Betts

July 2013

Time Flies. The annual newsletter is 15 years old. Having joined the department last August as assistant lecturer, I was tasked with editing this issue and reporting what the members of staff and our students have been up to during the past twelve months. Undeniably, as one reads through the features one cannot but see that the majority of our activities were related to research: from undergraduate to postgraduate research projects, from conferences to research visits abroad, from internally funded research projects to national R&I projects.

One of the research areas which in the past was not given enough attention was that of sustainability in manufacturing and industry. Like any other sector, manufacturing is facing the sustainability challenge with an ever-increasing pressure to reduce its impacts on the environment. With this scenario in mind, in the forthcoming academic year, the department shall offer a new elective study-unit in Sustainable Manufacturing. The study-unit shall introduce the three pillars of sustainability together with the techniques which could be used to analyse and manage the use of resources (energy, water, materials and waste) in a manufacturing firm. Those interested in this study-unit and in this research area are invited to contact me for further details.

Finally, while hoping that you find the newsletter interesting, I thank all those who contributed their time, effort and expertise through the features in this issue. I wish our final year students success in their engineering career and a well-deserved break to all the other students and staff.

Ing. Paul Refalo - Editor

Editor: Ing. Paul Refalo

Editing & Printing: Ms Sharlene Cachia

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Highlights of this Issue:

- DIME Staff Members
- Research and Innovation Project
- Other Funded Research Projects
- Research and Training Visits
- Supervised Projects
- Post Graduate & International Research at DIME
- Participation in Conferences
- Recent Publications
- Public Lectures & Other News from our Staff
- Courses offered at DIME

Prof. Ing. Michael A. Saliba
Officer Laboratory Briffa Mr Josef
Senior Laboratory Pace Mr John P.
Systems Engineer Borg Ing. John P.
Assistant Lecturer Ing. Pierre Vella
Design of microscale products, manufacturing processes for microscale products
Assistant Lecturer Ing. Paul Refalo
Assistant Lecturer Dr Ing. Philip J. Farrugia
Computer-Aided Design, Product Design Engineering, Rapid Prototyping and Manufacturing
Assistant Lecturer Ing. Emmanuel Francalanza
Factory Planning, Digital Factory Tools, Simulation of Manufacturing Systems
Visiting Senior Lecturer Dr Ing. Conrad Pace
Autonomous Mobile Robotic Systems, Advanced Actuator and Sensory technology
Assistant Laboratory Manager Mr Michael Attard
Senior Laboratory Officer Mr Michael Curmi
Assistant Laboratory Manager Mr Joseph Curmi
Senior Laboratory Officer Mr Joseph Attard
Administrative Assistant Ms Sharlene Cachia
Part-Time Clerk Ms Therese Caruana

In August 2012 Ing. Paul Refalo was appointed Assistant Lecturer on Sustainable Manufacturing.

Ing. Paul Refalo was interviewed on a live TV programme part of the first edition of ‘Science in the City’, held in Valletta in September 2012. Together with Dr Ing. Stephen Abela, he discussed the outcomes of his research project on solar desalination.

As of October 2012, Prof. Ing. Michael A. Saliba was appointed the new Head of Department.

In October 2012, Prof. Jonathan C. Borg attended after being appointed as external expert reviewer, a meeting organized by the EC in Brussels to assist it in assessing the progress of a project concerning smart objects and the internet of things technology forum initiated by the Polish National Centre for Research and Development, the main focus of the presentation was on the use of Digital Factory Tools on the planning of production systems. The process of interaction between the real and the virtual world was explained together with the function and benefits, but also challenges of digital tools. A short demonstration of selected tools was given at the end of the presentation.

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In February 2013, Prof. Jonathan C. Borg assisted the Polish National Centre for Research and Development with evaluating engineering research projects submitted under the Polish-Norwegian Research Programme.

Since 2010, Ing. Paul Refalo held the post of Public Relations Officer of the Chamber of Engineers. In March 2013, he was re-elected to the Executive Council and was appointed Membership Officer. The Chamber of Engineers is the local organisation representing professional engineers in Malta.

In its meeting held on 18th April 2013, the Council of the Malta Chamber of Commerce Enterprise & Industry appointed Prof. Jonathan C. Borg to continue serving on its RTDI Committee.

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The department set up a page on facebook to share any articles and news relevant to Industrial and Manufacturing Engineering. You are invited to follow us by ‘liking’ the page at www.facebook.com/IndManufEngineering

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Public Lectures and Other News from our Staff

On Wednesday 4th July 2012, Ing. Karoline Lüttsch from the Department of Mechanical Engineering at the Otto-von-Guericke University in Magdeburg, Germany, delivered a public lecture on An Approach of Integrated Product Development in Germany. The presentation was well attended from undergraduate and postgraduate students as well as people from industry.

Dr Sebastian Horbach between the 10th and 12th of April 2013. Dr Horbach held a number of lectures to both undergraduate and postgraduate students of the Faculty of Engineering and a seminar was also organized. He discussed how tools of the Digital Factory can help especially small and medium-sized enterprises (SMEs) to optimize their production. The main focus of the presentation was on the use of Digital Factory Tools on the planning of production systems. The process of interaction between the real and the virtual world was explained together with the function and benefits, but also challenges of digital tools. A short demonstration of selected tools was given at the end of the presentation.

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**Research and Innovation Project on Multi-Material Micro Injection Moulding**

**Project Background**
The Department of Industrial and Manufacturing Engineering has won a project financed by the Malta Council for Science & Technology through the National Research & Innovation Programme 2012. This 142kEur project is entitled “Exploiting Multi-Material Micro Injection Moulding for Enhancing Manufacturing Competitiveness” (EX-MMIM) (project reference number R&I-2012-002). This two-year research project started in November 2012 and is coordinated by DIME. The industrial partners are Tek-Moulds Precision Engineering Ltd, Techniplast Ltd and Playmobil Malta Ltd. Besides the overall project co-ordination and management, the role of the DIME is to design a multi-material component to be used as a case study, conduct experiments on a micro injection moulding machine and disseminate the project results. The roles of the three industrial partners will be respectively to share expertise on plastic part design, to fabricate the injection mould required, to provide the technical support required for optimizing the process parameters and to contribute to clustering local companies in this industrial sector.

