AFRC
ADVANCED FORMING RESEARCH CENTRE
UNIVERSITY OF STRATHCLYDE

University of Strathclyde Glasgow

Advanced Manufacturing Industrial Doctorate Centre Showcase

www.afrc.org.uk

Putting people at the heart of research

Throughout my career I have been passionate about academia and industry working together and in 2009, when I was part of the team setting up the University's Advanced Forming Research Centre (AFRC), the ambition was to create a dedicated research place that would fill the gap between fundamental academic research and the research and development work done in industry.

At the core of this ambition is people – not only the people working on current projects but ensuring industry has the right type of people it needs for future projects.

This belief led us to set up the Advanced Manufacturing Industrial Doctorate Centre (AMIDC). The centre offers doctorate programmes with a view to developing new and enhanced manufacturing techniques and technologies, as well as the people who will be implementing and working with them in the future.

It is a joint collaboration between the AFRC and the Department of Design, Manufacture and Engineering Management (DMEM) in the University of Strathclyde's Faculty of Engineering.

The AMIDC's programmes offer companies and students alike the opportunity to undertake world leading research in advanced manufacturing technologies while working alongside globally renowned businesses.

It offers companies a unique opportunity to work on advanced manufacturing production techniques with a dedicated researcher. The company has complete control over the research practices undertaken. In conjunction with this it helps the students to develop their knowledge and abilities to understand manufacturing issues and allow them to gain industrial experience in order to communicate and implement viable engineering solutions.

It is this close partnership that will ensure industry has the right type of people it needs to bring about great success in the future.

Professor William Ion
Vice-Dean (Knowledge Exchange) at the University of Strathclyde's Faculty of Engineering

Research with an industry focus

The Doctorate programme is focused on industry based research.

It offers students and graduates a unique opportunity to carry out in-depth study and research in advanced manufacturing techniques.

Doctorate students work with industry partners to define a programme of work to develop new knowledge and build experiments to test ideas and investigate potential solutions. This gives students the chance to work on advanced manufacturing production techniques with the time and flexibility to explore different solutions to specific industry problems.

This is an opportunity to achieve a qualification that is aimed specifically at pursuing a senior-level career in industry.

For industry, it provides ambitious and able students with the technical, business and personal development competencies needed to become the senior research managers of the future.

Dr Dorothy Evans
Doctorate Programme Coordinator

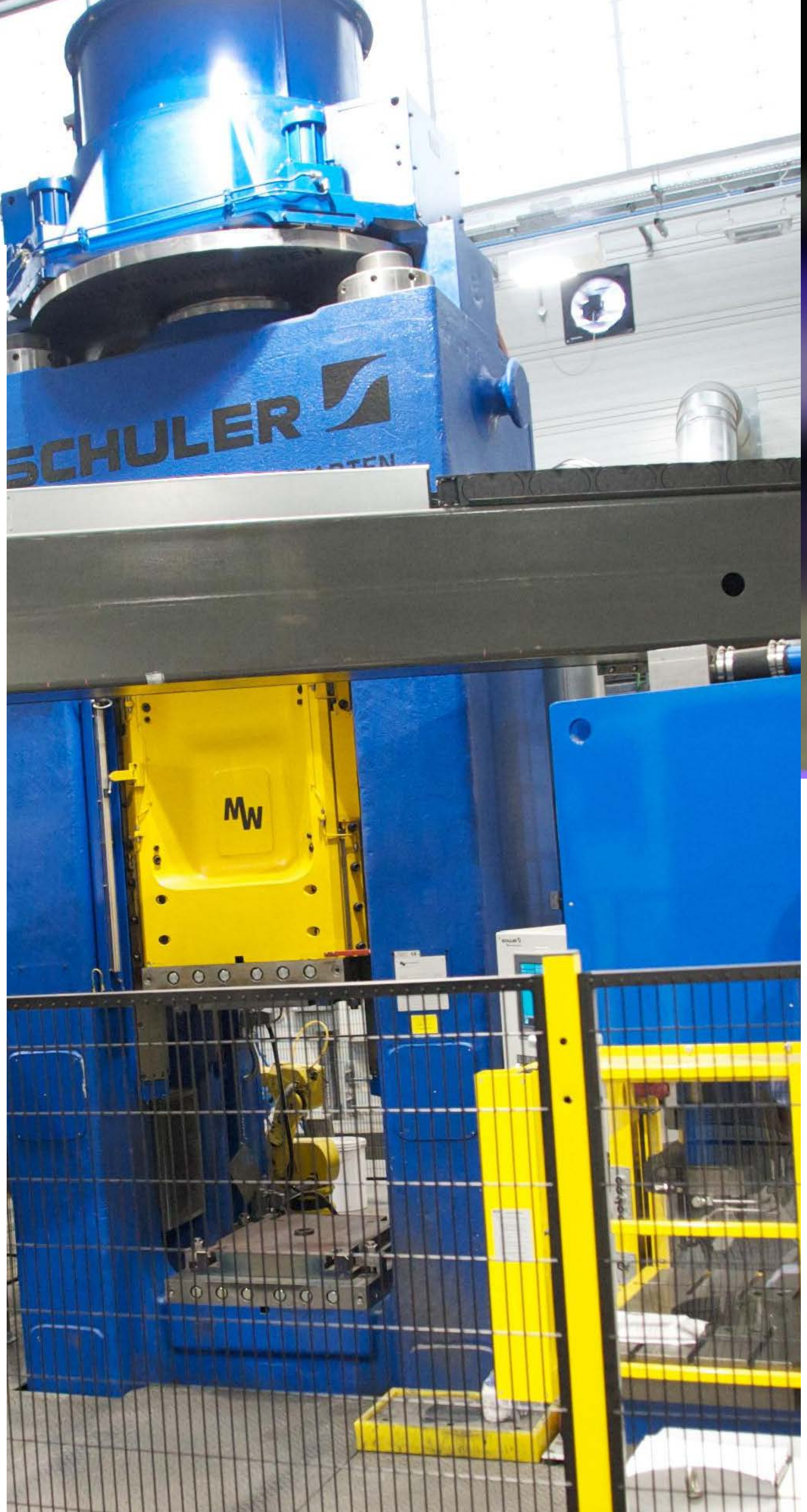
A meeting of minds

As well as working with industry based customers in commercial and collaborative research and development projects, the Advanced Forming Research Centre has three separate research programmes that focus on developing the centre's foundational capabilities and strengthening the overall manufacturing sector in the UK; the doctorate programme is one of these programmes.

The Doctorate programme sits perfectly with what the centre was set up to do – fill the gap in the TRL scale between academic and industry research. Through all of our research we aim to provide practical solutions to real industry issues and that's exactly what the EngD students are aiming to do with their work.

Through the Doctorate programme we can push the boundaries of advanced manufacturing while developing leaders of industry.

Dr Michael Ward
Research Director at at the University of Strathclyde's Advanced Forming Research Centre



About DMEM

The University of Strathclyde has one of the largest, most advanced and well equipped engineering faculties in the UK and the biggest in Scotland. It is renowned for international research, quality of teaching and its strong links with industry.

The Department of Design, Manufacture and Engineering Management (DMEM) is an internationally leading department providing learning which is both innovative and industry focused within the Faculty of Engineering.

The department's focus is on 'delivering total engineering' and it does this through:

- Research excellence
- Industrial partnerships
- Creative engineering education

The real-world nature of the department's work and the breadth of expertise residing within it, allows it to engage with a wide range of organisations, irrespective of sector and size, to help them solve problems and ultimately perform better.

As well as offering a range of challenging and innovative courses at undergraduate and postgraduate level, DMEM also offers a range of CPD courses. It is understood that some industry partners have specific requirements so the department offers tailored programmes to suit particular business needs.

About the AFRC

The University of Strathclyde’s Advanced Forming Research Centre (AFRC) is a globally-recognised centre of excellence in innovative manufacturing technologies, engineering research and development, and metal forming and forging research.

For almost a decade the centre has been at the heart of manufacturing research in Scotland. It is the only High Value Manufacturing Catapult centre in the country, one of only 7 in the UK making it the critical link between manufacturers in Scotland and the rest of this world-class network of manufacturing innovation and expertise.

The AFRC helps to fill the gap between fundamental academic research and industry. We help companies to turn innovative technologies and ideas into a commercial reality that will increase their competitiveness, boost their business and secure the manufacturing sector in Scotland and the UK for generations to come.

We offer world-class expertise and cutting-edge technologies that help firms develop solutions that bring about real business benefits for companies of all sizes from across the UK and internationally.

AFRC people:

- Started in 2009 with 12 members of staff, currently has around 147 highly-skilled engineers, researchers and business professionals
- 34% of the team is female including 24% of the technical delivery teams
- 30% of the team are non UK nationals – 35% of this group are from EU nations – 23 nationalities in total
- 25% of the team is under the age of 30
- As part of DMEM the centre has been awarded the Athena Swan bronze award for advancing women’s careers in science, technology, engineering, maths and medicine (STEMM) employment in higher education and research

Capabilities:

- High integrity forging and thermal processing
- Materials evolution, component resilience, and residual stress
- Near net shape design and make
- Sheet processing technology
- Digitalisation, technology planning of process and supply chains

About the programme

Very much an industry focused programme. Students and industry sponsors work together to define a programme of research work that fits with the original project proposal.

Students will work with the AFRC or within the sponsor's own facilities.

Research areas

The doctorate focuses on advanced manufacturing techniques as well as the forming and forging of metallic materials. Examples of research areas include, but are not limited to:

- Material characterisation
- Process modelling
- Superplastic forming (SPF)
- Residual stress
- Die life
- Metrology
- Process optimisation
- Knowledge management
- Automation/robotics
- Incremental sheet forming
- Process characterisation
- Digital manufacturing
- Lightweight manufacturing

Eng D programme structure

Orientation
The EngD programme commences in September around two weeks before the start of the academic term. It consists of:

Year one: instructional section

Students will undertake:

- Twelve academic modules selected from modules taught by DMEM at a masters or postgraduate level
- Background reading
- Initial research scoping study

Years two, three and four: research section

The years are typically structured as:

- Literature review in year two
- Experiments in year three
- Write-up in year four

Workshops, conferences and events are available for doctoral students to attend throughout the programme.

PhD structure

Orientation
PhD degree programmes enable students to undertake cutting edge research work for a period of three to four years.

It's expected the outcomes of this research will represent a significant and original advancement of knowledge in the chosen field and will be published in leading science and/or engineering journals, as well as in the end of programme doctoral thesis.

