2018 Student Conference

Abstracts

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1. Brodie McDonald – RMIT University

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

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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.

2. Nathan Edwards – Swinburne University of Technology

Adiabatic Shear Bands in 2024-T351 Aluminium

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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 overview of an experimental mechanistic study observing the flow localisation and formation of adiabatic shear bands at different stress states, strain rates and temperatures. In ongoing work, the results of Split Hopkinson Pressure Bar (SHPB) testing of hat-shaped specimen are modelled in LS Dyna. A set of instability criterion developed for use with the generalised incremental stress state model (GISSMO) model utilizing a hybrid experimental/numerical approach are used to re-model the SHPB tests. Future work will apply the developed damage model to ballistic tests to predict adiabatic shear during ballistic impact.

3. Daniel Clayton – University of Tasmania

Blast Survivability of a Fatigued Naval Surface Platform

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As naval vessels are being asked to perform over longer service lives and under more intensive operational tempos, it is increasingly pertinent that the effects of structural aging be accounted for. Fatigue is an important aspect of structural aging of a vessel. Currently, fatigue analyses are conducted to determine the point at which fatigue failure might occur. However, fatigue can induce changes to the material properties long before full fatigue failure occurs. These changes in material properties can affect the outcomes of other forms of structural failure, such as blast loading.

An experimental investigation is being undertaken to determine the extent to which fatigue impacts blast survivability of a naval vessel. Benchmark tensile testing and fatigue testing has been performed, fatigued specimens of shipbuilding steel have been created, and a methodology for high strain rate tensile testing of shipbuilding steel plate has been developed. An important outcome has been the optimisation of specimen dimensions, whereby the gauge length of a Split Hopkinson's Tension Bar specimen was found to be the critical dimension in achieving failure at high strains >40%.

Future work to be conducted will see: the completion of quasi-static and high strain rate tensile testing on fatigued shipbuilding steel; the creation of a constitutive model which accounts for the effect of fatigue and high strain rate loading; and, the implementation of that constitutive model into a numerical investigation to determine the effect that fatigue has on the blast survivability of a simplified naval surface platform.

4. Jimmy Toton – RMIT University

Additively Manufactured Cutting Tools for Aerospace Machining Via Laser Metal Deposition

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Additive Manufacturing (AM) technologies, such as Laser Metal Deposition (LMD), have the capability to manufacture fully functional parts and potentially reduce production time and cost for high value, complex shaped components, such as custom cutting tools. This work aims to develop process methodologies & build strategies to AM milling cutters via LMD using Fe-Co-Mo steel powder and compare them to conventional High Speed Steel (HSS) cutting tools used in Titanium alloy machining.

The capability to additively manufacture crack-free cylindrical bars made of a carbon-free Fe-Co-Mo based steel was achieved by implementing high temperature substrate heating to supress in-situ age hardening during the LMD manufacturing process. The effect on the as-built microstructure and hardness was characterised revealing a microstructure consisting of irregular ferrite grains with µ-phase particles precipitating along grain boundaries with an average hardness of 430 HV. Post heat treatment experiments have revealed that AM samples respond similarly compared to their commercial Powder Metallurgy (PM) analogue in terms of hardness, 900-1000 HV. Solution treatment was found not to be necessary to attain desired hardness's used in HSS cutting tools, potentially due to the in-situ quenching during the LMD process. However, solution treatment was found to significantly reduce the variance in hardness.

Milling cutters made from FCM steel achieved a tool life equal to and greater than their PM analogue machining mill annealed Ti6Al4V. Further work is needed to quantify the fracture toughness of these materials as the cutting tool tests show qualitatively that the AM material has a high fracture toughness, desirable in-milling and broaching operations.

Keywords: Additive Manufacturing, Laser Metal Deposition, cutting tools, Fe-Co-Mo steel

5. Panneer Selvam Ponnusamy – Swinburne University of Technology

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

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Selective Laser Melting (SLM) is a layer-by-layer metal additive manufacturing process. Parts processed by SLM can be subjected to severe dynamic loadings and high temperature in service, in applications such as defence, aerospace, automotive and high-speed machining. Very few studies have reported on the behaviour of additively manufactured metal parts subjected to high strain rate loading conditions. The present work is focused on studying the mechanical behaviour of SLM-processed and heat treated AlSi12 aluminium alloy parts under quasi-static and high strain rate dynamic compression. The quasi-static low strain rate tests were carried out at 4 × 10-3 s-1 , whereas dynamic high strain rate tests were carried out in the range of 1 × 103 – 2 × 103 s-1 using the split Hopkinson pressure bar (SHPB) apparatus. A significant reduction in both quasi-static and dynamic yield strength and ultimate compressive strength was observed when the as-built AlSi12 samples were tested at elevated temperatures. This reduction in flow stress was attributed to the softening of the samples due to the agglomeration and growth of Si-rich precipitates at the test temperatures (200°C and 400°C). Residual stress calculation of SLM using ABAQUS FEA software has been scheduled for future work.