**Motivation**
The demand for micro-products or products with micro features has been rapidly increasing. Examples of such products include micro hearing aid devices, microfluidic devices for biomedical applications and micro lenses for cameras in endoscopes.

The trend towards product miniaturization has brought with it a number of challenges. In particular, designers tend to develop new products, whose components collectively integrate a variety of functions, thus broadening the products’ application areas without increasing significantly their weight or overall size. A recurring issue in the fabrication of such multi-functional (material) parts is the cost and complexity of micro assembly. One way to tackle such an issue is to reduce or eliminate micro material handling and manipulation by increasing the integration between a part’s constituent materials using one high value adding manufacturing process. Polymers are desirable in the fabrication of micro injection moulding machine as well as other advantages such as transparency, biocompatibility, mechanical strength etc. Multi-material micro injection moulding technologies give the possibility to design and fabricate polymeric multi-material micro parts in one high value adding manufacturing process.

**Research Objectives and Deliverables**
In view of this context, the overall goal of the EX-MMIM project is therefore to create and share new knowledge on the design and manufacture of multi-material micro components fabricated by micro injection moulding. The key project deliverables consist of (i) the design and fabrication of a case study two-material micro component (ii) creating a platform to share the knowledge generated with relevant Maltese industrial stakeholders.

As part of the EX-MMIM project a two-component or two-material injection moulding machine, capable of producing micro parts has been purchased and is in the process of being installed at the Advanced Manufacturing Lab of the Department of Industrial and Manufacturing Engineering. The machine model of the main injection unit is BOY 22E (220-52), which is equipped with a second injection unit (BOY KS-2K).

Further details on this research project are available at: www.exmmim.com. As part of the aforementioned platform, an on-line forum has been set up (see link: http://exmmim.fullforums.org/). The aim of this forum is to provide relevant stakeholders in industry and academia the opportunity to share and exchange their views on issues related to micro multi-material injection moulding. If you are interested in the subject, we strongly encourage you to register and contribute in this forum.

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**Recent Publications**

- * This paper won the ‘Outstanding Paper Award’ in the session on Renewable Energy.
Digital Planning and Simulation for the Factory of the Future

Digital Models are an essential part of any digital project. Information has to be visualized, accessed, stored, and reproduced to enable collaboration between different aspects within an Enterprise. This is becoming even more important for the Factory of the Future as expanding network capabilities make ubiquitous factories a reality. From the research carried out in the previous stages of this project, it has been concluded that in order to provide support during the digital planning and simulation activities in manufacturing system design a digital model of the business strategy, product and evolving factory are required.

In this research project we are currently developing the requirements of digital models required by factory planning support software. In particular an analysis is being carried out to understand better the information and knowledge that have to be embedded within these models to ensure that the designer can make better decisions during the factory planning activity.

Interchangeability in Micro Scale Parts

This trend is a direct consequence of the growing needs and demands across a range of industry sectors to integrate multiple functions within the smallest possible enclosures/packages by combining the latest advances in functional materials and high throughput micro and nano manufacturing technologies. Standalone micro and nano manufacturing technologies are limited in their capabilities for producing cost effectively structures with different length scale features.

The research efforts in this project are focused on designing, validating and implementing processes and process chains that satisfy the specific functional and technical requirements of new emerging multifunctional interchangeable miniaturised products and thus to create the necessary pre-requisites for their scale up manufacture. This is an ongoing project, which commenced in February 2008 and the main results achieved to date have been published in several conference papers.

A Selection of Other Funded Research Projects

The trade-off between complexity and dexterity in artificial hand design

A DIME research project that has been ongoing since 2006 has culminated in the publication of an important research paper in the International Journal of Humanoid Robotics in June 2013, entitled “Towards the rationalization of robot hand design: Extracting knowledge from constrained human manual dexterity testing”. This paper is authored by Prof. Michael A. Saliba, Alistaire Chetcuti, and Matthew J. Farrugia. The work involved the detailed design, development, execution, analysis and interpretation of a number of experiments to investigate the manual dexterity of human subjects with constraints applied to various attributes of their hands, in order to infer and quantify the contribution of each attribute to dexterity, and in order to transpose the results into guidelines for the design of artificial hands. The experimental runs involved 40 volunteers and over 35 hours of direct experimentation. The results suggest that an artificial hand comprising only two fingers and a thumb, coupled with an effective sense of touch, can potentially reach a dexterity level equal to 84% of that of a normal human hand. In a stark validation of this result, it is shown that a human with the ring and little fingers completely constrained on both hands can wire an electrical 3-pin plug using standard tools in approximately the same amount of time as with unconstrained hands. The paper recognizes that in order to reach this upper limit on dexterity, control of the artificial hand would need to involve or adequately replace the human brain, and that the replication of the human tactile sensing system is still beyond current technological capability. It is suggested that minimal hands with this configuration could be used on basic models of humanoid robots in the not too distant future, and, more contemporarily, as a platform for the development of prosthetic hands that combine mechanical and control simplicity with dexterity.

Interchangeability in Micro Scale Parts

The global market for miniaturised products has been increasing continuously in the last decade. This trend is a direct consequence of the growing needs and demands across a range of industry sectors to integrate multiple functions in the smallest possible enclosures/packages by combining the latest advances in functional materials and high throughput micro and nano manufacturing technologies. Standalone micro and nano manufacturing technologies are limited in their capabilities for producing cost effectively structures with different length scale features.

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Participation in Conferences

In September 2012, Dr Arif Rochman attended the 5th International Polymers and Moulds Innovations (PMI) Conference in Ghent, Belgium, and presented a paper on “Influence of Mould Surface Roughness on Morphological Structure and Mechanical Properties of Micro Injection Moulded Part”.