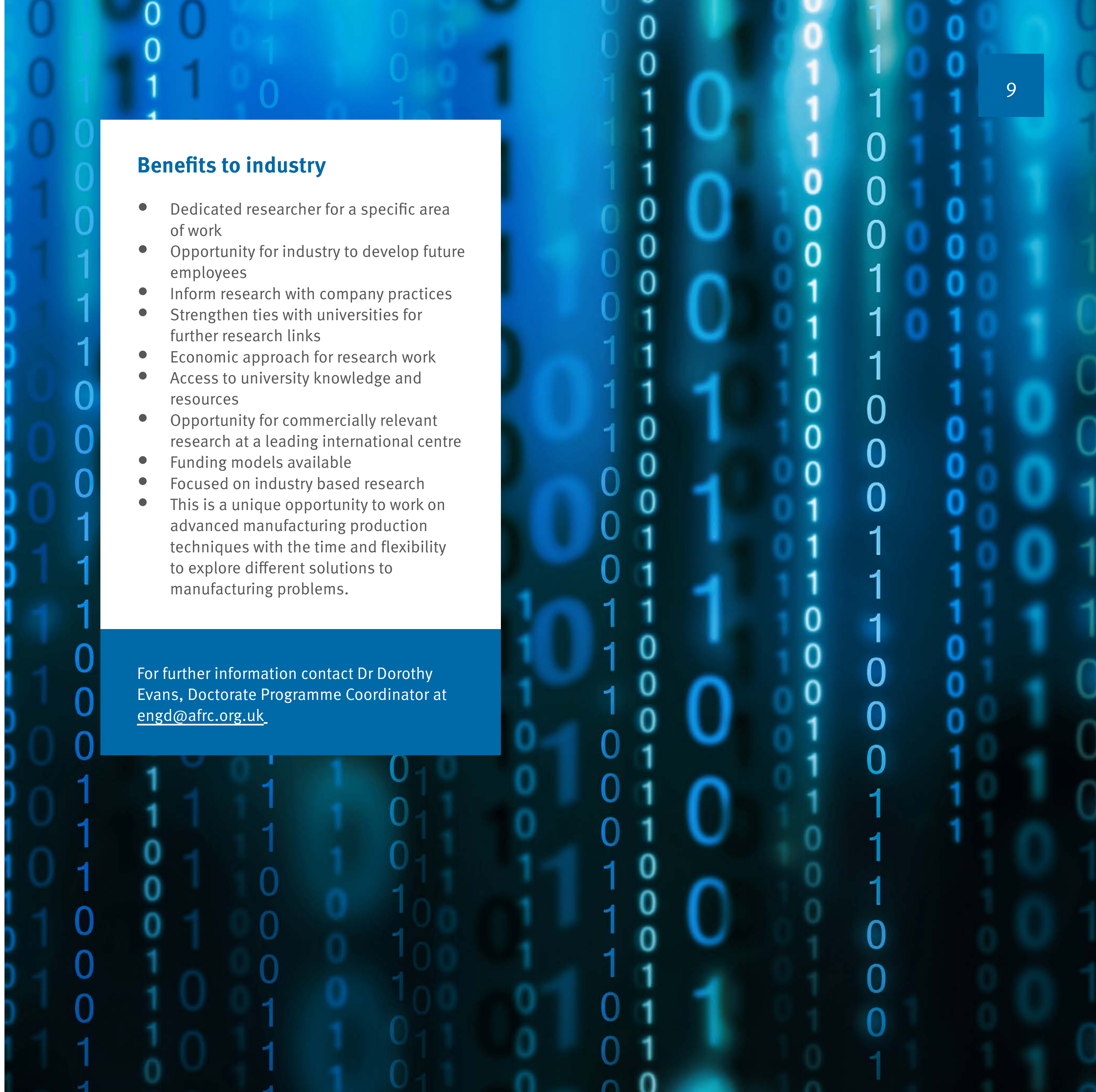
PhD programmes can be self-funded or sponsored by industry, the University, a research council, or combination of these.

As part of your PhD degree, you'll be enrolled on the Postgraduate Certificate in Researcher Professional Development (PG Cert RPD).

The PG Cert. will help you improve skills which are important to professional development and employability:

- The knowledge and intellectual abilities to conduct your research
- The personal qualities to succeed in your research and chosen career
- The standards, requirements and conduct of a professional researcher in your discipline
- Working with others and communicating the impact of your research

All you have to do is plan these activities alongside your doctorate, documenting and reflecting your journey to success along the way.



Benefits to industry

- Dedicated researcher for a specific area of work
- Opportunity for industry to develop future employees
- Inform research with company practices
- Strengthen ties with universities for further research links
- Economic approach for research work
- Access to university knowledge and resources
- Opportunity for commercially relevant research at a leading international centre
- Funding models available
- Focused on industry based research
- This is a unique opportunity to work on advanced manufacturing production techniques with the time and flexibility to explore different solutions to manufacturing problems.

For further information contact Dr Dorothy Evans, Doctorate Programme Coordinator at engd@afrc.org.uk

AFRC

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Advanced Manufacturing Industrial Doctorate Centre

Project abstracts

Project title

Sustainability assessment in manufacturing including stakeholders' expectations

Sustainability Score System in Manufacturing (3SM)				Units of measurements	Elements weightage considering stakeholders impact	Actual (Sus. data) 2017-18	Sector Targets (2020)	Legal limits	Sustainability elements short term & long term targets: Short term 2018 (Targets)	Long term 2025 (Targets)	Individual elements contribution in overall sustainability	Sustainability elements performance considering stakeholders impact FY 2017-18 (%)	
Elements representing the status of sustainability	Environment 49%	Emissions	Carbon emissions for unit of production	(kg CO2e /l)	0.10	0.75	0.70	N/A	0.70	0.60	9.5%	93.3%	88%
		Energy consumption	Electricity used for unit of production	(Kwh /l)	0.05	0.27	0.25	N/A	0.25	0.20	4.3%	91.8%	
			Fossil fuels used for unit of production	(MJ/l)	0.04	20	20.0	N/A	18	16	3.7%		
		Water Utilisation	Effluent water against unit production	(l/l)	0.08	30	30.0	N/A	27	20	6.8%	88.7%	
		Biodiversity	BOD contents in water	(mg/L)	0.11	210	N/A	800	200	150	10.1%	95.2%	
		Materials Consumption	Recycled materials used	Recycled/non-recycled	0.12	0.30	0.40	N/A	0.40	0.60	9.1%	75.0%	
	Social 32%	Producer Responsibility (EPR)	Packaging waste to unit of production	(g/L)	0.07	110	90	N/A	100	80	6.7%	90.9%	79%
		Employees Satisfaction	Consumer wellbeing & responsibility	no.	0.03	4	N/A	N/A	5	7	2.3%	86.2%	
			Employee satisfaction survey	%	0.06	80%	N/A	N/A	90%	95%	5.8%		
		Equal opportunities & Gender pay gap	Gender Pay gap	%	0.05	25%	N/A	0%	20%	0%	3.7%	76.6%	
			Equal opportunity policy and practices	N/A	0.02	4	N/A	N/A	6	8	1.1%		
		Health & safety	Minor & major incidents on all sites	no.	0.06	26	N/A	N/A	12	2	2.6%	61.5%	
			Safe working hours at work	(hours)	0.03	1600	N/A	N/A	1820	1920	2.8%		
	PM 15%	Program & policy	Total initiatives and no. CI projects	no.	0.10	80	N/A	N/A	120	200	6.4%	66.7%	61%
		Conformances	Major & minor non conformances in audits (Internal & external)	no.	0.09	22	N/A	N/A	12	6	5.0%	54.5%	

Project background

Trends are showing that Factories of Future (FoF) are to be adaptable not only to the needs of the markets but also to the growing requirements for economic and ecological efficiency, as well as the corporate social responsibility to address consumers and sustainability concerns. There have been various approaches proposed to assess sustainability over the last decades. Most of these approaches have limitations including: marginal relevance to the manufacturing environment, focused on only one aspect of sustainability, or are too complicated for most organisations to implement them. Numerous studies have shown that a gap exists on sustainability expectations among various stakeholders in manufacturing.

Research theme

Sustainability performace in manufacturing

Programme

Engineering Doctorate

Student

Aamir Rasheed

Supervisor(s)

Rentzelas Athanasios and William Ion

Industry sponsor(s)

AFRC

Overall aim

To incorporate sustainability stakeholders in performance and prioritisation of sustainability indicators considering manufacturing dynamics and local and global sustainability trends. Further sustainability performance tools should have applicability and should have relevancy in manufacturing, considering sector and legal companies.

Project title

Two steel sheets simultaneous cutting optimisation and investigation on the reemployment of the residual plasma stream energy to cut a second layer and the effect of the air gap distance on the quality cut

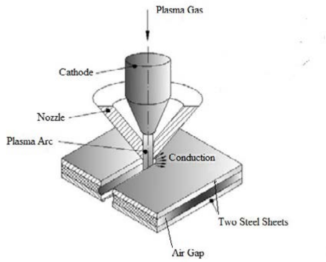


Fig. Simultaneous Plasma Arc Cutting Process of Two Steel Sheets with an Air Gap Distance

Project background

Plasma cutting processes (unconventional) are taking over the traditional way of cutting. This is due to improvements over the last 50 years in flexibility, high quality of cut, cutting profile and edges. This state of the art technology allows for a high level of automation, better quality, speed, ease of use and better tool life, making it the optimal choice for metal fabricators. A lot of research has been done in the field of assessing the quality cut and how the main plasma parameters (current, speed of cut, distance nozzle work piece, gas pressure) can reflect on the overall cut, but there is a gap which will be investigate in this study which will determine the capability of plasma technique to cut multiple steel sheets simultaneously and parameters optimisation and cutting process methodology for the best quality cut result.

Research theme

Advanced manufacturing

Programme

Engineering Doctorate

Student

Adel Gani

Supervisor(s)

William Ion, Mark Post and Tony Rodden

Industry sponsor(s)

Allied Vehicles

Overall aim

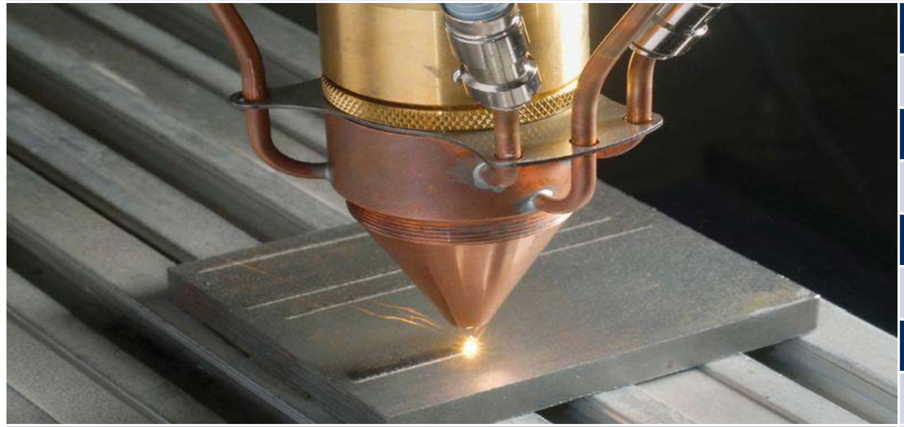
The aim of this research in general is to answer the question (with a series of experiments) if the Plasma Arc has the ability to perform simultaneously a multiple cut (2 to 3 steel sheets), and how the air gap distance between the sheets could reflect on the cutting quality, in other words can we reuse the residual energy of the Plasma to perform simultaneously a second cut, and what are the optimised input parameters for an optimum quality of cut.