6. Riyan Abdul Rahman Rashid – Swinburne University of Technology

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

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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-printed AlSi12 alloy parts were conducted using different scan strategies. Relative density of 99.98% was obtained 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. Further investigations found that printing area of a single SLM-printed layer and its corresponding energy per layer are additional parameters which control the relative densities of SLM-printed samples.

In future, tensile properties of AlSi12 SLM manufactured parts would be incorporated in improved topological optimization algorithm to obtain industry-ready components. Moreover, the optimized SLM manufactured part would be experimentally validated.

7. Olexandra Marenych – University of Wollongong

Effect of heat treatment on microstructure, mechanical properties and wear resistance of Ni-Cu alloys fabricated by wire arc additive manufacturing

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Wire arc additive manufacturing (WAAM) is a promising low-cost technology for production or repair of functional machine components. A successful application of WAAM for making Ti-, Fe-, Al-, Cu- and Ni-Cr-base alloys has been reported, however, there was no evidence for producing Ni-Cu alloys. This project is focused on the first ever investigation of the potential use of WAAM technology for repair of damaged Ni-Cu parts of maritime equipment.

To achieve the project's goal, two Ni-Cu alloys with various contents of Ti, Mn, Al, Fe and C were deposited in the forms of walls/plates on a metal base plate using WAAM technology. The samples were heat treated by applying three procedures: annealing at 1100 °C for 15 min followed by either (i) air cooling to room temperature, (ii) slow cooling to 610 °C, holding for 8 h and air cooling to room temperature or (iii) slow cooling to 610 °C, holding for 8 h, slow cooling to 480 °C, holding for 8 h and air cooling to room temperature. Microstructure characterisation, in particular a detailed study of the precipitate's parameters (size, number density and chemistry) was carried out using optical, scanning, transmission and atomic resolution electron microscopy. Mechanical properties were assessed using hardness, tensile and wear testing. For similar deposition and heat treatment conditions, an alloy with higher C and Al, and lower Mn content exhibited smaller grain size, higher number density of >20 nm TiC particles, higher number density of <20 nm □'-Ni3(Al, Ti) particles, and, associated with these, superior hardness, tensile strength, toughness and wear resistance. The effects of alloy composition and heat treatment on the microstructure-properties relationship in the studied Ni-Cu alloys are discussed.

8. Akif Soltan – University of Queensland

Temporary Corrosion Protection of New Generation of Magnesium Alloys

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Magnesium alloys are used in navy helicopters. Because of the environment they operate corrosion is a serious and life limiting issue. Reduction of corrosion is therefore is of vital importance. Corrosion inhibiting compounds (CICs) are used to provide temporary protection for magnesium alloys against the effects of corrosion. The CICs applied onto the alloy surfaces form a barrier between the alloy and the environment.

In the current study four CICs, namely Ardrox 3961, LP2, LP3 and AMLGuard were applied by immersion onto the magnesium alloys of EV31A, WE43B, ZE41A and Pure Mg. The coated alloys were immersion tested in 3.5 wt % NaCl solution to (a) assess the effect of CICs on the corrosion behaviour of the magnesium alloys, (b) evaluate effectiveness of CICs in reducing corrosion rates and (c) understand the scientific principles of interaction between the CICs and the alloys.

The CICs were generally effective in reducing corrosion rates of the alloys. However, their effect was different on different alloys. It was found that LP3 that formed translucent waxy coating provided the best protection against corrosion.

The next stage of experimental work will entail field exposure tests of the alloys coated with different CICs.

