2017 Student Conference

Abstracts

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1. Akif Soltan – University of Queensland

Temporary Corrosion Protection of New Generation of Magnesium Alloys

Soltan[1,3], A. Atrens[1], M. Dargusch[1], D. Gerrard[2]
[1] School of Mechanical and Mining Engineering, Faculty of Engineering, University of Queensland
[2] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia
[3] Defence Materials Technology Centre

Magnesium alloys containing rare earth elements, such as ZE41A–T5, WE43B–T6 and EV31A–T6, are used in the production of the gearbox housing of navy helicopters due to their good high temperature mechanical properties (strength and creep resistance).

The navy helicopters are routinely exposed to seawater during their normal operation, especially during take–off and landing. The exterior of the gearbox housing is typically coated with corrosion resistant paint to provide protection against corrosion. However, overtime the coating deteriorates. Because Mg alloys have high corrosion rates, any degradation of the surface coating leads to rapid localised corrosion, which considerably increases frequency and cost of maintenance and may ultimately reduce service life of the helicopter. Therefore, control of corrosion is essential to ensure that normal operation of the helicopters is not compromised.

A considerable body of research has been carried out on the corrosion behaviour of magnesium alloys ZE41 and WE43 in different environments. However, a knowledge gap exists in understanding the influence of alloying elements (Ce, La, Nd, Gd) on the corrosion behaviour of these alloys.

The magnesium alloy EV31 is a new alloy and very little research has been conducted to study the corrosion behaviour of the alloy.

The project seeks to gain further insights into the influence of microstructure and alloying on corrosion of ZE41 and WE43 and understand the corrosion behaviour of EV31 in various environments.

In addition, the project seeks to understand the scientific principles of the interaction between the corrosion inhibiting compounds (applied directly onto the surface of the alloys) and magnesium alloys in corrosive environments and the effect of different classes of CICs on the corrosion behaviour of the magnesium alloys ZE41A, WE43B and EV31.

In majority of instances, the corrosion rates of pure magnesium with impurity levels below the tolerance limit are lower than magnesium alloys. However, initial studies showed that the magnesium alloy WE43B had the lowest corrosion rates among all alloys studied followed by EV31A tested in 3.5 wt % NaCl solution. This was found to be due to the positive influence of alloying elements Y, Nd and Gd on the stability of the surface films formed during immersion.

The next stage of experimental work will entail (i) field exposure tests and laboratory corrosion tests of the alloys coated with different CICs.

2. Andrew Short – University of Wollongong

Sampling-Based Motion Planning with Contacts

A. Short[1,2], S. van Duin[1,2], T. Bandyopadhyay[3]
[1] Faculty of Engineering and Information Sciences, University of Wollongong, NSW, Australia
[2] Research Training Centre for Naval Design and Manufacturing
[3] Robotics and Autonomous Systems Group, CSIRO

Autonomous robots frequently need to generate motion plans which include contact with their environment. Examples of this include a legged robot traversing a complex 3D environment, or a manipulator picking and placing an object. Planning motions which include contacts remains a challenging problem. We present Contact Dynamic Roadmaps (CDRMs), which extend Dynamic Roadmaps with contact information. The CDRM is precomputed offline to generate a discretised mapping from a robot's configuration space to its workspace and contact space. This is then used online to rapidly identify both collision and contact configurations. We show how this can be coupled with a Rapidly exploring Random Tree planner for full-body legged motion planning, and discuss applications for manipulation. The performance of the approach is validated and compared in simulation for a quadruped robot navigating a number of complex 3D environments.

3. Bradley Donnelly – Flinders University

The Effect of Antifouling Coatings on Maritime Acoustic Sensor Performance

B. Donnelly[1,4], K. Sammut[1,4], Y. Tang[1], I. Bedwell[2], A. Scardino[4]

[1] Centre for Maritime Engineering, Control and Imaging, Flinders University, Adelaide, South Australia, Australia.