Project title

Zero defect manufacturing in laser metal depostion

Research theme

Defect detection and error correction



Programme

PhD

Student

Ahmed Murtaza Qureshi

Supervisor(s)

Paul Xirouchakis and Remi Zante

Industry sponsor(s)

National Physical Laboratory

Project background

Laser Metal Deposition is a metal 3D printing process where powder metal is jetted into the laser beam at the point of deposition with the help of a carrier gas. The laser melts the powder material on to the substrate creating a Meltpool. The Meltpool solidifies upon cooling after the laser moves off the deposition area. This layer by layer deposition of material can create a complete 3D component with the help of a 3D CAD software and a CNC machine. The process is not readily adopted for operations in the aerospace and automotive industry due to the defects created in the work piece during the LMD process. Broadly, there are two types of defects in Laser Metal Deposition; pores and cracks. Currently due to hardware and methodology limitations of detection, a completely defect free product is very difficult to produce.

Overall aim

The objective is to develop a Data Acquisition Platform capable of in-situ data collection and processing using multiple sensors. An offline study of this data is to be made in correlation to machine parameters and defects to that certain trends and anomalies may be recognized. Once these patterns and trends are understood, a control algorithm is to be developed that is capable of proactively avoiding defects in process.

Project title

Effect of tool/workpiece temperature and lubrication parameters on the rate of heat transfer under hot forging conditions

Research theme

Modelling strategy for heat transfer coefficient

Programme

Engineering Doctorate

Student

Aimable Ntaganda

Supervisor(s)

Andrzej Rosochowski and Paul Blackwell

Industry sponsor(s)

AFRC

Project background

The rate of heat transfer between two elements in a system which have dissimilar temperatures is controlled by the heat transfer coefficient (HTC). The measurement of the heat transfer coefficient provides an important boundary parameter for the Finite Element modelling of hot forging (or any other hot working process) in which the workpiece and tool materials may have widely dissimilar temperatures. As such, it is important that the HTC can be accurately measured and represented in process models.

Overall aim

Developing a methodology that could be used to give meaningful HTC data for FE models of hot forging processes.

Project title

Optimisation of processing parameters of the rotary forging of stainless steel and aluminium

Research theme

Advanced manufacturing

Programme

Engineering Doctorate

Student

Alexander Clayton

Supervisor(s)

Jonathan Corney and Himanshu Lalvani

Industry sponsor(s)

AFRC

Project background

Rotary forging is an incremental cold forming process used to produce near net shape and net shape cylindrical components most commonly in the automotive industry. Advantages of the process include lower levels of vibration and noise; uniform quality; low energy and material costs. While there have been a number of academic studies of rotary forging processes reported, there has been only limited investigation of the empirical relationships between process parameters (e.g. rotational speed, inclination angle) and the properties of the formed part.

Overall aim

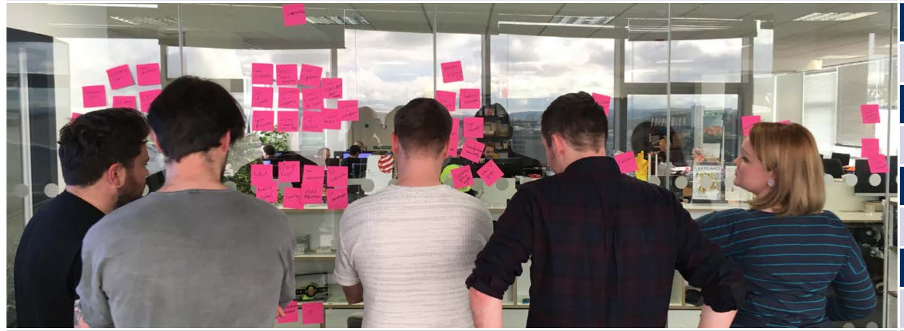
The aim of this research is to determine the effects that processing parameters have on the rotary forging process. Specifically on the response functions of surface roughness; dimensional variation; residual stress and hardness which will be investigated using a classical design of experiments approach.

Project title

The dataless forecasting of resources for product design engineering projects

Research theme

Design management, product design and resource forecasting



Programme

PhD

Student

Alexander Holliman

Supervisor(s)

Avril Thomson and Abigail Hird

Industry sponsor(s)

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Project background

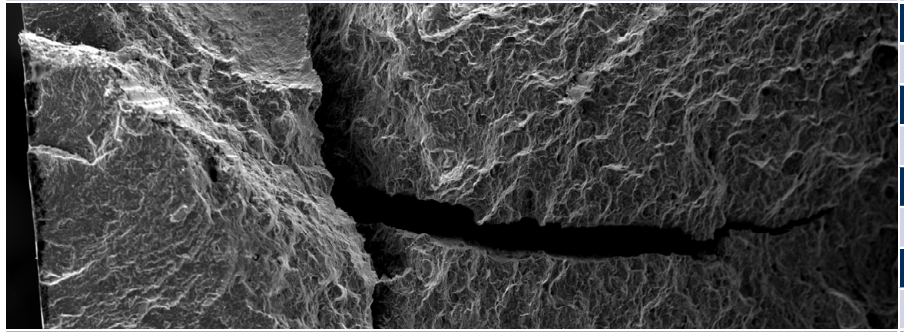
Dataless forecasting is an innovative resource forecasting method developed in DMEM for new product development (NPD) projects within large companies in a range of industries. Accurate, transparent and repeatable, dataless forecasting has improved forecasts and reduced estimation time from weeks to minutes. This research project takes this innovative method and applies it to the extremely diverse industry of product design engineering agencies; a field characterised by highly diverse client ranges and project types. This variance in projects and clients provides, not only the greatest challenge to design managers, but also the greatest opportunities for improvement, with success leading to significant financial and productivity benefits. In the latest case study, a predictive tool has been created producing forecasts with and accuracy of 84.9%, not only saving hours of planning time, but is also an average increase of accuracy of 13.9%, based on current methods.

Overall aim

To determine the suitability of the dataless forecasting method in producing accurate resource forecasting tools for product design engineering agencies. This will be achieved by developing custom estimation tools for participants of a multi-case study approach, comparing the results of each study with current estimation efforts and monitoring performance post-deployment.

Project title
Machining strategy improvement for forming dies

Research theme
High speed machining, process optimisation and modelling



Programme
Engineering Doctorate

Student
Andreas Reimer

Supervisor(s)
Xichun Luo and William Ion

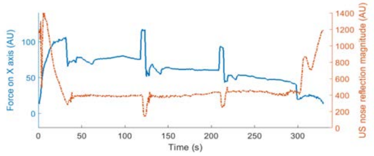
Industry sponsor(s)
AFRC

Project background
Forming dies and tools are categorised as consumables in metal forming processes and as such have a direct impact on the economics of the process and profit margins. With growing trends towards greater material utilization, there is a trend towards near net shape forming of precision components such as aerofoils and gears. Additional requirements to produce these components in increasingly higher strength materials, this poses a significant challenge to die manufacture and die life. Challenges come from the high precision machining of increasingly complex geometries in harder and more costly tool steels, while at the same time trying to extend the useful life of the tools in service. All costs incurred in tool manufacture are passed directly to the piece part price of the product, hence the requirement to simultaneously reduce tool manufacture costs and extend the life of the tool. It is known that, the surface integrity plays a major role in the fatigue life of components. However, there is only little reserach on increasing die life through machining strategies. This proposal aims to model the induced surface integrity in dies, thought the modelling of the cutting process.

Overall aim
The aim of this research project is to establish a cost-effective approach to predict and increase bulk forming die performance through a systematic experimental study accompanied by FEA simulation, furthermore, optimisation of precision die machining process.

Project title
Monitoring of incremental rotary forming

Research theme
Digital manufacturing



Programme
Engineering Doctorate

Student
Andrew Appleby

Supervisor(s)
William Ion and Alastair Conway

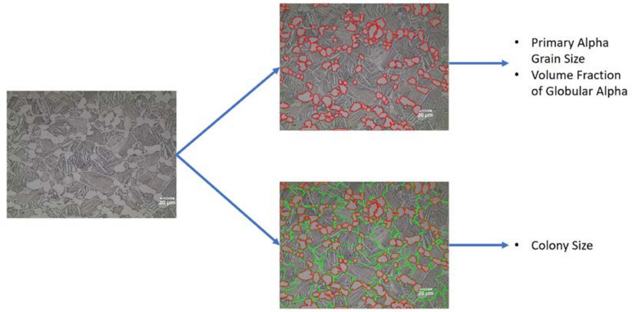
Industry sponsor(s)
AFRC

Project background
This project is investigating the use of acoustic and ultrasonic testing to monitor the flow forming (FF) process in real time. The aim is to develop a better understanding of the behaviour of FF, including the tool-material interface and the developing stress state and crack formation in the material. This information will contribute to improved FF capability in the areas of process design, process control and quality assurance.

Overall aim
To improve the understanding, operation and control of IRF through improved instrumentation

Project title
Automating microstructural analysis using digital image processing

Research theme
Digital imaging



Programme
Engineering Doctorate

Student
Andrew Campbell

Supervisor(s)
William Ion, Steven Marshall, Evgenia Yakushina and Paul Murray

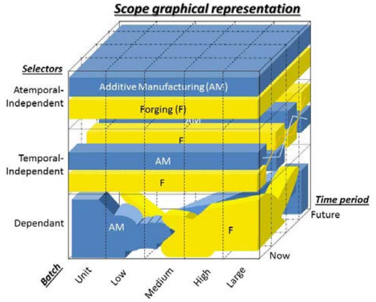
Industry sponsor(s)
AFRC

Project background
Analysis of complex microstructures such as those in Ti6Al4V are currently conducted at the AFRC using a manual process. For example, measuring grain size requires experienced materials experts who are able to locate the axis of every grain to be measured. This process is slow, time consuming and has poor repeatability. Image segmentation techniques offer a solution to these issues by partitioning an image into its constituent grains in an automated way. Software can then easily produce a variety of measurements based on this partition.

Overall aim
The aim of this project is to develop digital image processing techniques to improve the microstructural analysis of alloys with complex microstructures such as Ti-6Al-4V. This includes features such as alpha grain size, platelet width and the size and orientation of colonies these platelets form.

Project title
Future potential analysis and selection of typological manufacturing processes

Research theme
Manufacturing process selection



Programme
Engineering Doctorate

Student
Antonio Heredia

Supervisor(s)
Michael Ward, Ian Whitfield and Hilary Grieson

Industry sponsor(s)
AFRC

Project background
Manufacturing process technology capabilities have changed dramatically in the last decade. Furthermore, designs are rapidly analysed and produced, leading to a highly complex scenario for deciding which manufacturing process to invest in. This investment must be amortised and a profit generated before the manufacturing process becomes uncompetitive, outdated, or obsolete for the required task. Accordingly, the previous manufacturing selection tools proved their efficiency within their related developing context, but not within the current manufacturing context. It must be said that few were focused on delimited both manufacturing processes and facts. However, those that were aimed to capture the overall manufacturing context also lack from proper evaluation of the current context. The main cause of it is the rapid manufacturing technologies' development that even makes recently published approaches obsolete. Hence, the future manufacturing processes context must be forecasted and considered within the comparison.

Overall aim
A decision-making approach or tool for future potential analysis and comparison of typological manufacturing processes (TMP) represented by additive manufacturing and forging. The outcome of the project aim will minimise investment risk and rapid technology development's uncertainty.