9. Zhenyu Fei – University of Wollongong

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

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Motivated by the undesired microstructure and unsatisfactory weld properties during K-TIG welding process of High Hardness Armour (HHA) and poor weldability of DH36, the use of filler materials and pulse mode current waveform have been introduced in K-TIG to modify the weld microstructure and improve weld properties in HHA and to improve weldability of DH36 respectively. The results showed that the applied austenitic filler material can significantly change the weld microstructure with just 6.7% dilution, along with much increased weld metal hardness and joint efficiency, matching the welds produced by using conventional arc welding processes with V-joint preparation and matching filler metal. The introduction of filler material shows great potential to produce high performance armour steel joint with high productivity. As for DH36, it is impossible to achieve fully stable welding process with constant current under conditions without back purging. High temperature laser confocal microscope revealed that the kinetics of peritectic reaction is much faster and sulfur partitioning is severer for DH36 compared with HHA, which may play a role in destabilizing the keyhole process. Pulsed mode current wave form was successfully applied with square pulse current. Stable keyhole process and weld with acceptable quality was achieved at lower heat input. The weld formation is further improved with increased pulsed frequency. Further research will focus on the fundamental mechanism by which the keyhole failure occurs as well as improvement of mechanical properties and reduction of residual stress in K-TIG welded dissimilar DH36/304 stainless steel joint.

10. Emily Kibble – University of Western Australia

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

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Neisseria meningitidis is the bacterial causative agent of invasive meningococcal disease (IMD). The rate of IMD in Australia is increasing, with over 300 cases in 2017. Therefore, there is increased need for novel drugs against *N. meningitidis*.

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 different Mip-like proteins. We hypothesise that both Mip proteins are important novel anti-virulence targets in *N. meningitidis*.

The roles of these proteins are being elucidated by construction of *N. meningitidis* Mip deletion mutants. These deletion mutants have significantly decreased survival in macrophage cells, as well as increased susceptibility to stresses and antibiotics. Recombinant expression, purification and crystallography studies for the structural and enzymatic analysis of the Mip proteins has begun. On-going is the testing of novel inhibitors against recombinant Mip protein, as well as against strains of *N. meningitidis*, which gives a more detailed understanding of the effect and potency of these inhibitors. These inhibitors have an inhibitory effect on the enzymatic activity of Mip, and result in a significant decrease of bacterial association with host cells. Mip and Mip-like proteins have been shown to have a role in cell infection, and represent an important set of anti-virulence targets in *N. meningitidis*.

11. Alain Moriana – University of Wollongong

Exploring ferroelectric domain engineering through ceramics texturing, for underwater acoustics applications

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Many underwater acoustic transducers, such as sound navigation and ranging (SONAR) systems, are based on piezoelectric materials, taking advantage of the direct (receiver) and converse (transmitter) piezoelectric effects. High-coupling and high-strain relaxor ferroelectric single crystals have been researched actively in recent years due to their significant enhancements to acoustic transducer performance, especially in terms of the sensitivity (high piezoelectric coefficient and electromechanical coupling), frequency bandwidth (high electromechanical coupling) and compactness (large elastic compliance and piezoelectric coefficient). However, single crystals are limited in applications due to the complexity of fabrication, composition inhomogeneity, high cost and time of synthesis as well as the inferior mechanical properties compared to their ceramic counterparts, limiting their transition to SONAR systems. In parallel to single crystals, textured piezoelectric ceramics are being studied based on the template grain growth process (TGG). This process, uses various types of ceramic systems and has been show to achieve performances that are close to those of the first generations of relaxor ferroelectric single crystals. Additional advantages include reduced cost of manufacturing, significant performance enhancements compared to polycrystalline piezoelectric ceramics and machinability for easier industrial transition into SONAR systems.

In this study, several ceramic systems will be explored (PMN-PT and PIN-PMN-PT, etc.) as well as template seed crystals (BT, ST, NN, etc.) in an effort to induce texturing, hence maximising piezoelectric response by focusing on properties favourable for SONAR systems: High electromechanical coupling (kp), piezoelectric strain constant (d33), mechanical quality factor (Qm) and coercive field (EC). Manufacturability and the impacts of the processing parameters involved in fabricating textured piezoelectric ceramics will also be explored, the relationship of the complex microstructures and engineered ferroelectric domains with macroscopic properties will be established.

12. Scarlet Kong – University of NSW

Exploring electro-mechanical response of textured ceramics for underwater acoustic applications

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Piezoelectric materials have the unique ability to change their shape on application of an electric field, and conversely, produce electric charge under mechanical force. It is this reversible phenomenon that allows us to use these materials as acoustic transducers in applications such as medical imaging or SONAR systems.

Typically, high performance or high strain piezoelectrics are in the form of single crystals. However, the complexity and cost of single crystal piezoelectrics growth is challenging, additionally the long-term reliability of these materials is yet to be completely understood. This currently prevents their use in larger-scale SONAR systems.