[2] Thales Underwater Systems, Sydney, NSW, Australia

[3] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia

[4] Research Training Centre for Naval Design and Manufacturing

As surfaces become fouled by the growth of soft and hard organisms there is often a significant adverse effect on their operational functionalities. For sensors this can include a camera becoming obstructed or an acoustic signal being muffled and degraded before it reaches an acoustic sensor. For acoustic sensors it is also possible that the coating used to protect it, could also interfere with the signal. The application of various antifouling coatings could change interfacial properties of a surface and affect its acoustic characteristics, however actual investigations into the characterization of this are rare.

In this study, neoprene coated with four different marine antifouling coatings, such as a cuprous oxide based self-polishing coating; a hydrogel foul release coating; a hybrid biocidal-foul release coating and uncoated neoprene doped with the biocide DCOIT during the curing process were used to evaluate effects of the coating, biocidal components and fouling on acoustic signal of a sensor. The acoustic properties of these samples were measured and compared to those of bare neoprene. These samples were deployed in temperate waters to gauge the short term effectiveness of the antifouling technologies. The samples were removed and again had their acoustic properties ascertained to elucidate the effects of early fouling on signal performance. The test will be repeated after a prolonged sea water exposure to identify the efficacy of each coating on neoprene plus the input of various stages of fouling on sensor performance, however to get an indication of long term performance samples from a previous DST experiment were also acoustically tested. The results will inform industry on the most appropriate measures to protect acoustic sensors and signals from the rigors of the marine environment.

Acknowledgements: The authors wish to acknowledge the support of the ARC Research Training Centre for Naval Design and Manufacture, and the Defence Science and Technology Group.

4. Brodie McDonald – RMIT University

Improved Vehicle Protection Through the Modelling of Advanced High Strength Steels Under Blast Loading

B. McDonald[1,2], H. Bornstein[3], A. Daliri[1], A. Orifici[1]
[1] School of Engineering, RMIT University, Bundoora, Victoria, Australia
[2] Defence Materials Technology Centre
[3] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia

With the current trends in asymmetric warfare, damage from blast has become a serious threat to armoured vehicles due to the increased use of weapons such as landmines and IED's. As a response to these threats, modern armoured vehicles require increased protection against blast damage while maintaining a low vehicle weight and high manoeuvrability.

A powerful tool in the design of armoured vehicles is the use of finite element analysis (FEA) to simulate the response of the armour system under blast loading, reducing the need for complex and expensive experimental blast testing. Reliable results however rely on a detailed mathematical model of the armours mechanical behaviour and an accurate representation of the blast loading event including the interaction between the structure and the extreme conditions produced by the close-proximity detonation of an explosive charge.

This project involves the development of a FEA approach to modelling the deformation and rupture of high strength steel armour under severe blast loading. The experimental test program performed to characterise four armour materials is presented including calibration of an advanced strength and fracture model. The development of a 3D blast simulation with full fluid structure coupling is presented and results for the deformation and rupture of the steel target plate are compared to a number of experimental blast tests also performed as part of this project.

Key Words: Blast Protection, Armour Steel, Finite Element Analysis, Material Characterisation.

5. Candice Francis – Flinders University

The challenge of developing separators for ionic liquid electrolytes

C. Francis[1,2,3], K. Sammut[2], A. Best[3] , R. Louey[1]
[1]PMB Defence Engineering, Osborne, South Australia, Australia.
[2]Centre for Maritime Engineering, Control and Imaging, Flinders University, Adelaide, South Australia, Australia.
[3]CSIRO Manufacturing, Clayton South, Victoria, Australia

Ionic liquids are an interesting material for the replacement of organic solvent based electrolytes for both lithium-ion and lithium metal batteries [1]. They are attractive for these devices due to their negligible vapour pressure, high thermal decomposition temperatures and wide electrochemical window. However, relatively high viscosities have proven difficult to overcome during battery prototyping.