Project title

Triple hybrid additive manufacturing

Research theme

State of the art process development and best practice

Programme

Engineering Doctorate

Student

Besa Mumba

Supervisor(s)

Jorn Mehnen and Paul Blackwell

Industry sponsor(s)

AFRC

Project background

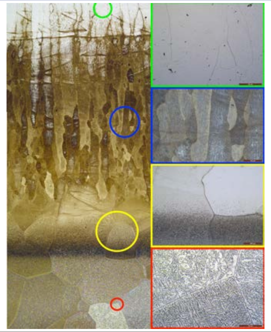
Manufacturing throughout history has always been the backbone of society. Thus, as societies have advanced naturally so have the technologies utilised. As a result, many fabrication processes exist today aimed at supporting production throughput, design complexity and increasingly challenging application requirements. This has opened the door for the hybridisation of multiple fabrication processes combined in a singular manufacturing cell. These developments have been aimed towards synergistically gaining the benefits that each fabrication technology provides to support industry needs. At Strathclyde, we are looking at the limitations of hybridisation and the ways in which these limits can be overcome and the scope of hybridisation extended.

Overall aim

The specific focus is on investigating wire arc additive manufacturing and its combination with CNC and powder additive fabrication processes. Moreover, investigating the limitations of combining 3 fabrications process in terms of technical challenges found in certain geometries to quality assurance.

Project title

Examination of hybrid manufacturing techniques to produce titanium parts for safety critical applications for aerospace.



Research theme

Additive manufacturing

Programme

PhD

Student

Calum Hicks

Supervisor(s)

Paul Blackwell and Tatyana Konkova

Industry sponsor(s)

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Project background

Titanium alloys are increasingly being used in heavily loaded applications such as aircraft undercarriages due to their low density, excellent corrosion resistance and good fracture properties. The downside of using such alloys are that they are expensive to produce.Typical manufacturing methods are 'subtractive': machining material from large forgings. The process produces high material waste. Moreover, Titanium is notoriously difficult to machine. Therefore, closer to form manufacturing options, such as Additive Manufacturing, are of interest to industry. This project aims to investigate the use of additive manufacturing technologies, such as laser metal deposition and wire and arc additive manufacturing, to add details to safety critical titanium forgings. Such a process results in microstructural, and therefore mechanical property, variations between the parent part and the additive section. Such structures also demonstrate high levels of anisotropy and residual stress which must be carefully managed.

Overall aim

To determine the effectiveness of laser metal deposition and wire and arc additive manufacturing to deposit an aerospace high strength beta-titanium alloy on a forged substrate material, with particular interest on the microstructure, residual stress and mechanical properties around the substrate and deposition interface.

Project title

Active chatter suppression in machining processes

Research theme

Chatter vibration suppression

Programme

Engineering Doctorate

Student

Chee Keong See

Supervisor(s)

Jorn Mehnen and Stephen Fitzpatrick

Industry sponsor(s)

AFRC

Project background

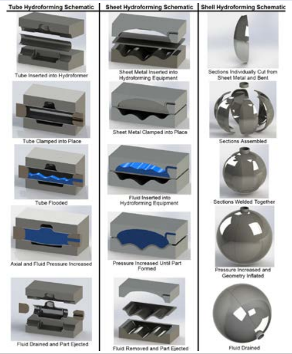
The current state of the art explores real time chatter monitoring technology. Topics investigated include detection of chatter using innovative algorithms and techniques, and control through passive and adaptive techniques. There is also growing interest in developing an intelligent chatter suppression system, where it can learn, adapt and make decisions to inhibit chatter vibration at real time, without any assistance from the operators. This project will have a similar theme and looks to develop an active chatter suppression system that can control machining vibration at real time.

Overall aim

The aim of this project is to be the first to develop the capability to transition 'active' chatter monitoring system for high-speed machining into industrial applications.

Project title

Design for hydroforming



Research theme

Hydroforming technology

Programme

Engineering Doctorate

Student

Colin Bell

Supervisor(s)

Jonathan Corney, Nicola Zuelli, David Savings and Steven Halliday

Industry sponsor(s)

Rolls-Royce

Project background

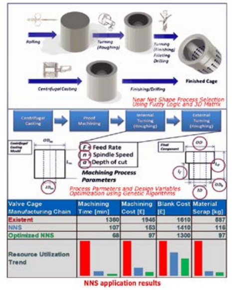
A knowledge gap exists in the use of hydroforming techniques in the area of sheet hydroforming within the aerospace industry. This processes potentially offers the capability to replace not only conventional forming techniques but possibly even processes like casting and forging. The potential is visible in several different areas, first the complicated feature generation enables a reduction and simplification of press tooling specifically because hydroforming (generally) uses a single die instead of a matching set. Second, the number of components in an assembly can be reduced because as each component is more individually complex, fewer are necessary to create a final finished assembly or component. Lastly, because the numbers of components in an assembly are reduced it is possible to reduce weight in a component which is of particular interest to the aerospace industry. This work intends to capitalise on these process capabilities by enabling hydroforming technology through the creation of a design guide.

Overall aim

The overall aim is to create a "design for hydroforming" process for complex aerospace structures in aerospace grades of material. This is to be completed a combination of a thorough review of the scientific literature and the results from several sets of hydroforming experiments.

Project title

An application protocol for near net shape technologies implementation



Research theme

Manufacturing modeling and optimisation

Programme

Engineering Doctorate

Student

Daniele Marini

Supervisor(s)

Jonathan Corney and Paul Xirouchakis

Industry sponsor(s)

The Weir Group

Project background

The near net shape (NNS) approaches aim to develop semi-finished products that are as close as possible to the desired final geometry and technological characteristics. Thus the objective of NNS is the elimination, or reduction, of finishing steps (e.g. machining operations, heat treatments etc.) and the minimisation of raw material usage (e.g. reductions in scrap and wastage). Reduction of machining steps, or the grouping of many components into a single piece, can lead to both a shorter process chains and lower variability with increased quality. Reductions in fabrication and assembly operations reduce the opportunity for errors and result in lower scrappage. The literature review highlights a lack of systematic methodologies that support a holistic approach to assessing the impact of an NNS process (in terms of machining time and raw material consumption) on an established manufacturing chain as well as optimizing their implementation in established manufacturing processes.

Overall aim

The project aim is to implement a NNS manufacturing process into an existent manufacturing chain, selecting it among several candidates. A dedicated surrogate of the manufacturing chain can establish the NNS process' technological and economic feasibility, as well as optimise supply chain cost and product design.

Project title

Industry 4.0 and augmenting the millennial worker

Research theme

Energy

Programme

PhD

Student

Eleanor Smith

Supervisor(s)

Paul Blackwell, Dorothy Evans, and John Richardson

Industry sponsor(s)

Booth Welsh

Project background

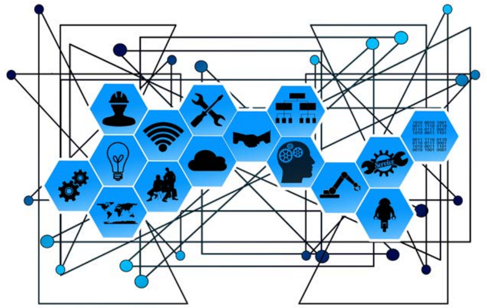
The Renewable Engine programme is a cross-border collaboration to contribute to research in the fields of Renewable Energy and Advanced Manufacturing, where students work between an academic institution and local industrial partner. This project is in collaboration with a local company, Booth Welsh, to discover how Industry 4.0 technologies can improve asset availability in offshore wind turbines. In particular, it will explore how augmented reality (AR) can be used to improve error rates and completion times of maintenance tasks, by superimposing relevant data, instructions and guidance onto technicians' view of the real world. Implementation costs and potential savings will also be assessed to determine the types of task which might most benefit from these technologies. A prototype AR system will then be built and tested on a real wind turbine, to verify performance outside of controlled laboratory conditions.

Overall aim

The aim of the project is to evaluate how augmented reality (AR) based instructions can improve the maintenance of offshore wind turbines, by developing and testing a prototype AR system in a real offshore environment

Project title

The emergence of supply networks for technological innovation: Modelling strategy and policy implications



Research theme

Supply chains for technological innovation

Programme

PhD

Student

Erica Melo de Carvalho

Supervisor(s)

Athanasios Rentizelas and William Ion

Industry sponsor(s)

AFRC

Project background

Innovation is a key driver of economic growth. However, it is estimated that four in five innovations fail to get commercialised. To address this challenge, the role of research institutions has been emphasised to facilitate the translation of research into commercial applications. However, emerging technology lacks the supply chain infrastructure to feed the deployment, operation and maintenance of these operations. Despite industry-academia-government combined efforts to develop advanced materials and manufacturing processes, without a supply chain to support it, there is no business case – unless organisations are prepared to make capital investment and manufacture in-house. While innovation is often associated with end products, less explored is the development of an upstream supply market of ancillary products and manufacturing services to enable technological innovations to succeed. The challenge lies in the amplified uncertainties faced by upstream actors in the supply chain with regards to both technological and non-technological issues.

Overall aim

Public policy and corporate strategy play a key role to de-risk the innovation process. Therefore, this research aims to develop an agent-based model to support the design and evaluation of policy and strategy to facilitate the development of domestic supply chains for emerging technology in the High Value Manufacturing sector.

Project title

Incorporating heat storage inside twin-walled evacuated tube solar collector

Research theme

Energy

Programme

PhD

Student

Fatin Abdalla

Supervisor(s)

Paul Blackwell and Dorothy Evans

Industry sponsor(s)

Soltropy

Project background

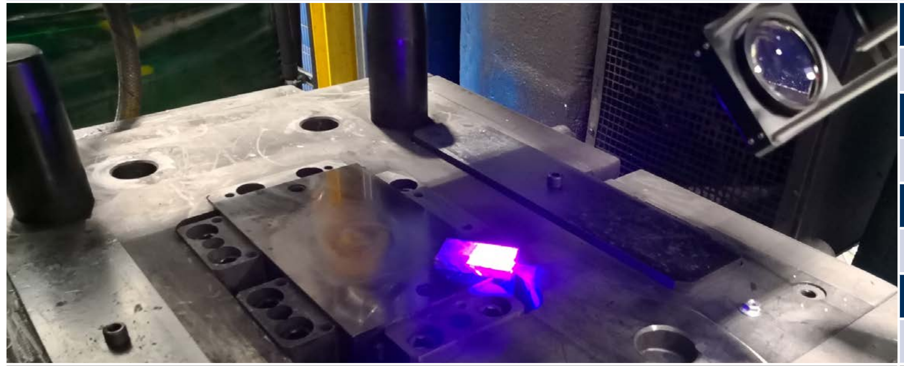
While government policies have encouraged the deployment of environmentally-friendly power producing plants, decarbonising heating systems have remained one of the greatest challenges. The UK set a target of 11% of heat being generated by renewable sources by 2020. However, the seasonal variation in heat demand is remaining a large challenge. Thus, future energy systems will require the integration of renewable electricity and heat with either short and/or long-term storages to satisfy the daily and seasonal mismatch. Against this background, the main aim of this project is to develop a low cost thermal energy storage for the solar thermal system, the evacuated tube solar collector type for domestic sector use. The project studies evacuated tube collectors, in particular, in the context of solar water heaters, aiming to open up this technology for space-heating and therefore reduce the reliance on fossil fuels to heat our homes.