Textured piezoelectrics fabricated using the templated-grain-growth process (TGG) have been found to achieve comparable performances to that of single crystals and potentially offers a more economical fabrication process. However, one difficulty in achieving single crystal level performances in textured ceramics is their complex microstructure. Due to the anisotropic piezoelectric response, grain-scale misorientation can produce high micro-strains at the grain boundaries that may initiate micro-cracking and reduce material reliability and lifetime.

The aim of this project is to understand the complex microstructures in textured piezoelectrics by investigating the development of inter-granular strain while under an externally applied electric field. Through computational simulation, the grain-scale response in different types of textured ceramics will be modelled. In parallel, high energy synchrotron X-rays will be used to quantify achieved texture in target materials, as well as perform in-situ electric field measurements to observe the strain response mechanisms. The results of these combined experiments will be used to optimise the texturing process of piezoelectrics and provide a direct correlation on how texture affects the piezoelectric properties of the ceramic.

13. Budi Kurniawan – Federation University

Multi-Objective Reinforcement Learning in Dynamic Team-Based Adversarial Games

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Multi-agent simulations are commonly used in the field of operations research to help support complex decision making. In defence operations research, constructive multi-agent simulations are used to support decisions regarding acquisitions, upgrades and tactics development. Existing approaches for modelling air combat used agent programming methods which relied on significant domain knowledge to be manually encoded into the simulation environment. Today, in order to maximise the advantages provided by new technologies (such as autonomous aircraft), new tactics will need to be discovered. In this research we explore multi-objective reinforcement learning as a mechanism for discovering new behaviour in multi-agent simulations of air combat.

14. Nicola Kloet – RMIT University

Acoustic Characterisation and Mitigation for Multi-Rotor Unmanned Aircraft Systems (MUAS)

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Unmanned Aircraft Systems (UAS) (commonly known as 'drones') are becoming increasingly common for commercial applications, such as payload delivery, meaning they are often used in urban areas. Widespread use of this technology has led to increased concerns surrounding safety and public privacy issues, but so far there has been limited investigation regarding the noise emitted by these vehicles. When flown low and in densely populated areas, the potential for acoustic annoyance is great. These problems were addressed by experimentally characterising the noise made by UAS, evaluating the response of a human listener, and by recommending noise mitigation strategies. Results are presented for common quadcopter noise sources. Propeller wake over support structures were measured using pressure probes, and propeller geometry was compared against the acoustic recordings taken over a range of tip speeds using B&K Sound Pressure Level (SPL) meter. Psychoacoustic software was used to determine the typical human reaction to the noise. Based on these findings, acoustic mitigation methods to reduce the acoustic features with the greatest impact are discussed.

Keywords: Unmanned Aircraft Systems (UAS), drones, acoustics, noise reduction, annoyance.

15. Andrew Short – University of Wollongong

Sampling-Based Motion Planning with Contacts

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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.

16. Bradley Donnelly – Flinders University

The Effect of Antifouling Coatings on Maritime Acoustic Sensor Performance

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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.

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17. Jane Cullum – University of Tasmania

Decisions to Improve Ship Maintenance Scheduling

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Increasing the scheduling efficiency of shipboard maintenance work remains a challenge. While current maintenance approaches ensure some vessel availability, they are not optimal uses of time or organisational resources. The presentation outlines how the Risk-Based Maintenance (RBM) framework can be applied to address these challenges. The framework is applied to a general service pump aboard a naval tug to develop a maintenance diagnostic system. Failure behaviour of the pump, condition monitoring measurements and the expertise of the vessel's Chief Engineer were used to develop a novel maintenance system which detects faults and suggests maintenance tasks automatically. The system is a combined application of a machine learning algorithm and lottery models and is calibrated to make suggestions according to the Chief Engineer's experience.

Maintenance suggestions according to the system are compared with actual preventative maintenance (PM) on the pump over a 6 month period. Although data collection was affected by non-uniform sampling conditions such as rocking of the ship; use of the system with a quality dataset is expected to increase annual availability of the pump over PM by 0.03% and reduce its annual maintenance cost by $41.4 AUD. Considering an estimated 20 pumps per vessel in the RAN fleet, this small saving translates into a reduction of $40,000 AUD annually, which is otherwise spent on unnecessary pump maintenance work.

The use of an RBM Scheduling system will result in greater availabilities and overall maintenance cost savings when applied to more complex machinery and whole systems beyond commercial and naval vessels.