A further challenge has appeared in recent times as researchers and companies try incorporating ionic liquid electrolytes – suitable separators [2, 3]. Due to the varying hydrophobic / hydrophilic nature and rapidly changing viscosity (as a function of temperature) of ionic liquid electrolytes, the choice of a suitable separator is extremely challenging. Traditional polyethylene and polypropylene separators are typically difficult to "wet" and as such, lead to relatively high internal resistance and low initial capacities as the cell components wet out. In most instances, researchers revert to Whatman glass fibre separators due to the ease of wetting.

In this presentation, we will examine various methodologies used to enhance separator performance and detail our approach to developing separator materials specifically for ionic liquid electrolytes.

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6. Emily Kibble – University of Western Australia

Macrophage infectivity potentiator (Mip) proteins as novel anti-virulence targets in pathogenic Neisseria.

E. Kibble[1,2,3], J. Iwasaki[1], G. Coombs[2], C. Kahler[1], M. Sarkar-Tyson[1]

[1] The Marshall Centre for Infectious Diseases Research and Training, University of Western Australia, Perth, WA

[2] School of Veterinary and Life Science, Murdoch University, Perth, WA

[3] Defence Materials Technology Centre

Neisseria meningitidis is the bacterial causative agent of invasive meningococcal disease (IMD). Rates of IMD in Australia are predicted to reach 1.2 per 100,000 in 2017, the highest it has been in five years.

Macrophage infectivity potentiator (Mip) proteins are found in a wide range of pathogens, and are known to be important in survival of bacteria within host cells. Mip proteins represent potential broad spectrum anti-virulence drug targets due to their conserved enzymatic and drug binding domains across species. While most bacteria are known to have one Mip protein, N. meningitidis encodes for two putative Mip-like proteins. The efficacy of inhibitors designed against the Mip protein in other bacterial species have been tested against N. meningitidis. Results showed an approximately 65-70% reduction of bacterial survival within epithelial cells. This level of reduction is much higher than seen with other pathogens. We hypothesise that both Mip proteins are important novel anti-virulence targets in N. meningitidis.

The aim of this PhD is to: (1) determine the role of these proteins within the cell, by deleting the two putative Mips from the N. meningitidis genome, and characterise the mutant strains; (2) determine the structure and inhibitor binding capabilities of both N. meningitidis Mips through recombinant expression, purification and crystallography and co-crystallization studies; (3) to test the design of Mip-inhibitors, by screening novel inhibitors against recombinant Mip protein, as well as against various strains of N. meningitidis to give a more detailed understanding of the effect and potency of these inhibitors.

7. Jane Cullum – University of Tasmania

Decisions to Improve Ship Maintenance Scheduling

J. Cullum[1,2], J. Binns[1,2], K. Tenekadjiev[1], R. Abbassi[1], V. Garaniya[1], M. Lonsdale[3]
[1] Australian Maritime College, University of Tasmania, Launceston, Tasmania, Australia
[2] Research Training Centre for Naval Design and Manufacturing
[3] Serco Defence, Sydney, NSW, Australia

Maintenance scheduling for naval vessels and ships requires ongoing improvement in order to manage rising maintenance costs within availability constraints. Existing maintenance scheduling approaches are not optimal. The state-of-the art of maintenance practice for ships and naval vessels is described. An overall framework for Risk-Based Maintenance Scheduling (RBM) is presented for ships and naval vessels. A probabilistic approach supported by condition monitoring data in combination with Decision Theory are suggested for the Risk Assessment and Maintenance Scheduling elements. The decision problem is formulated and detailed. Availability and maintenance cost are suggested as evaluation metrics against existing strategies. The development of an RBM Scheduling methodology within the framework is expected to result in reduced maintenance cost while meeting availability requirements for ship and naval vessel applications.