Overall aim

The aim is to combine heat storage and a solar thermal system. This can store and provide heat whenever little or no solar energy is available which will improve the utilization of the collected solar energy. Also, the efficiency will be increased, allowing oversizing and so contributing to space heating without increasing the hot water cylinder size.

Project title

On the use of phosphor thermometry for temperature monitoring in manufacturing processes



Research theme

Phosphor thermometry

Programme

PhD

Student

Fraser McCallum

Supervisor(s)

Andrew Heyes and David Butler

Industry sponsor(s)

NPL and AFRC

Project background

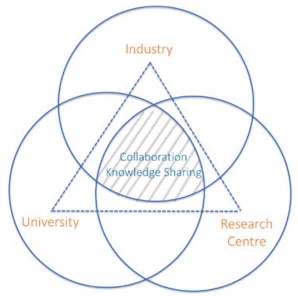
In the metalworking industry, continuous monitoring and control of temperature is vital to enhance process efficiency, reduce wastage, and attain product reliability in high-value manufacturing processes. The industry is currently limited in measurements of temperature, operating in high temperature environments for prolonged periods of time surface contact sensors are prone to drift and infra-red pyrometry which is troubled with emissivity issues. This project aims to explore an alternative thermometry technique – phosphor thermometry for use in metalwork manufacturing.

Overall aim

To further develop phosphor thermometry as an alternative thermometry technique for use in metalworking to enhance process control, directly improving finished product quality.

Project title

Development of framework for improving university-industry collaboration



Research theme

University and industry collaboration; intermediary centres; innovation; strategic management

Programme

Engineering Doctorate

Student

Gennaro Strazzullo

Supervisor(s)

William Ion and Abigail Hird

Industry sponsor(s)

AFRC

Project background

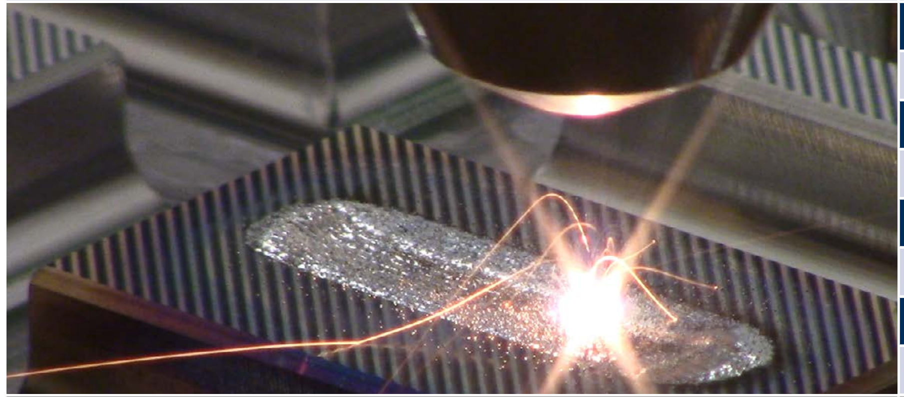
In the last decade, the phenomenon of university-industry collaborations has had substantial interest as a source for knowledge production and new technological advancements, providing one of the core pillars for the innovation and economic development. Many studies have been undertaken on this type of collaboration, which is based on the model such as the Fraunhofer model. However, this model is too general to describe the innovation and it does not fit well for the UK. The issue for this collaboration is due to the gap between the early stage basic research and commercialisation. This shows that there is not a model that addresses well the gap between research and practice. To overcome this problem, translation knowledge is necessary, which is carried out through translational infrastructure (i.e. research centres) that are positioned between academia and industry. Thus, the research centre has the aim to facilitate collaboration between university and industry to transfer academic result for commercial purpose.

Overall aim

The aim of this work is to investigate the nature of the collaboration among university, industry and research centre through the analysis of the factors that affect this collaboration in order to establish a positively impact in terms of competitiveness and performance. To do this, I will be developing a framework for working closer with universities in order to speed up the commercialisation of knowledge to help the UK industry to gain competitive advantage.

Project title

Evaluation of laser metal deposition using stellite® 21 for die remanufacturing



Research theme

Additive manufacturing / remanufacturing

Programme

Engineering Doctorate

Student

Grant Payne

Supervisor(s)

Stephen Fitzpatrick, Paul Xirochakis and William Ion

Industry sponsor(s)

AFRC

Project background

The exploitation of additive manufacturing (AM) in the repair and remanufacture of industrial components, such as moulds and dies, has become an emerging research area due to the expected reduction of replacement cost and the promise of better mechanical and wear resistance properties – moreover, the use of remanufacturing standards ensures a greater than or equal to warranty part quality. Laser metal deposition with powder (LMD-p) has been used to remanufacture artificially worn H13 Steel samples, allowing for benchmarking studies to be conducted in order to compare the mechanical and wear resistance performance of LMD-p against current welding repair technologies.

Overall aim

Valdidate and appraised laser metal deposition with powder (LMD-p) as a remanufacturing method of high value tools, moulds and dies.

Project title

A framework for Industry 4.0

Research theme

Industry 4.0

Programme

PhD

Student

Hanna Lilja Jonasdottir

Supervisor(s)

Jorn Mehnen and William Ion

Industry sponsor(s)

AFRC

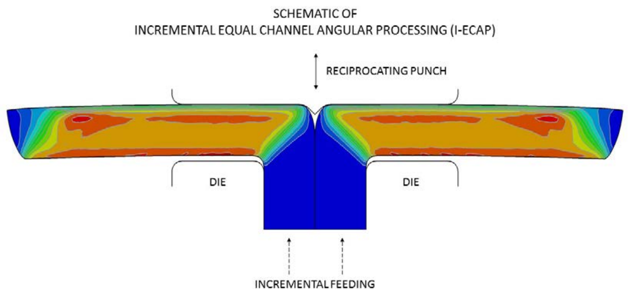
Project background

The fourth industrial revolution, or Industry 4.0, is currently taking place. Industry 4.0 has two major research themes, i.e. smart factories and intelligent production. Making manufacturing processes and factories smarter is important as it provides a better control of the process which will, as a consequence, increase the quality of the products produced. Furthermore, it allows for more integration throughout the product life cycle. Industry 4.0 requires the coordination between multiple disciplines and different technologies need to be used in order to deliver the objectives. Even though the technologies have been developed, they have yet to be integrated and combined into a system.

Overall aim

The aim of the thesis is to create a framework to make robotic cells smarter.

Project title
Nanostructured biocompatible titanium for biomedical implants



Research theme
Titanium, biomedical materials, severe plastic deformation and grain refinement

Programme
Engineering Doctorate

Student
Jacob Roszak

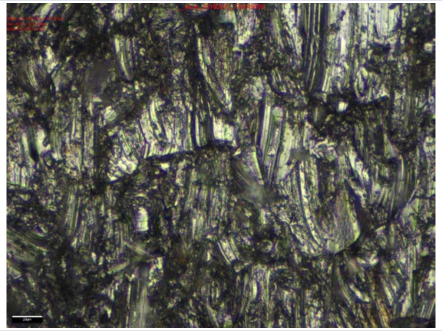
Supervisor(s)
Andrzej Rosochowski and Malgorzata Rosochowska

Industry sponsor(s)
AFRC

Project background
For orthopaedic implants, commercially pure titanium (CP-Ti) and titanium beta-alloys such as Ti-13Nb-13Zr are seen as potential alternatives to the commonly used alloy Ti-6Al-4V, due to their superior osseo-integration and biocompatibility, and reduced stiffness, which helps mitigate stress-shielding. However, due to insufficient initial strength, it is first necessary to achieve an ultrafine-grain (UFG) grain structure through severe plastic deformation (SPD). Incremental equal channel angular pressing (I-ECAP), a new SPD process, can process significantly longer billets compared to conventional ECAP, as friction is reduced by separating material feeding and material deformation.

Overall aim
To develop a method of using I-ECAP to produce UFG CP-Ti and Ti-13Nb-13Zr (a promising yet under-utilised material) and then further processing these via secondary processes in order to further improve the mechanical properties, which typically saturate during SPD.

Project title
Influence of sheet conditions on the formability



Research theme
Sheet metal forming - edge defects

Programme
Engineering Doctorate

Student
Kwame James Sefakor

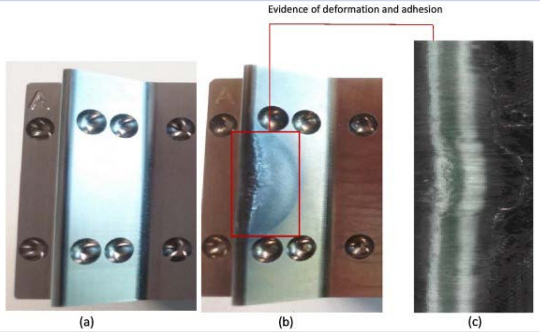
Supervisor(s)
Paul Blackwell and Evgenia Yakushina

Industry sponsor(s)
AFRC

Project background
Due to the specific forming conditions required for low temperature sheet forming (high forming forces), the materials become susceptible to surface defects. It is also known that, surface roughness of sheets have enormous impact on their formability. Surface roughness results in premature nucleation of micro cracks during forming and the subsequent failure of the part. Also, uniform distribution of surface features is known to influence the forming properties positively. However, relevant literature on the effect of surface conditions on the forming behaviour of titanium is scanty. Hence, understanding the effect of the types of single defects, their orientation and distribution over titanium parts formability will be vital towards further future developments in the industry. This will help inform the optimisation of forming regimes as well as clarify the requirements of supplied sheets. Poor lubrication of titanium is also one of the major causes of surface defects in cold forming. Understanding the lubrication regime occurring during room temperature forming process will help improve the efficiency of forming operations and reduce die wear.

Overall aim
This project seeks to establish the impact of deformed edges on the formability of sheet titanium. It also aims to assess the effect of surface roughness on surface quality and forming limit of titanium as well as establishing the lubrication mechanism during forming at room temperature.

Project title
Abrasive and Adhesive Wear Investigation on H13 Tool Steel in Hot Forging



Research theme
Forging h13 tool steel

Programme
Engineering Doctorate

Student
James Marashi

Supervisor(s)
Paul Xirouchakis and Remi Zante

Industry sponsor(s)
AFRC

Project background
Forging tools, according to statistics, are responsible for around 40% of the cost of any forging operation. Therefore, preserving these tools and investigating the cause of their failure is extremely valuable. H13 tool steel is one of the materials which is being used in the forging industry for its resistance towards wear, heat checking, fracture, thermal and mechanical fatigue. According to the literature wear is responsible for 70 % of failure in hot forging and abrasive and adhesive wear are the main failure modes in open die forging. Therefore, the concentration in this thesis has been given to abrasive and adhesive wear. For investigating these failure modes a full factorial design of experiments was applied on series of FE simulations followed by a series of forging trials. The wear prediction results from the FE simulations model were compared to the wear measurement of tools which showed a close correlation. During the forging process some deformation was observed on the tool which was investigated using cause and effect analysis and material characterisation investigation. The results confirmed that deformation and changing the tool was considered as a resolution. Further FE simulations followed by forging trials were performed and abrasive and adhesive wear maps at different sliding velocity and contact pressure were plotted. The produced wear maps were used by the Advanced Forming Research Centre (AFRC). The developed method will help to optimise H13 tool steel performance and make the manufacturing process more cost effective. The optimised and predicted wear conditions help to minimise tool wear and improve the quality of obtained parts. This methodology can also be used to compare different die materials, lubricants, and coatings.