Ing. Pierre Vella was invited to give a presentation on “The Use of Bulk Metallic Glasses for Producing Micro Replication Masters” at the MM Live UK 2012 event. Characterised by high quality presentations from leading users of the technologies and industry commentators, the event featured leading practitioners and technology experts from across the globe. The International Forum for Micro, Precision, MEMS and Nano Manufacturing, was held in September 2012, at “The National Exhibition Centre”, in Birmingham UK.

In October 2012, Ing. Pierre Vella attended the ninth annual conference on Multi-Material Micro Manufacture, in Vienna, Austria. He presented a paper on Bulk Metallic Glass Based Tool Making Process for Micro- and Nano- replication. This series of conferences on multi-material micro-manufacture is organised by the 4M Association. The 4M Association now has an established membership and has successfully continued the 4M Conference Series, whilst also linking up with the USA-based ICOMM Conference to become truly global.

Ing. Paul Refalo attended the 10th Global Conference on Sustainable Manufacturing “Towards Implementing Sustainable Manufacturing” in November 2012 which was organised by the International Academy for Production Engineering (CIRP) in cooperation with the Middle East Technical University in Istanbul, Turkey. The conference, being the 10th of a series of conferences, reached its maturity and the presenters discussed the implementation of sustainable manufacturing. Case studies of implementing the ideas, models, systems and methodologies, developed for various aspects of sustainability focused particularly on manufacturing, were presented.

In December 2012, Prof. Jonathan C. Borg attended the Design Ed Asia Conference jointly organised by the School of Design of The Hong Kong Polytechnic University, Hong Kong Design Institute and Hong Kong Design Centre. This Conference was part of the Business Of Design Week (BODW 2012) series of events covering design education, intellectual property, branding and industrial design. It provides a practical platform to bring international design educators and professionals together to share views, knowledge and experiences.

Dr Arif Rochman attended the 16th International Conference of the European Scientific Association for Material Forming (ESAFORM) in Aveiro, Portugal in April 2013. He presented a research paper entitled “Hybrid Manufacturing: Combining Additive and Subtractive Processes”
Postgraduate & International Research at DIME

The research work carried out by Mr Luke Said while reading for a Master of Science in Mechanical Engineering involved the investigation of the micro insert moulding process with regards to geometrical features and material selection. The bond strength in Newtons between the constituent materials was selected as a quality criterion and was investigated using a Design of Experiment Approach. The material selection indicated to be the most effective experimental variable. Supervisors: Dr Ing. Philip Farrugia, Ing. Pierre Vella. Sponsor: Strategic Educational Pathways Scholarships (STEPS).

Mr Steffen Aldinger, an Erasmus exchange student from the Department of Polymer Technology at Aalen University in Germany, spent 6 months at DIME for a research visit which was a part of his undergraduate studies. He successfully constructed and optimised a multi-functional thermoforming machine. This machine can be operated in different thermoforming modes such as vacuum forming, plug-assisted thermoforming or membrane vacuum forming to manufacture 3D products made from polymer or composite materials. Supervisor: Dr Arif Rochman.

Participation in Conferences

In May 2012, Prof. Ing. Michael A. Saliba attended the 22nd International Conference on Flexible Automation and Intelligent Manufacturing held in Helsinki, Finland in June 2012. The paper entitled "Robot Time and Cost Management in the Application to Multiple Low-Volume Production Processes" was presented.


In December 2012, Dr Ing. Philip Farrugia visited the Munich University of Applied Sciences, in Munich, Germany. Dr Farrugia visited the various laboratories at this university and discussed with Prof. Peter Leibl, potential research collaboration between the two institutions.

Ing Emmanuel Franclanaza conducted an Erasmus mobility between the 28th of April and the 2nd of May 2013 were he visited the Technical University of Chemnitz in Chemnitz, Germany. During this visit Ing Franclanaza was hosted by the Department of Factory Planning and Management. Ing Franclanaza presented a number of lectures based on the application of Digital Factory tools to Factory Planning and Manufacturing System Design. A research seminar was also held, and was well attended by lecturers, researchers and post graduate students. Prof Egon Muller, Professor for Factory Planning and Management at the Technical University of Chemnitz, also met with Ing Franclanaza, and a discussion on possible future collaboration between the departments ensued.

In April 2013, Prof Jonathan Borg made an Erasmus exchange visit to the Department of Information Technologies in Mechanical Engineering, Otto-von-Guericke University Magdeburg in Germany. During this exchange visit, Prof Borg delivered lectures to MSc Integrated Engineering Design Students and also held a number of one-to-one knowledge transfer meetings on the research topic/sub-topics of IPD with a number of PhD candidates. Prof. Borg was hosted for this exchange visit by the chair Prof. Dr. Ing. Dr. h.c. Sandor Vajna. During his visit, Prof. Borg also met University Rector Prof. Dr. Ing. habil. Jens Strackeljan, vice Dean Prof. Dr Michael Scheffler and the University's International Office official Ms Sylvia Zabel. As a result of this exchange, a number of further research initiatives between Prof Borg and Prof Vajna have been planned.

Staff Training at Strathclyde, Glasgow

Two of our colleagues from the DIME, namely Josef Attard and Josef Briffa, spent a one-week training period at Strathclyde University in Glasgow in October 2012. The visit conducted pertained to an Erasmus staff mobility programme in which both the University of Malta and the University of Strathclyde are participants.

