Materials Processing Institute

8th Postgraduate Research Symposium on Ferrous Metallurgy

The latest academic thinking on Ferrous Metallurgy

Tuesday 25th February 2025

VENUE:
Armourers' Hall,
Armourers & Brasiers' Company,
81 Coleman Street, London EC2R 5BJ

#Metallurgy8

2025 Programme

Organised by:

Materials Processing Institute

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Foreword by Terry Walsh

It is my pleasure to welcome you to the 8th Postgraduate Research Symposium on Ferrous Metallurgy.

This symposium has long been a collaboration between the Worshipful Company of Armourers and Brasiers, the Iron & Steel Group of the Institute of Materials, Minerals and Mining and the Materials Processing Institute. These three organisations have once again worked together to organise, fund and promote this event to showcase UK materials research and the steel industry.

Today we bring together some of the UK's leading and most talented postgraduate researchers to share the research that they are undertaking. The standard of applications to speak or to display a poster was extremely high and all selected can be assured that you have achieved a great deal in making it into the programme. Similar to previous years, the Symposium will include presentations and posters from PhD and EngD Students, keynote presentations and awarding of prizes for the best speakers and posters, alongside the Millman Scholarship and Ashok Kumar Fellowship announcements.

This year we thank Dr David Bowden, Materials Science and Engineering - Group Leader at the United Kingdom Atomic Energy Authority, for kindly agreeing to be our keynote speaker. We are also pleased have the Bessemer Lecture as part of the Symposium again; this lecture will be given by Professor Mark Rainforth, Professor of Materials Science and Engineering at the University of Sheffield, and winner of the 2024 IOM3 Bessemer Gold Medal. So, we can look forward to a wide range of presentations and posters from academia and industry involved in ferrous metallurgy research in the UK.

Also, thank you to our Session Chairs and Judges, several of whom have been ever-present since our first symposium in 2018. The expertise and guidance you provide contributes enormously to the Symposium's continued success.

This Symposium is also the third year of a five-year sponsorship arrangement with Tata Steel whose ongoing commitment is greatly appreciated. We also thank our other longstanding sponsors, The Henry Royce Centre at the University of Sheffield, the UKRI Interdisciplinary Centre for Circular Metals and the Cast Metals Federation for their continued support.

I hope that you all enjoy the Symposium today, and have new opportunities to see, hear and share experiences, expertise and knowledge; and make new friends from across the community. Please share your experience with friends and colleagues via social media and do register and encourage others to attend the next Symposium on 24th February 2026.

The Symposium forms part of the dissemination activities of the PRISM programme of research and innovation for the UK Steel & Metals sector. PRISM is funded by the UK government, through Innovate UK and delivered by the Materials Processing Institute.

Terry Walsh
CEO, Materials Processing Institute

Programme

09:00 - 10:00	**Registration, Poster Display, Exhibition and Networking**
10:00 - 10:10	**Welcome and Introduction** *Terry Walsh, CEO, Materials Processing Institute*
10:10 - 11:10	**Session 1: Theme – Product Development** ***Session Chair:*** *Gill Thornton, Globus Metal Powders Ltd* ***1.*** *Exploration of using ferrous alloys as radiation damage resistant materials for fusion* ***Presenter:*** *Sophie Barwick (University of Sheffield)* ***2.*** *3D lattice strain quantification in neutron irradiated steels for fusion energy* ***Presenter:*** *Lucy Fitzgerald (University of Birmingham)* ***3.*** *Low activation bainite steel: design and microstructure* ***Presenter:*** *Pengxin Wang (University of Leicester)*
11:10 - 11:30	**First Perambulation** *Poster Display, Exhibition and Networking*
11:30 - 12:30	**Session 2: Theme - Process Improvement** ***Session Chair:*** *Professor Hongbiao Dong, University of Leicester* ***4.*** *Effects of cold-wire gas metal arc welding (CW-GMAW) process variables on energy input and deposition rate during repair of S275JR structural steel* ***Presenter:*** *Zahraddeen Musa (Cranfield University)* ***5.*** *The impact of high recycled content on high formability products* ***Presenter:*** *Freya Hamblin (Swansea University)* ***6.*** *Ferrite grain size control via two-stage cooling for structural steel tubes* ***Presenter:*** *Nathan Dixon (University of Warwick)*
12:30 - 13:00	**Bessemer Lecture** *Designing steel for a sustainable low carbon future* *Presenter: Professor Mark Rainforth, awarded the Bessemer Gold Medal for 2024*