Overall aim
The purpose of this work is to identify the dominant failure mode in H13 tool steel during open die forging and to model this failure to allow life prediction and to establish a robust method of measurement.

Project title
Gravitational energy storage

Research theme
Energy storage

Programme
PhD

Student
James Reid

Supervisor(s)
Paul Blackwell and Dorothy Evans

Industry sponsor(s)
Caley Ocean Systems

Project background
The gravitational energy storage project presents a novel development in energy storage. The storage system, similar to pumped hydroelectric storage, involves the conversion of potential energy to electrical energy. This is conducted through releasing a suspended steel weight in a wellbore. The steel weight is returned to the surface of the wellbore when the energy supply exceeds the demand for the local grid or National Grid. The electricity delivered to the grid is controlled through varying the depth of weight release. The demonstrator design consists of a 1500m vertically drilled hole containing a string of 156 steel weights suspended in a drilled hole. The string of steel weights are connected at surface to a specialised winch system and ten 200 kW electric motors. The steel weights, totaling a length of 456m, are released to generate a maximum power of 3MW and a total energy output of 1MWh.

Overall aim
The main aim of the project is to maximise the round trip efficiency of the system. Further project aims are to: optimise the use control systems and electrical components. The levilised cost of storage (LCOS) will also be found to define the competiveness of the project in comparison to existing grid-scale energy storage systems.

Project title

Developing a device to upgarde legacy machines

Research theme

Smart computing in Industry 4.0 for legacy machines

Programme

Engineering Doctorate

Student

Karishma Dhanani

Supervisor(s)

Jörn Mehnen and Michael Ward

Industry sponsor(s)

AFRC

Project background

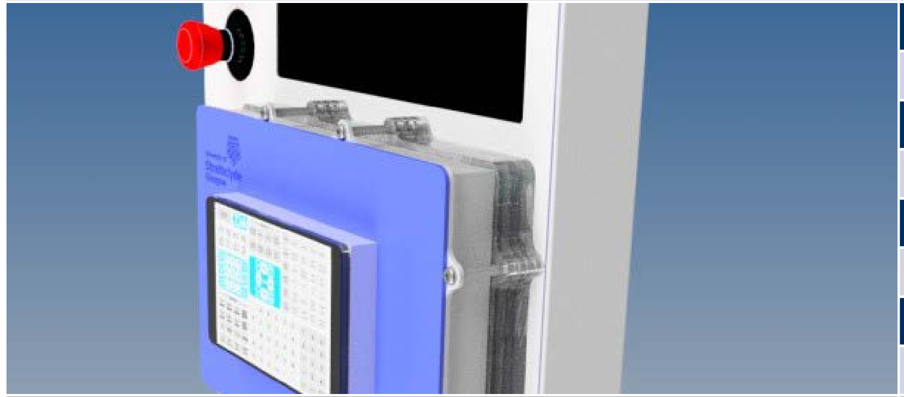
There has been a great development with Industry 4.0 technologies, with the benefits of these technologies being experienced across the entire manufacturing supply chain. Manufacturing organisations have identified the benefit of incorporation cyber physical systems within the factory shop floor, especially industrial internet of things (IIoT) devices which is said to improve the efficiency and performance of the manufacturing process. By creating a device that will allow machines to incorporate cyber physical systems will allow organisations to take advantage of digitalisation without having to invest large amounts of resources in new machinery and infrastructure.

Overall aim

The aim of this project is to implement an IIoT device with the capability and technology to create a platform which has the ability to upgrade machines currently used in factories into Industry 4.0.

Project title

Augmenting existing manufacturing equipment with a digital connection to a smart environment



Research theme

Implementation of smart modular sensors within manufacturing

Programme

Engineering Doctorate

Student

Kenneth McRae

Supervisor(s)

Jorn Mehnen and Michael Ward

Industry sponsor(s)

AFRC

Project background

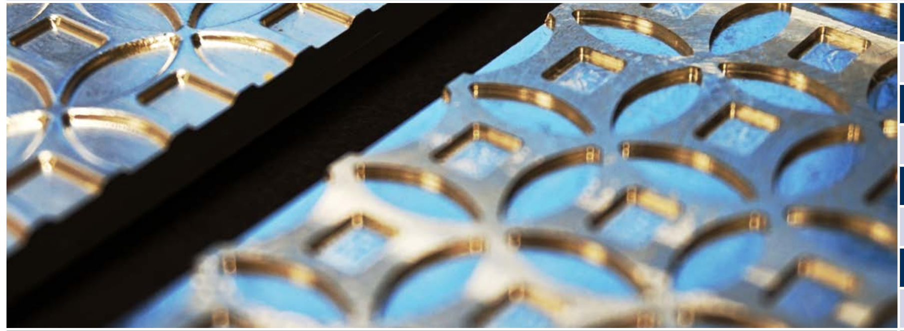
This research project aims to provide cost-effective hardware and a methodology to implement a connection for legacy manufacturing machines, so that Industry 4.0 techniques can be utilised without the need to replace working equipment. The design concept is to enable remote assistance to help the operator with the production and maintenance of the equipment, as well as provide technical support for errors and issues that arise. This will benefit the research and development of smart technologies by reducing the barriers of accessing capable equipment. With sufficient development, this could provide a marketable product for the industry to upgrade legacy equipment and production facilities to Industry 4.0 standards.

Overall aim

To provide a system that will non-intrusively retrofit manufacturing equipment, so that it can be integrated with a digital connection to the Industry 4.0 infrastructure, capable of controlling a smart production environment.

Project title

Embedded meaning - CNC machining strategies for emotional aesthetics



Research theme

Form creation and form perception

Programme

Engineering Doctorate

Student

Lewis Urquhart

Supervisor(s)

Andrew Wodehouse and Alastair Conway

Industry sponsor(s)

AFRC

Project background

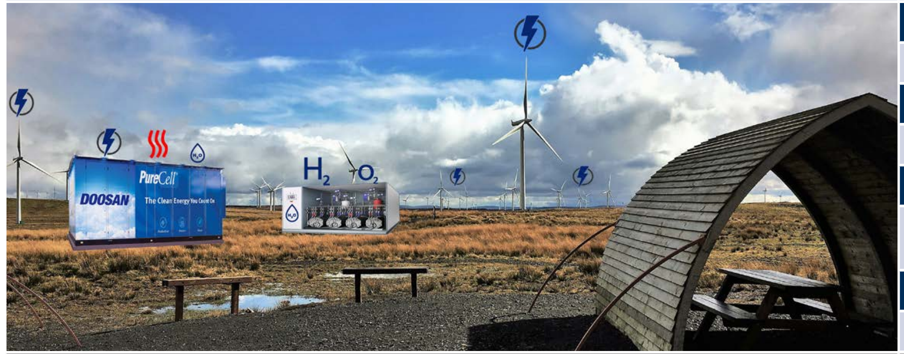
This project focuses on bringing concepts traditionally associated with conceptual design or aesthetics together with an understanding in advanced manufacturing technology, specifically CNC machining. We are focusing on using decorative pattern structures as a means of enhancing "emotional design" in an industrial/product design context. By translating two-dimensional patterns into three-dimensional structures, we will examine machining capability in terms of pattern production and quality. Additionally, we will analyse the emotive qualities of these forms after production both perceptually and interactively. This will allow us to contribute to the understanding of how form is perceived by us and how patterns can be used in this specific emotive context. It will also tell us the scope and feasibility of creating such forms utilising CNC machining technology.

Overall aim

1) Develop a range of patterns based on experimentation analysing form and human perception of form in terms of emotion 2) Translate these patterns into 3D CAD objects, ready to be extracted from material 3) Utilise CNC machining to extract designs from solid material 4) Carry out user testing experiments to determine the emotive content of the forms as a visual experience and an interaction experience.

Project title

Techno-economic analysis of decentralized sustainable energy systems installation and market potential at the sector and system level



Research theme

Energy

Programme

PhD

Student

Maria Damaskou

Supervisor(s)

John Harrison , Paul Blackwell, Dorothy Evans and Tekena Fubara

Industry sponsor(s)

Doosan Babcock

Project background

As developed countries try to implement a transition from current fossil-based energy systems to green-powered solutions, economic, environmental and social considerations need be taken into account in order to invest in the optimal technologies. Choosing between green technologies can be particularly complex due to the wide range of variables, parameters and constraints involved. Examples of these factors are the technical potential of a technology within a particular locality e.g. solar, wind, etc, the prevailing economics in the area, the available land area, the value drivers of the customer, the capital and operating cost of different technologies, the consumers' energy use volume and behaviour, etc. Hence, decision-making is often time consuming and difficult to handle with simple analytical approaches. The motivation for this research has been to develop methodologies and algorithms in order to ease decision-making when installing sustainable solutions, with an initial focus on fuel cells.

Overall aim

The project aims to enhance decision-making in industrial applications of sustainable systems. It would benefit both new and existing energy-efficient applications, with minimisation of the need for exhaustive manual calculations. The core is to optimise not only the design of sustainable installations but also their actual day-to-day operation.

Project title

Characterisation and development of the incremental shear forming process for nickel-based aerospace structures

Research theme

Incremental process – material characterisation

Programme

Engineering Doctorate

Student

Marine Guillot

Supervisor(s)

Paul Blackwell and Andrzej Rosochowski

Industry sponsor(s)

Rolls-Royce

Project background

Incremental cold forming processes are characterised by the use of a pre-form (bulk or sheet) that is shaped at room temperature, without the need for pre-heating of either tooling or input material. Through a combination of optimally designed part and tooling, the material is mechanically deformed in incremental stages beyond its elastic limit but within its tensile strength, enabling the input material to be converted to the required geometry whilst maximising net-shape geometry opportunities. Historically, cold forming processes have been experience-based technologies, however, more recently, scientifically structured approaches to its development are being furthered through focused R&D activity. The benefits of cold forming processes to Rolls-Royce can be described in terms of material cost savings, enhanced product characteristics, surface finish quality, reduced production costs and consistency in geometric control.