8. Jimmy Toton – RMIT University

Additively Manufactured Cutting Tools for Aerospace Machining Via Laser Metal Deposition

J. Toton[1,3], M. Brandt[1], S. Ding[1], S. Dowey[2]
[1] School of Manufacturing, Materials and Mechatronics, RMIT University, Melbourne, Victoria, Australia
[2] Sutton Tools, Thomastown, Victoria, Australia
[3] Defence Materials Technology Centre

Laser Metal Deposition (LMD) has the potential to reduce production time and cost for low volume, high value, complex shaped components. An opportunity exists for the cutting tool industry to apply LMD to complex/custom cutting tools, which increases productivity via increasing the material removal rate and eliminating the number of machining operations required. This work determined process methodologies for additively manufacturing crack-free cylindrical coupons and bar stock via LMD using a Fe-Co-Mo based carbon-free precipitation hardened tool steel powder. The aim was realised by characterising the effect of substrate heating on the as-built microstructure and hardness using optical and backscatter electron microscopy, Electron Back-Scatter Diffraction (EBSD) and Vickers hardness testing. It has been shown that with no substrate heating residual stress cracks form within cylindrical coupons. The primary source of stress was observed to be the formation of the μ-phase precipitates. Microstructural observations correlated with EBSD and Vickers hardness measurements, revealing that, as the cylindrical coupon is built, previously deposited layers are heat treated forming ~100 nm size precipitates increasing the bulk hardness to 600 HV. The top most layers showed no age hardening with an average bulk hardness of 370 HV, however, a limited number of μ-phase precipitates were observed. Substrate heating at 500°C was found to eliminate crack formation via supressing the formation of the μ-phase precipitates, increasing grain size and enabling a homogenous microstructure. Hardness measurements correlated with the observed microstructural features revealing that not only was the average bulk hardness 360 HV but that the standard deviation was significantly reduced compared to the no substrate heating, 14 HV and 53 HV respectively.

9. Kurt Mills – University of Queensland

Understanding the effect of external fields during the solidification of the Al-Mg series alloys – The effect of solute on ultrasonic grain refinement.

K. Mills[1,2], M. Dargusch[1,2], G. Wang[1,2]
[1] School of Mechanical and Mining Engineering, Faculty of Engineering, University of Queensland
[2] Defence Materials Technology Centre

Light metals have a key place in the defence industry, due to their high specific strength. This property results in them being used in a number of vehicle applications such as ground-based troop transports, aircrafts and sea-based transport. Additionally, these materials can be incorporated into personnel equipment to reduce weight.

Yet these metals (like most others) suffer from poor microstructures in their as-cast form, as the result of a large, uneven grain size. This results in subpar properties, and issues in downstream processing, increasing time and cost of production. While the typical method of grain refinement using master alloys is effective, it is expensive and doesn't work for all alloys.

Ultrasonic Treatment is an alternative method of grain refinement, where an ultrasonic field is applied during solidification. This method has proved effective in a number of alloys, yet there has been no direct research on the relationship between the solute content of the alloy, and the resultant grain size of the casting.

By casting a number of Al-Mg alloys with varying solute contents, and comparing the as-cast grain structure to that obtained when the ultrasonic treatment is applied, it was found that solute content has little influence on the castings treated with ultrasonic treatment. Similar results were also obtained with Al-Cu and Mg-Al alloys. On investigation it was determined that the application of the ultrasonic field results in an evener temperature gradient in the melt, resulting in a collapse of the nucleation free zone.

10. Martin Friebe – University of Tasmania

Naval Survivability Enhancement through Bayesian Networks

M. Friebe[1,2]

[1] Australian Maritime College, University of Tasmania, Launceston, Tasmania, Australia

[2] Research Training Centre for Naval Design and Manufacturing

While the concept of survivability is important within modern naval ship design, the majority of naval survivability assessments rely on detailed design information such that complex integrated survivability related design issues are often only identified in later design stages. As a result, the cost to correct these deficiencies can be prohibitive. Recent academic efforts to enable early stage survivability design assessments, though promising in their continued development, presently continue to employ statistical models which prohibit identification of previously unknown design inter-relations and as such, merely propagate the necessity to have ship specific detailed design information within early stage design. It is therefore necessary to develop an early stage naval engineering survivability estimation tool to support industry in design evaluation and assessment of survivability enhancements which is applicable to assess relative values of survivability effectiveness without necessitating industry to provide detailed design information at the early stage of design.