Topics shared and discussed between staff from the hosting university and our own laboratory officers included mechatronics, electronics, fluids, carpentry, rapid prototyping and metrology. In addition to these significant discussions, our lab officers observed various works within other departments including the advanced materials research laboratory, the architecture department, the civil and environmental engineering department and the mechanical and aerospace engineering department. This visit provided Mr. Attard and Mr. Briffa with a unique opportunity to acquire knowledge from experiences and good practices executed at Strathclyde University and which are relevant to their current job. Furthermore, they shared their own experience and expertise making this visit worthwhile and beneficial to both parties.
## Supervised Projects

### Undergraduate Final Year Projects - 2012/2013

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<td>Giulio Calleja</td>
<td>Manufacturing System Modelling and Simulation</td>
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### M.Sc. IPD Final Year Projects - 2012/2013

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<td>Duncan Zammit</td>
<td>An IPD approach for Modular Titanium Calipers for use with Spinal Cord Injury Patients</td>
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<td>Grazienza Fenech</td>
<td>An Integrated Product Development Model to Innovative Food Dispensing Systems</td>
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<td>Joseph Swain</td>
<td>Modular, Reconfigurable Automation System: An Industrial Case Study</td>
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</tr>
<tr>
<td>Saviour Busuttil</td>
<td>A decision support system for manufacturing system design in IPD</td>
<td>Ing. Emmanuel Fracalanza</td>
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**Postgraduate & International Research at DIME**

Mr Lawrence Farrugia, successfully defended his MSc by Research on multiple criteria decision support related to interfaces used in modular product design. The objective of this work was to support product design teams in the evaluation and subsequent selection of module interfaces. In modular product design, the interfaces are considered to be physical entities which enable individual product modules to interact with each other. The research work proposed a framework for the evaluation of module interfaces (FEMI) with the intent to aid product designers, through the provision of life-oriented evaluation criteria, the provision of relevant information sources and the selection of the appropriate multiple criteria decision making (MCMD) evaluation technique. The FEMI framework was then implemented into a prototype computer aided design tool for the evaluation of module interfaces (ACADEMI). The research work received positive feedback from appraisers within industry and academia. More details are available at: www.academi.co.nz. Sponsor: Strategic Educational Pathways Scholarships (STEPS). Supervisor: Prof. Ing. Jonathan C. Borg.

Mr Christian Spiteri recently defended his M.Sc. by Research Thesis entitled "Combining Additive and Subtractive Manufacturing". The aim of his research project was to investigate the synergy between electron beam melting (EBM) process as additive manufacturing and electric discharge machining (EDM) as subtractive post-processing technique. The work involved a study on the potential use of a robot in a number of low to medium volume production processes, typically in SMEs, where none of the individual processes have sufficient volume to economically justify the use of a dedicated robot. Theoretical frameworks were developed for the time and cost studies, taking into account scheduling constraints, robot set-up times and costs, operational costs, and product completion deadlines. An extensive simulation program was developed based on this theory, and was tested on a number of hypothetical scenarios as well as on an actual case study supplied by our Industrial partner Playmobil Malta Ltd. It was shown that through the exploitation of robotic flexibility, this approach can result in substantial cost savings, while meeting production time targets and potentially improving product quality. Supervisor: Prof. Ing. Michael A. Saliba.

Ms Maria Caruana successfully defended her M.Sc. by Research thesis entitled "Robot Time and Cost Management in the Application to Multiple Production Processes". The work involved a study on the potential use of a robot in a number of low to medium volume production processes, typically in SMEs, where none of the individual processes have sufficient volume to economically justify the use of a dedicated robot. Theoretical frameworks were developed for the time and cost studies, taking into account scheduling constraints, robot set-up times and costs, operational costs, and product completion deadlines. An extensive simulation program was developed based on this theory, and it was shown that through the exploitation of robotic flexibility, this approach can result in substantial cost savings, while meeting production time targets and potentially improving product quality. Supervisor: Prof. Ing. Michael A. Saliba.

For his M.Sc. thesis, Mr Timo Dolde who is a German student, carried out a research on "Integrative Development of Injection Moulded Fibre-Reinforced Polymer Parts for Highly Loaded Applications". Using a highly loaded pocket wheel as a case study, the integrative development started with the analysis of currently existing pocket wheels, then conception of a new pocket wheel for highly loaded application, Computer Aided Design (CAD) modelling, Finite Element Method (FEM) calculation and optimisation, mould design as well as cavity filling study and ended with the mechanical testing of the manufactured prototypes. Mr Timo Dolde completed his M.Sc. by Research at University of Malta in October 2012. Supervisor: Dr Ing. Arif Rochman.
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## M.Sc. IPD Final Year Projects - 2012/2013

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## Postgraduate & International Research at DIME

Mr Lawrence Farrugia, successfully defended his MSc by Research on multiple criteria decision support related to interfaces used in modular product design. The objective of this work was to support product design teams in the evaluation and subsequent selection of module interfaces. In modular product design, the interfaces are considered to be physical entities which enable individual product modules to interact with each other. The research work proposed a framework for the evaluation of module interfaces (FEMI) with the intent to aid product designers, through the provision of life-oriented evaluation criteria, the provision of relevant information sources and the selection of the appropriate multiple criteria decision making (MCDM) evaluation technique. The FEMI framework was then implemented into a prototype computer aided design tool for the evaluation of module interfaces (ACADEMI). The research work received positive feedback from appraisers within industry and academia. More details are available at: www.academi.co.nr. Sponsor: Strategic Educational Pathways Scholarships (STEPS). Supervisor: Prof. Ing. Jonathan C. Borg.

Mr Christian Spliter recently defended his M.Sc. by Research Thesis entitled “Combining Additive and Subtractive Manufacturing”. The aim of his research project was to investigate the synergy between electron beam melting (EBM) process as additive manufacturing and electric discharge machining (EDM) as subtractive post-processing technique. Sponsor: Strategic Educational Pathways Scholarships (STEPS). Supervisor: Dr Ing. Arif Rochman.