18. Martin Friebe – University of Tasmania

A framework to improve the naval survivability design process based on the vulnerability of a platform's systems

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Offshore Patrol Vessels (OPVs) are a relatively small type of vessel designed for quick naval defence response in littoral zone. OPVs also have a complex system layout, because they are constructed to include both commercial and naval aspects with functionality to facilitate its operational defence duties and capability. Furthermore, this complex system layout may not be optimised for survivability. This study presents a novel framework to examine survivability related system and functional dependencies of an actual OPV, combining different modelling techniques. The OPV is modelled and analysed using a physics-based vulnerability assessment model and integrated into a dynamic system supply and demand model. The output is then analysed through a machine learning algorithm to identify functional relationships between systems and the vessel's operational capabilities to then build a Bayesian Network for further analysis. The Bayesian Network model is used to identify single point failures and analyse the OPV's equipment/on-board systems for sensitivity to the survivability of the platform. The results demonstrate the ability of the machine learning algorithm to build a Bayesian Network that can effectively improve the naval design process and subsequently contribute to enhancing the survivability of OPVs.

19. Pragathi Dissanayaka – University of Wollongong

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

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Considering the through life support of Australia's ageing submarine fleet, it is crucial to understand the microstructural effects when carrying out multiple weld repairs. The submarine hulls are fabricated with a 690 MPa, quenched and tempered (Q&T) steel. Reoccurring weld repairs are an essential part of the maintenance program, which include; pad weld repairs for the rectification of corrosion damage, welding and re-welding of temporary support attachments to the hull and internal access cut-outs require full penetration welds for rejoining the hull.

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 investigate the occurrence and the influence to the overall performance of welds due to presence of these regions, a series of real weld repairs were conducted to simulate maintenance procedures. Data from these real welds was then used to setup simulated weld repairs using a Gleeble thermal mechanical simulator, which allowed LBZ's to be isolated and investigated. A range of microstructural and mechanical tests were conducted to investigate the effects of different thermal cycles and multiple thermal cycles on the parent plate properties.

The results of this study indicate that there is no considerable effect on toughness, hardness, residual stresses and microstructure in reoccurring repair welds compared to single repair weld.

It also envisaged that the results from the mechanical testing and subsequent characterization (optical, SEM, EBSD and TEM) will provide valuable guidance on the maintenance practices for damage repair on submarine hull steel.

20. Samuel Smith – University of Tasmania

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

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The unsteady interaction between multi-phase flow and the structural response of a hydrofoil involves complex phenomena key to the performance of propellers and control surfaces on marine vehicles. Despite recent extensive research into fluid-structure interaction of cavitating hydrofoils there remains insufficient experimental data to explain many of these observed phenomena. The dynamics of cloud cavitation about rigid and compliant 3D hydrofoils is investigated in a cavitation tunnel. The two hydrofoils have identical undeformed geometry of tapered planform with constant NACA 0009 section. Unsteady measurements of force and tip deformation were made simultaneously with high-speed imaging to enable correlation of forces and deflections with cavity physics. Two shedding modes have been identified, high and low, for both rigid and compliant hydrofoils although significant differences in peak amplitudes where observed. The high shedding mode that occurred at high cavitation numbers values varied in frequency with cavitation number and the high-speed imaging showed the dominant shedding mechanism to be due to re-entrant formation. The low shedding mode that developed at lower σ values where cavity lengths grew to about full-chord, occurred at a nominally constant frequency. In this case, the high-speed imaging showed the dominant mechanism to be due to shockwave formation. The flexibility of the compliant hydrofoil was found to notably increase the magnitude of the force fluctuations for the low frequency mode compared to the rigid foil. However, hydrofoil compliance was seen to dampen the fluctuating magnitude of the high frequency mode, despite being close to the hydrofoil's natural frequency.

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Characterisation of underwater explosion induced whipping responses

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An underwater explosion (UNDEX) poses a significant threat to naval platforms. The combination of a short duration, high pressure shock wave and the lower pressure, but longer duration of the pulsating bubble defines a unique and complex loading scenario. Better understanding of how a platform responds to these loads can aid designers and operators in their efforts. Based on results from a previous experimental investigation, a numerical model was developed and validated for assessing the UNDEX induced whipping response of a submerged platform. Further analyses on the validated model indicate three distinct whipping responses. These distinct responses primarily depend on the UNDEX location in relation to the platform's first bending mode shape. Limited extrapolation of these distinct whipping responses suggests that four whipping analysis regimes exist, all of which are promising areas of further study.

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