The purpose of this paper is to define the development of an early stage naval engineering survivability estimation tool using a Bayesian Network (BN) model which can support industry in design evaluation and assessment of survivability enhancements for concept future ships. The developed BN model survivability estimation tool outlined here-in is applicable in assessing relative effectiveness of a vessel's survivability design when constrained by limited initial data. Furthermore, the developed tool enables identification of system-to-system, layout-to-system, and system-to-crew inter-relations in order to accurately rank an individual survivability feature's importance based on the level of design effectiveness impact.

11. Nathan Edwards – Swinburne University of Technology

Adiabatic Shear Bands in 2024-T351 Aluminium

N. Edwards[1,2], S. Cimpoeru[3], D. Ruan[1,2], G. Lu[1]

[1] Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorn, Victoria, Australia

[2] Defence Materials Technology Centre

[3] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia

Adiabatic shear bands (ASBs) are a phenomenon that can result in catastrophic failure in susceptible materials. The formation of adiabatic shear bands during a ballistic impact event may result in a low energy plugging failure of the targeted material due to the rapid drop in flow stress in the ASB that initiates around the impacted region. This work presents an ongoing study observing the flow localisation and formation of adiabatic shear bands at different strains and strain rates. Initial compressive quasi-static tests are conducted on an MTS universal testing machine, whilst a split Hopkinson pressure bar is used for higher strain rates. At higher strain rates the material shears adiabatically. The effect on mechanical properties such as flow stress and hardness once ASBs have formed and observations of microstructure are discussed.

12. Nishit Joseph – RMIT University

Progressing Towards a Digital Twin: Aeroelastic Model Updating and Identification

N. Joseph[1,2], P. Marzocca[1], R. Carrese[1], O. Levinski[3]
[1] School of Engineering, RMIT University, Bundoora, Victoria, Australia
[2] Defence Science Institute
[3] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia

This research project aim at contributing to the development of the Digital Twin concept for better management of aircraft service life. The Digital Twin is a paradigm shift in the management of the development and post production life of an aircraft platform. The primary focus is to use a key concept of a Digital Twin i.e. continuous updating of a numerical model to better predict the life of an aircraft. The study will allow individual aircraft tracking approaches based on a direct measurement and numerical processing of aircraft flight parameters and airframe sensor data for prediction of dynamic loads and strains at any airframe location. The research proposes the use of a calibration process capable of continuously updating of normal modes using Operational Modal Analysis (OMA) techniques to track the dynamic parameters of an aircraft. The updated normal modes are used to reconstruct the dynamic loads that are intern used to estimate the stress spectrum experienced at any location of the aircraft. Work completed is the development of a novel flexible Fluid-Structure interfaces method capable of varying levels of fidelity of either solver. OMA techniques reported in literature have been developed and verified using flight data. Current efforts involve building the calibration models incorporating the outputs from OMA into the FSI model to obtained transformed normal modes for use in stress range estimation.

13. Olexandra Marenych – University of Wollongong

Investigation of repair procedure of Monel K500 maritime components by WAAM.

O. Marenych[1,2], Z. Pan[1,2], H. Li[1,2], S. van Duin[1,2]
[1] School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, NSW, Australia
[2] Defence Materials Technology Centre

Ni-Cu-based alloy Monel K500 is widely used in marine industry to produce machine parts. Despite its good mechanical properties and corrosion resistance, the components may fail in operation. Since Ni-Cu-base alloys are expensive, a repair technology is required. Here we investigate a new repair technology based on wire arc additive manufacturing.

Weld repair simulation was carried out by cold metal transfer (CMT) using a robotic welder. Two alloys, Monel K500 (60Ni-30Cu-1.5Mn-3.15Al-0.85Ti) and FM 60 (66Ni-22Cu-4.0Mn-1.25Al-2.0Ti), have been deposited at three speeds, and heat treated using four schedules. The heat treatment included: as deposited condition, annealing at 1100 °C for 15 min, annealing followed by ageing at 610 °C for 8 hours, and annealing followed by ageing at 610 °C for 8 hours and ageing at 480 °C for 8 hours. Microstructure characterisation was carried out using optical and scanning electron microscopy. Mechanical properties were assessed using hardness, tensile and wear testing. The analysis of data has shown hardness, strength, toughness and wear resistance of Monel K500 being higher than those of FM 60 for all studied conditions, due to precipitation of hard densely dispersed TiCN particles in Monel K500. First ageing increased hardness and strength in both alloys, although the second ageing could decrease those in both alloys, as a result of particle coarsening and decrease in their number density.