Ms Maria Caruana successfully defended her M.Sc. by Research on multiple criteria decision support related to interfaces used in modular product design. The objective of this work was to support product design teams in the evaluation and subsequent selection of module interfaces. In modular product design, the interfaces are considered to be physical entities which enable individual product modules to interact with each other. The research work proposed a framework for the evaluation of module interfaces (FEMI) with the intent to aid product designers, through the provision of life-oriented evaluation criteria, the provision of relevant information sources and the selection of the appropriate multiple criteria decision making (MCDM) evaluation technique. The FEMI framework was then implemented into a prototype computer aided design tool for the evaluation of module interfaces (ACADEMI). The research work received positive feedback from appraisers within industry and academia. More details are available at: www.academi.co.nr. Sponsor: Strategic Educational Pathways Scholarships (STEPS). Supervisor: Prof. Ing. Jonathan C. Borg.

For his M.Sc., Mr Timo Dolde who is a German student, carried out a research on “Integrative Development of Injection Moulded Fibre-Reinforced Polymer Parts for Highly Loaded Applications”. Using a highly-loaded pocket wheel as a case study, the integrative development started with the analysis of currently existing pocket wheels, then conception of a new pocket wheel for highly loaded application, Computer Aided Design (CAD) modelling, Finite Element Method (FEM) calculation and optimisation, mould design as well as cavity filling study and ended with the mechanical testing of the manufactured prototypes. Mr Timo Dolde completed his M.Sc. by Research at University of Malta in October 2012. Supervisor: Dr Ing. Arif Rochman.

Ms Maria Caruana successfully defended her M.Sc. by Research Thesis entitled “Combining Additive and Subtractive Manufacturing in the Application to Multiple Production Processes”. The work involved a study on the potential use of a robot in a number of low to medium volume production processes, typically in SMEs, where none of the individual processes have sufficient volume to economically justify the use of a dedicated robot. Theoretical frameworks were developed for the time and cost studies, taking into account scheduling constraints, robot set-up times and costs, operational costs, and product completion deadlines. An extensive simulation program was developed based on this theory, and was tested on a number of hypothetical scenarios as well as on an actual case study supplied by our Industrial partner Playmobil Malta Ltd. It was shown that through the optimal exploitation of robot flexibility, this approach can result in substantial cost savings, while meeting production time targets and potentially improving product quality. Supervisor: Prof. Ing. Michael A. Saliba.
Postgraduate & International Research at DIME

The research work carried out by Mr Luke Said while reading for a Master of Science in Mechanical Engineering involved the investigation of the micro insert moulding process with regards to geometrical features and material selection. The bond strength in Newtons between the constituent materials was selected as a quality criterion and was investigated using a Design of Experiment Approach. The material selection indicated to be the most effective experimental variable.


Participation in Conferences

In May 2012, Prof. Ing. Michael A. Saliba attended the IEEE International Conference on Robotics and Automation held in St. Paul, Minnesota, USA: “Robots and Automation: Innovation for Tomorrow’s Needs”. The conference is the leading conference in robotics and automation algorithms and technologies. It covers a wide spectrum of topics and provides a view of the most recent state-of-the-art in the respective fields.

Prof. Ing. Michael A. Saliba attended the 22nd International Conference on Flexible Automation and Intelligent Manufacturing held in Helsinki, Finland in June 2012. The paper entitled “Robot Time and Cost Management in the Application to Multiple Low-Volume Production Processes” was presented.


Research and Training Visits

In December 2012, Dr Ing. Philip Farrugia visited the Munich University of Applied Sciences, in Munich Germany. Dr Farrugia visited the various laboratories at this university and discussed with Prof. Peter Leibl, potential research collaboration between the two institutions.

Ing Emmanuel Francalanza conducted an Erasmus mobility between the 28th of April and the 2nd of May 2013 were he visited the Technical University of Chemnitz in Chemnitz, Germany. During this visit Ing Francalanza was hosted by the Department of Factory Planning and Management. Ing Francalanza presented a number of lectures based on the application of Digital Factory tools to Factory Planning and Manufacturing System Design. A research seminar was also held, and was well attended by lecturers, researchers and post graduate students. Prof Egon Muller, Professor for Factory Planning and Management at the Technical University of Chemnitz, also met with Ing Francalanza, and a discussion on possible future collaboration between the departments ensued.

In April 2013, Prof Jonathan Borg made an Erasmus exchange visit to the Department of Information Technologies in Mechanical Engineering, Otto-von-Guerick University Magdeburg in Germany. During this exchange visit, Prof Borg delivered lectures to MSc Integrated Engineering Design Students and also held a number of one-to-one knowledge transfer meetings on the research topic/sub-topics of IPD with a number of PhD candidates. Prof. Borg was hosted for this exchange visit by the chair Prof. Dr.-Ing. Dr. h.c. Sandor Vajna. During his visit, Prof. Borg also met University Rector Prof. Dr.-Ing. habil. Jens Strackeljan, vice Dean Prof. Dr Michael Scheffler and the University’s International Office official Ms Sylvia Zabel. As a result of this exchange, a number of further research initiatives between Prof Borg and Prof Vajna have been planned.

Staff Training at Strathclyde, Glasgow

Two of our colleagues from the DIME, namely Josef Attard and Josef Briffa, spent a one-week training period at Strathclyde University in Glasgow in October 2012. The visit conducted pertained to an Erasmus staff mobility programme in which both the University of Malta and the University of Strathclyde are participants.