Overall aim

- Identification of the gaps and issues in research on shear forming
- Practical understanding through forming of different geometries and thicknesses relevant to aerospace structures:
- Generate and collect data
- Identification and study of the effect of the key processing variables study of the material data (microstructure and texture)
- Critical review of the work completed

Project title

Autonomous robotic systems for efficient and effective manufacture and inspection

Research theme

Robotics and manufacturing

Programme

PhD

Student

Martin Grant

Supervisor(s)

Mark Post, Winifred Ijomah, Domenico Campolo (NTU)

Industry sponsor(s)

N/A

Project background

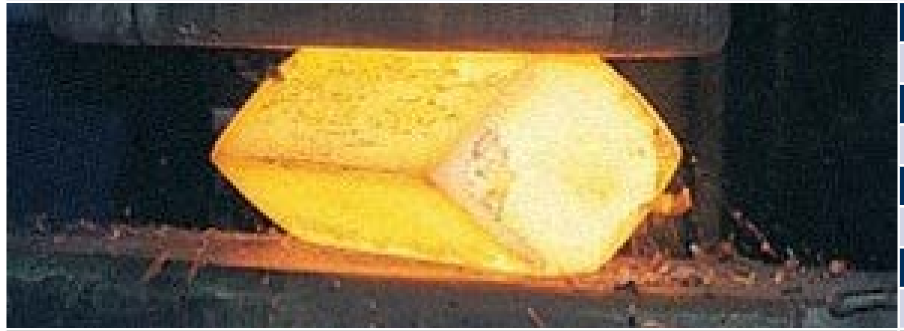
Industry 4.0 demands flexible and dynamic manufacturing factories with intelligent and collaborative robotic technologies. Industrial robots in their current state are ill suited for reprogramming to carry out new tasks and are not able to work closely for collaborative tasks with humans, requiring use of restrictive cages and safety equipment. In addition, industrial robots have been out of reach for many SMEs as they have traditionally been suited for large scale mass production. Recent advances in artificial intelligence (AI) and computer vision can be applied to industrial robots to enable them to work closely and safely with humans. This would allow robots to be utilised for more complex, low volume tasks seen in SMEs.

Overall aim

The aim of this project is to develop computer algorithms to allow an industrial robot to gain intelligent awareness and understanding of their surrounding environment to carry out complex tasks more effectively. This will also allow for easier and more intuitive methods for programming robotic tasks.

Project title

Investigation of the spheroidization process in titanium alloy



Research theme

Materials and process modelling

Programme

Engineering Doctorate

Student

Mathieu Fabris

Supervisor(s)

Andrzej Rosochowski and Salah Rahimi

Industry sponsor(s)

Aubert & Duval and TIMET

Project background

The production of titanium alloys is often done through complex processes which involve a number of steps alternating hot deformation and heat treatment. During these stages microstructural transformations occur, which modify the mechanical properties of the produced alloy. Spheroidization of the lamellar alpha phase during hot deformation is one of the possible microstructural changes. It is dependent on several process parameters such as strain and temperature. This transformation is critical as it produces the more ductile material required for further forming. Substantial amount of research has hence been performed on this transformation; however the impact of strain path on spheroidization kinetics has not been thoroughly studied.

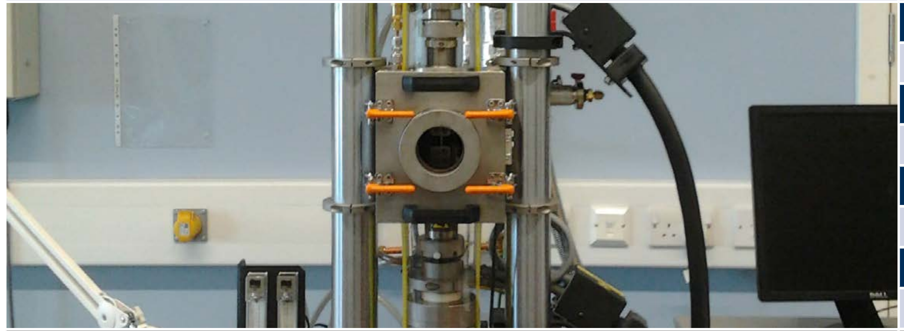
Overall aim

The aim of the EngD is to generate knowledge on the impact of strain path on the spheroidization process in Ti-6Al-4V alloy.
The objectives are:

- Determine the state of the art of spheroidization in titanium alloys
- Evaluate the impact of the processing route on the final microstructure and establish the mechanisms involved in the spheroidization process
- Derive constitutive equations describing this phenomenon

Project title

Understanding the precipitation kinetics of alloy AD730



Research theme

Material science

Programme

PhD

Student

Michael King

Supervisor(s)

Salah Rahimi and Paul Blackwell

Industry sponsor(s)

Aubert & Duval

Project background

Nickel based superalloys are the preferred choice of materials in gas turbine engines due to their excellent mechanical properties at high temperatures. AD730 is one of these alloys which is newly developed and relatively unexplored, it seeks to improve on the important ratio of high temperature mechanical properties versus cost whilst still being manufactured via the cast and wrought route, making it cheaper to produce than the powder metallurgy manufactured superalloys. Alloy AD730 is specifically designed to be a cheaper alternative to Udimet720Li with similar mechanical properties and better workability.

Overall aim

To explore the influence of heat treatments on microstructure evolution and specifically to understand:

- The kinetics of precipitation and dissolution of precipitates as a function of heat treatment temperature
- The evolution of stress as a function of microstructure evolution and in turn the evolution of residual stress during heat treatments

Project title

The identification of the effect of high rate deformation on the microstructure and properties of titanium alloys

Research theme

High speed manufacture and process optimisation

Programme

Engineering Doctorate

Student

Michail Ntovas

Supervisor(s)

Paul Blackwell and Andrzej Rosochowski

Industry sponsor(s)

AFRC

Project background

The understanding of material behavior is critical in process optimisation. The strain rates encountered in either screw press or hammer forging are in the range from approximately 10-200s-1. Such strain rates are at the lower end of the dynamic testing regimes in which the analysis methodologies become more complex than for slower quasi-static tests. In addition, conventional testing machines struggle to reach velocities required to generate strain rates more than 5s-1. There consequently exists a paucity of data regarding material behaviour in this strain rate regime. Furthermore, titanium alloys have a relatively low thermal conductivity and hence are prone to the formation of adiabatic shear zones which localize metal flow. This can produce a deleterious non-uniform deformation pattern across a forged part that can generate poor properties in the final component. Titanium alloys are also prone to the formation of strong crystallographic textures which can further complicate the deformation behavior. The project will examine the effects of both of these phenomena.

Overall aim

The experimental process for high rate compression experiment is challenging. The aim of the project is to optimise and create a framework for high rate deformation experiments. Based on that framework the effect of strain, temperature and strain rate on the microstructure of Ti6Al4V will be investigated.

Project title

Investigating relationships between laser metal deposition deployment conditions and material microstructural evolution

Research theme

Laser metal deposition

Programme

Engineering Doctorate

Student

Mike Wilson

Supervisor(s)

Paul Xirouchakis and Jonathan Corney

Industry sponsor(s)

AFRC

Project background

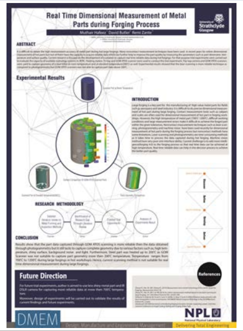
Laser metal deposition (LMD) as a form of additive manufacturing has provided a new and unique method for manufacturing a wider range of components when compared to traditional subtractive methods. LMD can be utilised for the repair and remanufacture of metallic components with reduced replacement costs and with the potential for better mechanical and wear resistance properties ensuring remanufactured components are better than or equal to originals. The primary attraction for AM is the ability to create components with materials, geometries, complexity, accuracy and programming which would previously have been extremely difficult or impossible with traditional methods. It has long been established that the primary factor in determining material microstructure evolution is cooling rates, which are substantially effected by scanning path speed (mm/min) and toolpath geometry. Further studies have shown considerable material microstructural variance depending on laser power (W), scan speed (mm/min), layer thickness (μm), overlap percentage (%) and flow rate (g/min) input parameters.

Overall aim

The overall aim is to establish correlations between the microstructural evolution of LMD materials and varying LMD deployment parameter inputs. Understanding the correlations affords the ability to control mechanical properties such as surface roughness, density, hardness, yield strength and ultimate tensile strength through material composition selection.

Project title

Real time dimensional measurement of metal parts during hot forging process



Research theme

Manufacturing

Programme

PhD

Student

Muthair Hafeez

Supervisor(s)

David Butler and Remi Zante

Industry sponsor(s)

NPL

Project background

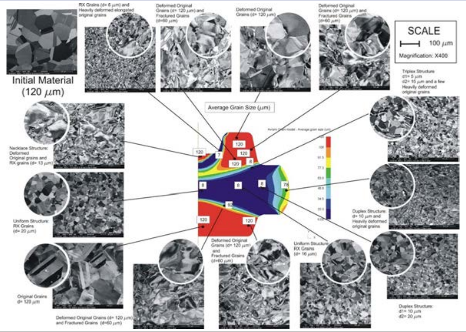
Large forging is a key part for the manufacturing of high value metal parts for the aerospace and steel industries. It is difficult to do precise dimensional measurement of hot part during large forging. Contact measurement tools such as calipers and scales are often used for dimensional measurement of hot part in forging workshops. However, the high temperature of metal parts (700'C-1200'C) ,difficult working conditions and large measurement errors make it difficult to achieve the forged part within the given tolerances. Non contact measurement techniques such as laser scanning, photogrammetry and machine vision have been used recently for dimensional measurement of hot parts during the forging process but non contact methods have some limitations. Laser scanning and photogrammetry are time consuming methods as it takes time to process the data captured during hot forging. Machine vision method have very poor anti-interface ability. The current challenge is to add more intelligence (forging4.0) to the forging process so that real time data can be achieved at high temperature. Real time reliable data can help in the decision process to achieve the better part quality.

Overall aim

The research aim is to add more intelligence (forging 4.0) to the forging process so that real time data can be achieved at high temperature. Real time reliable data can help in the decision making process to achieve the better part quality.

Project title

Microstructural modelling in nickel superalloys



Research theme

Modelling

Programme

Engineering Doctorate

Student

Nicola Stefani

Supervisor(s)

Paul Blackwell, Olga Bylya and Aleksey Reshetov

Industry sponsor(s)

AFRC

Project background

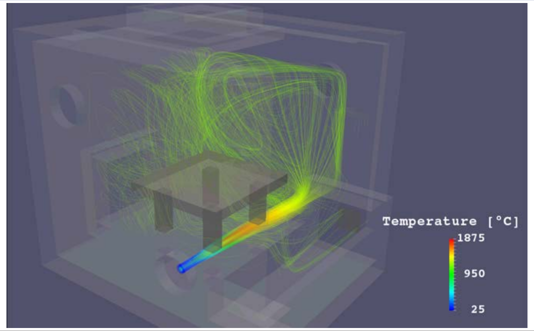
Nickel Alloys are used in the aerospace sector for their ability to withstand high stresses at elevated temperatures. (e.g. in gas turbine engines). The final properties of the forged part significantly depend on the obtained material microstructure. Some types of microstructures can be obtained by heat treatments while the development of others has to be taken care of through the total chain of manufacturing operations. Through-process FE modelling of the microstructural evolution can play a vital role in the optimisation of such manufacturing technologies. Moreover, the main data used in the material models is normally obtained from uniaxial lab tests conducted under constant temperature and strain rate for small strains (<=0.7). Extrapolation of the experimental data as well as interpolation of it for complex loading histories remains an open question. The embedment of microstructure evolution prediction into a constitutive model gives an opportunity to resolve this problem.

Overall aim

The main project aim is to develop a coupled microstructure evolution model for IN718 that can be embedded within commercial software FE packages.