Transmission electron microscopy of nano-sized precipitates, corrosion testing and weld repair simulation of real Monel K500 component are ongoing.

14. Panneer Selvam Ponnusamy – Swinburne University of Technology

High strain rate behaviour of AlSi12 and 17-4 PH parts produced by Selective Laser Melting

P. Ponnusamy[1,2], S. Masood[1,2], D. Ruan[1,2], S. Palanisamy[1,2]

[1] Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorn, Victoria, Australia

[2] Defence Materials Technology Centre

AlSi12 is a readily castable aluminium alloy which finds wide application in automotive, aerospace, and defence industries owing to its high specific strength and low density. On the other hand, 17-4 PH is a precipitation hardenable martensitic stainless steel, also used in components for defence applications. In recent times, with the advent of additive manufacturing technology, there is an interest in evaluating the physical and mechanical properties of 3D-printed AlSi12 and 17-4 PH parts. Therefore, in this study, the performance of AlSi12 test coupons printed using the selective laser melting (SLM) technique was investigated under both quasi-static and dynamic compression loading. Additionally, since the SLM-printed samples show anisotropic characteristics, the coupons were fabricated along three different orientations, viz. horizontal (0°), inclined (45°), and vertical (90°) to study the effect of build orientation on the compression performance of the samples. Furthermore, the testing was carried out at room temperature as well as high temperature, relating to the fact that the components made from these alloys are often subjected to severe service environments including high temperatures. It was observed that there was a negative strain rate effect at room temperature and a positive strain rate effect at high temperature. This was attributed to the difference in the microstructure and microhardness of the as-built AlSi12 samples. The next stage of research will involve working on SLM produced 17-4 PH samples by carrying out quasi-static and dynamic studies supported by micro-structure and micro-hardness.

15. Pragathi Dissanayaka – University of Wollongong

The Effects of Reoccurring Weld Repairs on the HAZ of a 690MPa, Quenched and Tempered Steel

P. Dissanayaka[1,4], H. Li[1,4], S. van Duin[1,4], K. Carpenter[1,4], Z. Sterjovski[2], J. Donato[2], D. Miller[3]

[1] Faculty of Engineering and Information Sciences, University of Wollongong, NSW, Australia

[2] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia

[3] ASC, Osbourne, South Australia, Australia

[4] Research Training Centre for Naval Design and Manufacturing

This project aims to understand the microstructural effects when multiple weld repairs are carried out within the same region of a 690 MPa, quench and tempered (Q&T) steel. This is important when considering the through life support of Australia's ageing submarine fleet where the outcomes of this work could provide guidance on the maintenance practices for damage repair.

In the process of fusion welding, a heat affected zone (HAZ) is generated next to the weld, potentially leading to the formation of local brittle zones (LBZ). It is understood that the coarse grain heat affected zone (CGHAZ) and inter-critically reheated coarse grain heat affected zone (ICCGHAZ) are the regions with lowest toughness. To quantify this, a series of weld repair scenarios (bead-on-plate, pad welds and full penetration butt welds) were experimentally undertaken to measure the size of the effected regions and resultant mechanical properties of the welded steel. To further investigate these regions, a combination of simulated HAZ samples where made using the Gleeble thermal mechanical simulator in order to isolate and accentuate the effects of LBZ regions and to establish the significance of each HAZ for this particular steel type. The combination of examining real welds with a focused and detailed study of the simulated sub-HAZ regions enables the full characterization of the effects of reoccurring welds on the base plate properties.