Topics shared and discussed between staff from the hosting university and our own laboratory officers included mechatronics, electronics, fluids, carpentry, rapid prototyping and metrology. In addition to these significant discussions, our lab officers observed various works within other departments including the advanced materials research laboratory, the architecture department, the civil and environmental engineering department and the mechanical and aerospace engineering department. This visit provided Mr. Attard and Mr. Briffa with a unique opportunity to acquire knowledge from experiences and good practices executed at Strathclyde University and which are relevant to their current job. Furthermore, they shared their own experience and expertise making this visit worthwhile and beneficial to both parties.
A Selection of Other Funded Research Projects

The trade-off between complexity and dexterity in artificial hand design
A DIME research project that has been ongoing since 2006 has culminated in the publication of an important research paper in the International Journal of Humanoid Robotics in June 2013, entitled “Towards the rationalization of robot hand design: Extracting knowledge from constrained human manual dexterity testing”. This paper is authored by Prof. Michael A. Saliba, Alistaire Chetcuti, and Matthew J. Farrugia. The work involved the detailed design, development, execution, analysis and interpretation of a number of experiments to investigate the manual dexterity of human subjects with constraints applied to various attributes of their hands, in order to infer and quantify the contribution of each attribute to dexterity, and in order to transpose the results into guidelines for the design of artificial hands. The experimental runs involved 40 volunteers and over 35 hours of direct experimentation. The results suggest that an artificial hand comprising only two fingers and a thumb, coupled with an effective sense of touch, can potentially reach a dexterity level equal to 84% of that of a normal human hand. In a stark validation of this result, it is shown that a human with the ring and little fingers completely constrained on both hands can wire an electrical 3-pin plug using standard tools in approximately the same amount of time as with unconstrained hands. The paper recognizes that in order to reach this upper limit on dexterity, control of the artificial hand would need to involve or adequately replace the human brain, and that the replication of the human tactile sensing system is still beyond current technological capability. It is suggested that minimal hands with this configuration could be used on basic models of humanoid robots in the not too distant future, and, more contemporarily, as a platform for the development of prosthetic hands that combine mechanical and control simplicity with dexterity.

Digital Planning and Simulation for the Factory of the Future
Digital Models are an essential part of any digital tool. Information has to be visualized, accessed, stored, and reproduced to enable collaboration between different aspects within an Enterprise. This is becoming even more important for the Factory of the Future as expanding network capabilities make ubiquitous factories a reality. From the research carried out in the previous stages of this research project it has been concluded that in order to provide support during the digital planning and simulation activities in manufacturing system design a digital model of the business strategy, product and evolving factory are required.

In this research project we are currently developing the requirements of digital models required by factory planning support software. In particular an analysis is being carried out to understand better the information and knowledge that have to be embedded within these models to ensure that the designer can make better decisions during the factory planning activity.

Interchangeability in Micro Scale Parts
The global market for miniaturised products has been increasing continuously in the last decade. This trend is a direct consequence of the growing needs and demands across a range of industry sectors to integrate multiple functions in the smallest possible enclosures/packages by combining the latest advances in functional materials and high throughput micro and nano manufacturing technologies. Standalone micro and nano manufacturing technologies are limited in their capabilities for producing cost effectively structures with different length scale features.

The research efforts in this project are focused on designing, validating and implementing processes and process chains that satisfy the specific functional and technical requirements of new emerging multifunctional interchangeable miniaturised products and thus to create the necessary pre-requisites for their scale up manufacture. This is an ongoing project, which commenced in February 2008 and the main results achieved to date have been published in several conference papers.

Participation in Conferences
In September 2012, Dr Arif Rochman attended the 5th International Polymers and Molds Innovations (PMI) Conference in Ghent, Belgium, and presented a paper on “Influence of Mould Surface Roughness on Morphological Structure and Mechanical Properties of Micro Injection Moulded Part”.

Ing. Pierre Vella was invited to give a presentation on “The Use of Bulk Metallic Glasses for Producing Micro Replication Masters” at the MM Live UK 2012 event. Characterised by high quality presentations from leading users of the technologies and industry commentators, the event featured leading practitioners and technology experts from across the globe. The International Forum for Micro, Precision, MEMS and Nano Manufacturing, was held in September 2012, at “The National Exhibition Centre”, in Birmingham UK.

In October 2012, Ing. Pierre Vella attended the ninth annual conference on Multi-Material Micro Manufacture, in Vienna, Austria. He presented a paper on Bulk Metallic Glass Based Tool Making Process for Micro- and Nano-replication. This series of conferences on multi-material micro-manufacture is organised by the 4M Association. The 4M Association now has an established membership and has successfully continued the 4M Conference Series, whilst also linking up with the USA-based ICOMM Conference to become truly global.

Ing. Paul Refalo attended the 10th Global Conference on Sustainable Manufacturing “Towards Implementing Sustainable Manufacturing” in November 2012 which was organised by the International Academy for Production Engineering (CIRP) in cooperation with the Middle East Technical University in Istanbul, Turkey. The conference, being the 10th of a series of conferences, reached its maturity and the presenters discussed the implementation of sustainable manufacturing. Case studies of implementing the ideas, models, systems and methodologies, developed for various aspects of sustainability focused particularly on manufacturing, were presented.

In December 2012, Prof. Jonathan C. Borg attended the Design Ed Asia Conference jointly organised by the School of Design of The Hong Kong Polytechnic University, Hong Kong Design Institute and Hong Kong Design Centre. This Conference was part of the Business Of Design Week (BODW 2012) series of events covering design education, intellectual property, branding and industrial design. It provides a practical platform to bring international design educators and professionals together to share views, knowledge and experiences.

Dr Arif Rochman attended the 16th International Conference of the European Scientific Association for Material Forming (ESAFORM) in Aveiro, Portugal in April 2013. He presented a research paper entitled “Hybrid Manufacturing: Combining Additive and Subtractive Processes”.

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**Recent Publications**


* This paper won the ‘Outstanding Paper Award’ in the session on Renewable Energy.

Rochman A., Spiteri C., Hybrid Manufacturing: Combining Additive and Subtractive Processes, in 16th International Conference of the European Scientific Association for Material Forming (ESAFORM), Aveiro, Portugal, 22-24 April, 2013.