Project title

Experimental study of a semi-industrial gas furnace



Research theme

Energy

Programme

PhD

Student

Nicolas Torino

Supervisor(s)

Jonathan Corney, William Dempster and Sebastien Nouveau

Industry sponsor(s)

Aubert&Duval

Project background

Heat treatment process involves typically 3 steps: heating at a specified rate (°C/s), soaking at a specific temperature for a defined period and cooling at a specified rate (°C/s). During these stages, metallurgical transformations occur, which modify the mechanical properties of the produced component. Even though knowledge of material science is well established, questions still remain on the effect and control of heat treatment processes at the industrial scale. Indeed, the production of heat-treated parts is currently achieved through large industrial gas furnaces using empirical based guidelines. However, the temperature control desired by metallurgical requirements is challenging with temperature tolerances of the order of 10 oC on temperatures of 10000C which have largely been not achievable in industrial scale furnaces. To improve this situation a better understanding of the furnace heat transfer processes are required and it is believed that this can be achieved through computational fluid dynamic modelling approaches.

Overall aim

The objectives are:

- Examine the technical literature and establish the current state of the art regarding high temperature measurement, mathematical modelling and computational solution of heat treatment furnaces.
- Evaluate the most important flow and thermal physics that need to be understood to satisfactorily control heat treatment processes.
- Validate a mathematical model able to scale from a small scale pilot furnace to industrial sizes.

Project title

Development of capability framework in managing manufacturing improvement within innovation providers

Research theme

Technology management

Programme

Engineering Doctorate

Student

Olga Uflewska

Supervisor(s)

Andy Wong and Michael Ward

Industry sponsor(s)

AFRC

Project background

This project is the first to define a new perspective on capability management of research centres shaping the High Value Manufacturing (HVM) Catapult network in the UK. The HVM Catapult network was established to address the valley of death (i.e. the gap between Industry and Academia) in the UK's manufacturing sector as well as to drive the country's economic and technological growth. Literature in both management and manufacturing areas, however, has long focused on industrial companies and how these companies can better manage their capabilities in order to improve their competitiveness. Capability management of research centres which are the most crucial players in addressing valley of death is rarely examined. Through our exploratory approach, we uncover a knowledge gap which confirms a lack of understanding of capability management within research centre environment.

Overall aim

New capability management framework aims to make decision making process and strategy building more efficient and robust. This framework aims to become a first standard within the HVM Catapult network.

Project title

Development of a guided wave emat online inspection system for al/al-sn/al/steel and cusn/steel bimetal strip bond quality used in the automotive industry

Research theme

Non-destructive testing

Programme

Engineering Doctorate

Student

Philipp Johannes Tallafuss

Supervisor(s)

Andrzej Rosochowski and William Ion

Industry sponsor(s)

MAHLE Engine Systems UK

Project background

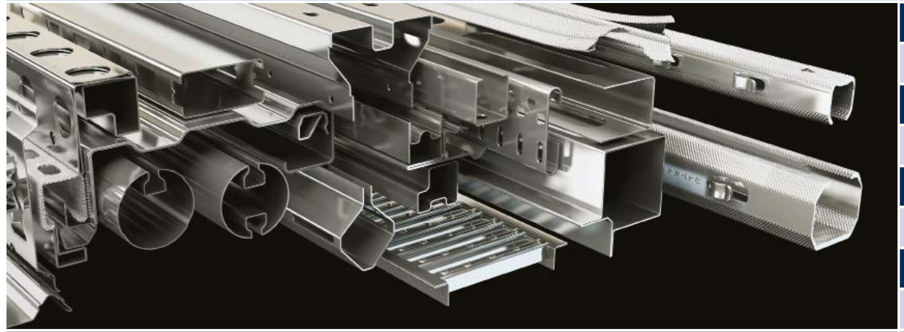
In cold roll bonding, the solid state weld is achieved by a substantial and simultaneous plastic deformation of the different metals at room temperature. The disadvantage is the large number of secondary operations and high requirement for bonding surface preparation, which are critical to the bond quality. Bond defects are most critical because they are not visible and therefore difficult to detect, but can cause catastrophic failure of the components in the field. Considering the difficulty to create a metallurgical bond between two dissimilar metals in the CRB process and the limitations of destructive testing, there is a need to develop an automated, online inspection technique to examine the bond of bimetal strips. A non destructive testing (NDT) system could help to correct the production process, minimise scrap, avoid value adding to defective material and reduce the business risk and financial losses.

Overall aim

1. Establish defects in bimetal strip production.
2. Literature review to identify NDT techniques that could be employed for serial inspection.
3. Feasibility study on promising NDT techniques to detect bond defects.
4. Development of a prototype NDT system.
5. Identification of defect root causes and prevention controls.

Project title

Validation of complex product geometry from finite element data of the cold roll forming process



Research theme

Cold roll forming

Programme

Engineering Doctorate

Student

Richard (Kwun Sing) Tsang

Supervisor(s)

William Ion, Paul Blackwell and Martin English

Industry sponsor(s)

Hadley Group

Project background

This project is in collaboration with Hadley Group, Birmingham, the largest independent manufacturer of cold rolled metal sections and profiles in the UK. Hadley Group implemented FE simulations in 2009 to assist tooling designers in making design decisions, traditionally made through an empirical approach. Through the use of FE, the tooling designer can investigate the effects of certain parameter changes within the forming process without the risk of expensive tooling costs. Whilst the designers recognise that the design of profile geometry has improved via use of the software, the global geometry of the linear product still causes significant problems during commissioning, resulting in on-line tooling modifications, down time and cost. In short, FE has proved to be accurate in predicting the forming strategy of a profile, but is poor at predicting when forming defects may occur.

Overall aim

The overall aim is to close the knowledge loop within Hadley Group between the following stages: the design of tooling for a new profile and the commissioning of tooling prior to production. It is through understanding the role of FE that this is to be achieved.

Project title

Determination of key resin parameters to support fe modelling of composites forming

Research theme

Data acquisition and methodology development

Programme

Engineering Doctorate

Student

Rory Brown-Kerr

Supervisor(s)

Paul Blackwell and Dorothy Evans

Industry sponsor(s)

AFRC

Project background

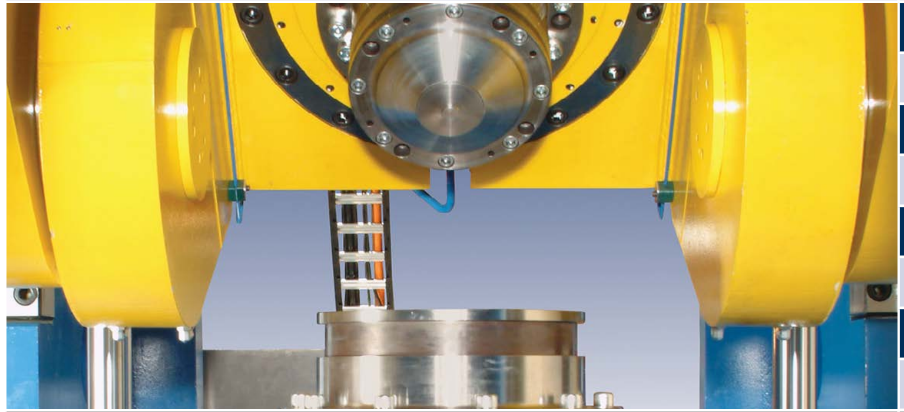
This project was undertaken to help fully understand the presence of processing induced stresses and how resin parameters can be measured in order to successfully create an accurate FE model of the composites forming process. The key properties of the resin which effect processing induced warpage will also need to be determined. Acquiring such information regarding the properties of the resin will require the creation of new test methodologies along with possible creation of novel testing apparatus.

Overall aim

Development of new testing methologies and apparatus. Determination of which resin properties have a meaningful impact on processing induced warpage

Project title

Characterisation and development of rotary forging process



Research theme

Net shape manufacturing

Programme

Engineering Doctorate

Student

Subha Chandra Tamang

Supervisor(s)

Xichun Luo, Michael Ward and Martin Tuffs

Industry sponsor(s)

Rolls-Royce

Project background

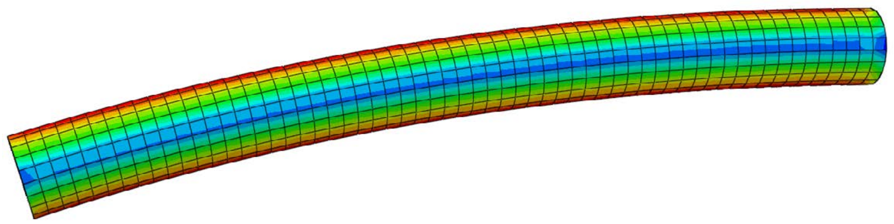
Rotary forging is an incremental metal forming process which offers excellent benefits over conventional forging processes. Some of its benefits are a massive reduction in forming load, relatively low energy cost, high material utilisation, better material formability and high flexibility. This has attracted significant interest from the aerospace industry. Rotary forging seems to fit perfectly well as an alternative low cost manufacturing process. It is an ideal process for low volume and high value production. In compared to conventional forming processes, very little knowledge has been accumulated over past 100 year since its invention. process design rules and guidelines are almost non-existent . This narrows the process design method to mostly trial and error method. This project aims to develop a better understanding of the process through the used of modern metal forming analysis techniques and through series of experiments.

Overall aim

The project has enabled a better understanding of the rotary forging process through the development of a robust finite element process model and through a series of experiments which helped gained an in-depth understanding of the process behaviour and deformation mechanism during the rotary forging process.

Project title

Lightweight robotic arm design for harsh environments



Research theme

Materials selection, topology optimisation, functionally graded materials

Programme

Engineering Doctorate

Student

Thomas McMaster

Supervisor(s)

Xiu T Yan and William Ion

Industry sponsor(s)

AFRC

Project background

Originally, robotic arms were cumbersome and structurally-over redundant to ensure accuracy and repeatability within their work envelope (the entire space the arm can reach between its minimum and maximum range) as a result of control algorithms that were slow and relatively imprecise. Since then, the design of arms has been evolving, expanding the possibilities and applications in which they are used and reducing structural redundancy. However, modern day arms can still be refined, further reducing structural over compensation while maintaining load bearing capabilities. Historically constrained by repeatability, accuracy and rigidity, robotic arms are now constrained by torque, inertia and speed. Lighter arms are therefore advantageous. Design of a lightweight robotic arm can be broken into four interlinked areas: form, structure, material and manufacturing technique. Incorporating these four areas, lightweight robotic arms for future applications can be created.

Overall aim

To create a methodology for the design of lightweight robotic arms for harsh environments. To validate this methodology using practical case studies.

Project title

Residual stress studies in ti-6al-4v alloy

Research theme

Residual stress

Programme

Engineering Doctorate

Student

William Rae

Supervisor(s)

Salah Rahimi, Michael Ward and Jonathan Corney

Industry sponsor(s)

TIMET and Aubert & Duval

Project background

A great body of literature exists on the generation and evolution of thermo-mechanically induced residual stress in aluminium alloys, steels and nickel based superalloys. However, limited studies concerning the heat treatment induced residual stress evolution in titanium alloys exist. The increasingly high numbers of structural parts and engineering components in aircraft with important sizes and geometries that are made from titanium makes this area of research very attractive for the aerospace industry.

Overall aim

To develop and validate a thermo-metallo-mechanical (TMM) model for the prediction of residual stress in heat treated Ti-6Al-4V alloy with consideration for microstructural variations and accompanying constitutive relations.

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