16. Riyan Abdul Rahman Rashid – Swinburne University of Technology

Design optimization of defense/industry parts manufactured using Selective Laser Melting (SLM)

R. Rashid[1,2], S. Masood[1], D. Ruan[1,2], S. Palanisamy[1,2]

[1] Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorn, Victoria, Australia

[2] Defence Materials Technology Centre

Additive manufacturing (AM) is an advanced manufacturing process with ability to develop parts with complex shapes, which has increased the bandwidth of product design. Further, Topological Optimization (TO) technique is employed in order to optimise the distribution of material throughout the part and obtain least weight without compromising the mechanical performance of the component. Application of TO to mechanical components would significantly lower the material cost. Hence, integration of TO techniques with AM methods has a huge potential of fabricating essential components for defence-based applications wherein weight reduction is a key factor in addition to maintaining the mechanical properties. The research aims to investigate coupling the Selective Laser Melting (SLM) technique with TO techniques using Finite Element Analysis (FEA) software to produce fully dense parts. Initial trials on densification of SLM manufactured parts using 17-4 PH stainless steel and AlSi12 alloy were conducted using different scan strategies. The density was measured using X-Ray Computed Tomography (XCT) scans and optical microscopy. Relative density of 99.98% was obtained for both materials using a suitable combination of scanning strategies and scan speeds. Furthermore, relative density and tensile properties of AlSi12 SLM samples printed in three different orientations were analysed and a significant effect of anisotropy was found. The difference in tensile properties was directly related to the porosities in the samples build in different orientations. In future, tensile properties of 17-4PH SLM manufactured parts would be determined and incorporated in improved topological optimization algorithm to obtain industry-ready components. Moreover, the optimized SLM manufactured part would be experimentally validated.

17. Robin Guan – RMIT University

Mobile Robot Localization using a Doppler-Azimuth Radar: Part II

R. Guan[1,3], B. Ristic[1], L. Wang[1], R. Evans[2], B. Moran[2]

[1] School of Engineering (Electrical and Electronic Engineering), RMIT University, Melbourne, Victoria, Australia

[2] Mechanical Engineering, The University of Melbourne, Melbourne, Victoria, Australia

[3] Defence Science Institute

Simultaneous localization and mapping (SLAM) by mobile robots is an important area of research to produce mobile robots that can assist with automating human activities in environments without GPS. Mobile robot localization and mapping is most commonly performed using cameras, and LIDAR/sonar range sensors. The novel possibility of achieving the goal with Doppler radars could produce robots that are smaller, cheaper and more energy efficient. Autonomous robot exploration is useful in GPS-denied environments such as extra-terrestrial, indoor, underground or undersea environments.

Results to Date: Localization using Doppler radar in a known, feature-based map has been proven to be possible in simulation under realistic assumptions using particle filters.

Work to be completed: Applying a basic SLAM algorithm to experimental data using a LIDAR sensor with the aim of integrating state of the art research in improved proposal distributions. A future goal is to have in-house robot experiments to develop optimal robot exploration strategies (Active SLAM) and to verify the Doppler radar localization simulations.

Keywords: Simultaneous Localization and Mapping (SLAM), Mobile Robots, Autonomous Robot Exploration, Doppler Radar, Particle Filter, Bayesian Estimation.

18. Rowan Pivetta – Flinders University

3D Coverage Planning for Tank Inspection Robots

R. Pivetta[1,2], K. Sammut[1], A. Lammas[1,2]
[1] School of Computer Science, Engineering and Mathematics, Flinders University, SA, Australia
[2] Research Training Centre for Naval Design and Manufacturing

The manual inspection of corrosion inside ballast tanks is a hazardous, time consuming, expensive and subjective process. To overcome subjectivity and increasing costs, the ability to perform robotic inspection will allow for objectivity and comprehensive coverage of the tank. The benefits of this proposal would result in repeatable inspection tours, reduced risk to workers and shorter maintenance downtime.