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**Research and Innovation Project on Multi-Material Micro Injection Moulding**

**Project Background**

The Department of Industrial and Manufacturing Engineering has won a project financed by the Malta Council for Science & Technology through the National Research & Innovation Programme 2012. This 142K€ project is entitled “Exploiting Multi-Material Micro Injection Moulding for Enhancing Manufacturing Competitiveness” (EX-MMIM) (project reference number R&I-2012-002). This two-year research project started in November 2012 and is coordinated by DIME. The industrial partners are Tek-Moulds Precision Engineering Ltd, Techniplast Ltd and Playmobil Malta Ltd. Besides the overall project co-ordination and management, the role of the DIME is to design a multi-material component to be used as a case study, conduct experiments on a micro injection moulding machine and disseminate the project results. The roles of the three industrial partners will be respectively to share expertise on plastic part design, to fabricate the injection mould required, to provide the technical support required for optimizing the process parameters and to contribute to clustering local companies in this industrial sector.

**Motivation**

The demand for micro-products or products with micro features has rapidly increasing. Examples of such products include micro hearing aid devices, microfluidic devices for biomedical applications and micro lenses for cameras in endoscopes.

The trend towards product miniaturization has brought with it a number of challenges. In particular, designers tend to develop new products, whose components, collectively integrate a variety of functions, thus broadening the products’ application areas without increasing significantly their weight or overall size. A recurring issue in the fabrication of such multi-functional (material) parts is the cost and complexity of micro assembly. One way to tackle such an issue is to reduce or eliminate micro material handling and manipulation by increasing the integration between a part’s constituent materials using one high value adding manufacturing process. Polymers are desirable in the fabrication of micro parts due to their ease of replication via high volume manufacturing processes such as micro injection moulding, as well as other advantages such as transparency, biocompatibility, mechanical strength etc. Multi-material micro injection moulding technologies give the possibility to design and fabricate polymeric multi-material micro parts in one high value adding manufacturing process.

**Research Objectives and Deliverables**

In view of this context, the overall goal of the EX-MMIM project is therefore to create and share new knowledge on the design and manufacture of multi-material micro components fabricated by micro injection moulding. The key project deliverables consist of (i) the design and fabrication of a case study two-material micro component (ii) creating a platform to share the knowledge generated with relevant Maltese industrial stakeholders.

As part of the EX-MMIM project a two-component (or two-material) injection moulding machine, capable of producing micro parts has been purchased and is in the process of being installed at the Advanced Manufacturing Lab of the Department of Industrial and Manufacturing Engineering. The machine model of the main injection unit is BOY 22E (220-52), which is equipped with a second injection unit (BOY KS-2K).

Further details on this research project are available at: www.exmmim.com. As part of the aforementioned platform, an on-line forum has been set up (see link: http://exmmim.fullforums.org/). The aim of this forum is to provide relevant stakeholders in industry and academia the opportunity to share and exchange their views on issues related to micro multi-material injection moulding. If you are interested in the subject, we strongly encourage you to register and participate in this forum.
Public Lectures and Other News from our Staff

On Wednesday 4th July 2012, Ing. Karoline Lüttsch from the Department of Mechanical Engineering at the Otto-von-Guericke University in Magdeburg, Germany, delivered a public lecture on An Approach of Integrated Product Development in Germany. The presentation was well attended from undergraduate and postgraduate students as well as people from industry.

The DIME hosted Dr Sebastian Horbach between the 10th and 12th of April 2013. Dr Horbach held a number of lectures to both undergraduate and postgraduate students of the Faculty of Engineering and a seminar was also organized. He discussed how tools of the Digital Factory can help especially small and medium-sized enterprises (SMEs) to optimize their production. The main focus of the presentation was on the use of Digital Factory Tools on the planning of production systems. The process of interaction between the real and the virtual world was explained together with the function and benefits, but also challenges of digital tools. A short demonstration of selected tools was given at the end of the presentation.

In August 2012 Ing. Paul Refalo was appointed Assistant Lecturer on Sustainable Manufacturing.

Ing. Paul Refalo was interviewed on a live TV programme part of the first edition of ‘Science in the City’, held in Valletta in September 2012. Together with Dr Ing. Stephen Abela, he discussed the outcomes of his research project on solar desalination.

As of October 2012, Prof. Ing. Michael A. Saliba was appointed the new Head of Department.

In October 2012, Prof. Jonathan C. Borg attended after being appointed as external expert reviewer, a meeting organized by the EC in Brussels to assist it in assessing the progress of a project concerning smart objects and the internet of things technology and its applications.

In December 2012, Prof. Jonathan C. Borg after being appointed as external expert reviewer, attended the final review meeting organized by the EC in Brussels to assist it in assessing the progress of a project concerning Integrated Product Development in Germany. The presentation was well attended from undergraduate and postgraduate students of the Faculty of Engineering and a seminar was also organized. He discussed how tools of the Digital Factory can help especially small and medium-sized enterprises (SMEs) to optimize their production. The main focus of the presentation was on the use of Digital Factory Tools on the planning of production systems. The process of interaction between the real and the virtual world was explained together with the function and benefits, but also challenges of digital tools. A short demonstration of selected tools was given at the end of the presentation.

Ing. Paul Refalo (2nd from left) at ‘Science in the City’

The department set up a page on facebook to share any articles and news relevant to Industrial and Manufacturing Engineering. You are invited to follow us by ‘liking’ the page at www.facebook.com/IndManufEngineering

LIKE us on facebook - 'Industrial and Manufacturing Engineering’

On Wednesday 4th July 2012, Ing. Karoline Lüttsch from the Department of Mechanical Engineering at the Otto-von-Guericke University in Magdeburg, Germany, delivered a public lecture on An Approach of Integrated Product Development in Germany. The presentation was well attended from undergraduate and postgraduate students as well as people from industry.
The Department of Industrial and Manufacturing Engineering (DIME) makes a major contribution to the Bachelor of Engineering (Honours) degree, and in particular spearheads the Industrial and Materials Engineering stream within this degree together with the Department of Metallurgy and Materials Engineering (DIMME). This is a four-year interdisciplinary programme created to meet the requirements of today’s industry.

By spreading the course over a period of 4 years, the technical and management skills imparted allow the graduates to be able to take up management, entrepreneurial or technically oriented jobs. B.Eng(Hons) graduates will be able to deal with the conceptual, methodological and technological tools used by industry and service companies in the design, production and implementation of products and processes. Due to their interdisciplinary training, they will be in an excellent position to engage in a range of Industrial R&D activities, to take up technical managerial posts and will also be eligible to embark on postgraduate degrees offered by the faculty.

Prospective students and employers can learn more about this new exciting career by visiting our website (www.um.edu.mt/eng/ime). Those interested in learning more about this career are asked to contact either Prof. Ing. Michael A. Saliba (Head DIMME) or Dr Ing. John C. Betts (Head DIMME) by phoning 2340 2061 or 2340 2065 respectively.

Testimonials from 4th year B.Eng. Students

Malcolm Zammit

“I look back at my time at the faculty of Engineering as a holistic experience. The rich academic formation prompts us students to improve our approach and way of thinking. Engineering is all around us and the course content managed to outline those aspects which are contributing to our daily lives. Manufacturing is a major element of the course which drives us students to contribute to this key sector of the economy through our future careers. Various industrial visits helped me further appreciate the engineering profession. The final year project on water management in sustainable manufacturing provided me with a stepping stone to put into practice the theoretical aspect of the study and to familiarise myself with a wide range of manufacturing processes. Dedicated lecturing staff provides continuous guidance and support to encourage students to further their studies beyond the undergraduate level. Technical personnel also assist students with the practical aspects of their work, which are enabled through investment in latest laboratory equipment. The course also prepares graduates to pursue an industrial carrier and to take on new manufacturing challenges.”

Althea Kate Borg

“The engineering course offers a holistic understanding of a wide variety of subjects. The industrial and manufacturing stream presents students with the required tools and knowledge on various industrial practices. During my last year of study, I was grateful for the opportunity to have collaborated with a prominent manufacturing company for a final year project which provided me with a stepping stone to put myself updated throughout his/her career. I always wanted to pursue my studies at a postgraduate level, and after having spent one year in industry, I recognised that it requires that one keeps himself/herself updated throughout his/her career. I decided to take the M.Sc. in Integrated Product Development as it is a blend between entrepreneur- man, management and engineering subjects. This degree, along with the benefits of enhancing my engineering skills, this course would help me achieve business-related skills which are essential skills for an engineer in the industry. Moreover, this M.Sc. is offered on a part-time basis, which enabled me to keep my job whilst undertaking my studies. I recommend this interdisciplinary taught course on IPD, as today’s competitive world requires engineers who are an expert in the different phases of product/service development. In addition, having a combination of engineering and management expertise would help give a boost to our career as an engineer.”

Postgraduate Courses

- M.Sc. in Integrated Product Development
- M.Sc. and Ph.D. by Research

The Department of Industrial and Manufacturing Engineering in collaboration with the Faculty of Economics, Accounts and Management (FEMA) is offering a part-time M.Sc. in Integrated Product Development (IPD). The M.Sc. IPD is aimed for engineers or scientists, who have recently graduated in either mechanical or electrical engineer who or who have already achieved experience in industry. It is intended to fortify skills and to maximize performance and success in the industry by integrating all the aspects of product development including product function and design, product materials and manufacturing, product use and environmental impact, product marketing and costing, entrepreneurship and business management. Further details can be obtained from the course coordinator Dr Ing. Philip J. Farrugia or at www.eng.um.edu.mt/*dime/msc/

The department also offers the possibility to students to pursue their studies by research in a specific area of interest. Interested students are invited to contact Prof. Ing. Michael Saliba or any other academic member of staff of the department for further details.

Testimonials from Postgraduate Students

Ing. Graziella Fenech

“...”

In my Master by Research Degree, I worked on an Integration of Injection Moulded Glass Fibre Reinforced Polymer Parts for Highly Loaded Application. This project was in collaboration with a German industrial partner and Aalen University. The study units taught in this degree such as Research Methods, Professional Development, Presentation Techniques or Statistics were essential knowledge for my scientific work. The Master by Research course is therefore for me a very rewarding education for a career both at the University as well as in industry. Crucial for the success of my research project was the supervision of my work by Dr Artf Rochman who has always offered support and professional support. I’m very thankful that he shared with me his comprehensive knowledge particularly in Polymer Engineering”.

Timo Diddie

In “my Master by Research Degree, I worked on an Integration of Injection Moulded Glass Fibre Reinforced Polymer Parts for Highly Loaded Application. This project was in collaboration with a German industrial partner and Aalen University. The study units taught in this degree such as Research Methods, Professional Development, Presentation Techniques or Statistics were essential knowledge for my scientific work. The Master by Research course is therefore for me a very rewarding education for a career both at the University as well as in industry. Crucial for the success of my research project was the supervision of my work by Dr Artf Rochman who has always offered support and professional support. I’m very thankful that he shared with me his comprehensive knowledge particularly in Polymer Engineering”.

Time Flies. The annual newsletter is 15 years old. Having joined the department last August as assistant lecturer, I was tasked with editing this issue and reporting what the members of staff and our students have been up to during the past twelve months. Undeniably, as one reads through the features one cannot but see that the majority of our activities were related to research: from undergraduate to postgraduate research projects, from conferences to research visits abroad, from internally funded research projects to national R&I projects.

One of the research areas which in the past was not given enough attention was that of sustainability in manufacturing and industry. Like any other sector, manufacturing is facing the sustainability challenge with an ever-increasing pressure to reduce its impacts on the environment. With this in mind, in the forthcoming academic year, the department shall offer a new elective study-unit in Sustainable Manufacturing. The study-unit shall introduce three pillars of sustainability together with the techniques which could be used to analyse and manage the use of resources (energy, water, materials and waste) in a manufacturing firm. Those interested in this study-unit and in this research area are invited to contact me for further details.

Finally, while hoping that you find the newsletter interesting, I thank all those who contributed their time, effort and expertise through the features in this issue. I wish our final year students success in their engineering career and a well-deserved break to all the other students and staff.

Ing. Paul Refalo - Editor

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