To allow an autonomous robot the ability to perform an inspection task that ensures that all surfaces are surveyed, it will need to be provided with a route generated by a coverage path planner. The challenges in developing a coverage path planning algorithm arise when incorporating the complexity of the environment and robot design. As a result, many proposed coverage algorithms produce offline plans. Whilst offline plans can solve for optimality, problems arising during runtime may impair the robot's mission execution. Therefore, there is a need to develop adaptive coverage planning algorithms that are able to replan routes during inspection.

This research extends the capabilities of the offline Redundant Roadmap algorithm to provide adaptive tours through complex and potentially cluttered confined spaces. To date, the focus of this research has been to develop the offline Redundant Roadmap algorithm and associated solutions to turn it into an adaptive online algorithm. The proposed solution will utilise regular map and positioning updates during execution to rectify compromised paths through region based replanning. Region based replanning will allow for localised replanning around identified areas of change therefore reducing the need to recalculate the whole inspection tour while making the algorithm robust to unforeseen environmental changes.

19. Samuel Smith – University of Tasmania

Experimental development to investigate unsteady loading on a hydrofoil immersed in a turbulent boundary layer

S. Smith[1,3], P. Brandner[1], B. Pearce[1], D. Clarke[2], Y. Xue[1,3]
[1] Australian Maritime College, University of Tasmania, Launceston, Tasmania, Australia
[2] Defence Science and Technology Group, Fishermans Bend, Victoria, Australia
[3] Research Training Centre for Naval Design and Manufacturing

Significant advancements made in the field of hydrodynamics has been made possible through the development of novel experimental equipment and techniques. To investigate the unsteady flow phenomena about a hydrofoil immersed in a turbulent boundary layer, the cavitation tunnel at the Cavitation Research Laboratory is to be utilized in conjunction with recently developed equipment and techniques. A key component to the required hydrofoil loading measurements involves extending the relatively low resolvable frequency range of current equipment due to its structural response. This is achieved by developing a novel force balance design through the use of modal analysis, empirical data and innovative piezoelectric force sensor technology that extends the current limit of 100 Hz up to 900 Hz. To investigate different levels of immersion in the boundary layer, the state-of-the-art cavitation tunnel provides the ability to actively vary the test section ceiling boundary layer thickness via an array of cross flow jets. To effectively artificially thicken the boundary layer, several design iterations are undertaken to develop the desired velocity and turbulence profiles. This ensures that hydrofoil performance measurements are being conducted in an appropriate flow field while providing the ability to extensively investigate the effect that the level of immersion has on the performance. Through developing these techniques and equipment, limitations imposed by existing equipment can be overcome allowing new data to be obtained and advancing our understanding of this canonical flow.

20. Zhenyu Fei – University of Wollongong

Application of Keyhole tungsten inert gas welding (K-TIG) in high strength steel

Z. Fei[1,2], H. Li[1], Z. Pan[1], D. Cuiuri[1]
[1] School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, NSW, Australia
[2] Defence Materials Technology Centre

Motivated by low efficiency associated with multi-pass welding and high cost resulting from the use of large amount of filler materials, the feasibility of keyhole tungsten inert gas (K-TIG) welding for joining HHA and DH36 was investigated. Welding trials of these two peritectic steels showed disparate weldability of the two grades. Single pass full penetration can be achieved on both 6mm and 8.5mm HHA plates without using any filler materials and edge preparation, while DH36 has been proved very unstable under K-TIG conditions. Control strategy was applied to improve the process stability by using efflux plasma voltage as feedback control signal. Results showed that it was not sensitive enough to reflect the keyhole state in real time, which leads to either weld pool collapse or incomplete penetration. A novel sensing system will be developed in order to establish the relationship among arc behaviour, keyhole beahviour and weld pool state and to identify the feedback signal that gives the fastest response. Furthermore, high temperature laser scanning confocal microscope will be used to identify the role peritectic reaction may play in destabilizing the keyhole by using five kinds of high strength steels with different chemical composition, which would provide theoretical and physical basis on keyhole failure mechanism and lay a solid foundation for improve the weldability of peritectic steel. Finally, K-TIG will be compared with plasma arc welding, its most formidable competitor, to identify the difference between them as well as to stand out the advantages of K-TIG.