13:00 - 14:00 **Lunch Break**
Poster Display, Exhibition and Networking

14:00 - 15:20 **Session 3: Theme - Structure Measurement and Property Prediction**
Session Chair: *Dr Richard Thackray, University of Sheffield*

7. *Correlation between electrical resistivity, ultrasonic measurements and microstructural changes in SS316 under high-cycle fatigue*
Presenter: *Maryam Izadi (Brunel University)*

8. *Investigation of fatigue and fracture mechanics properties of structural steels in adverse environments*
Presenter: *Monisha Manjunatha (University of Strathclyde)*

9. *A computational approach towards proactive scale management for steel pipelines*
Presenter: *Megan Kendall (Swansea University)*

10. *Influence of iron oxide corrosion on hydrogen uptake and susceptibility to embrittlement in pipeline steels*
Presenter: *Anthony Reilly (University of Strathclyde)*

15:20 - 15:50 **Second Perambulation**
Poster Display, Exhibition and Networking

15:50 - 16:30 **Keynote Speaker**
Dr David Bowden, UK Atomic Energy Authority
Increasing the heat: Developing next-generation high-temperature steels to deliver commercial fusion energy

16:30 - 17:00 **Awarding of Prizes by the Armourers & Brasiers' Materials Science Committee**
1. Millman Scholarship
2. Ashok Kumar Fellowship
3. Poster Winner
4. Presentation Runner-up
5. Presentation Winner

17:00 - 18:30 **Symposium Ends and Drinks Reception**

Chair of Session 1

Gill Thornton

SESSION 1
Product Development

Gill Thornton
Globus Metal Powders Ltd

Gill Thornton holds a degree in Materials Science and an MBA from Warwick Business School. She has worked in the steel industry for 38 years in technical and R&D roles across the UK. Gill has extensive experience in leading collaborative research projects, mainly in BOS, EAF, Concast and Powder Metals. A recent powder metals project led to Liberty Steel starting a new business; Liberty Powder Metals (sold in 2023 and now called Globus Metal Powders Ltd) to develop and vacuum atomise high quality steel and nickel based alloy powders. Gill is currently the R&D Manager for Globus Metal Powders Ltd. She is also a board member of the IOM3 Iron and Steel Group, a trustee and past president of the Cleveland Institution of Engineers and was awarded the 2021 IOM3 Thomas Medal & Prize in recognition of scientific or technological contribution to the production of any ferrous alloys. In 2023 Gill was made a Fellow of the IOM3.

Presentation 1

Exploration of using ferrous alloys as radiation damage resistant materials for fusion

SPEAKER / LEAD AUTHOR:
Sophie Barwick

INSTITUTION:
University of Sheffield

OTHER AUTHORS:
Dr Jack Haley, UKAEA
Dr Samir de Moraes Shubeita, University of Manchester
Professor Katerina Christofidou, University of Sheffield
Professor Christopher Race, University of Sheffield
Professor Amy Gandy, UKAEA
Professor Russell Goodall, University of Sheffield

ABSTRACT:
Fusion energy offers great potential for zero carbon power, but poses severe challenges for materials. This work explores the effects of the life-limiting factors on breeder blanket structural materials and aims to expand the operational window of current steel options. Existing literature shows manganese contributes to irradiation induced degradation and enhances clustering effects in fusion steels, which will result in embrittlement upon the cool-down of a reactor. To further this knowledge, Fe-based model alloys, with varying levels of Mn, have been subjected to stimulant reactor irradiation, and the effects on the formation of clusters analysed. Due to their atomistic scale, TEM and APT will be used to determine the formation, location and size of the clusters, particularly their vicinity to irradiation induced defects and dislocation loops. Verification of critical content of Mn will then allow development into industrially applicable materials and set significant boundaries on the composition of fusion steels.

Presentation 2

3D lattice strain quantification in neutron irradiated steels for fusion energy

SPEAKER / LEAD AUTHOR:
Lucy Fitzgerald

INSTITUTION:
University of Birmingham

OTHER AUTHORS:
Dr Biao Cai, University of Birmingham
Slava Kuksenko, UKAEA
Duc Nguyen, UKAEA
Yiqiang Wang, UKAEA
Steven Leake, ESRF

ABSTRACT:
Iron-chromium (Fe-Cr) steels are top candidates for development as structural materials within Demonstrator fusion reactors, such as the UK designed STEP. The addition of oxide-dispersion strengthened nanoparticles (ODS) such as Y_2O_3 further improve these alloy's tensile and creep properties at high temperatures and increases radiation damage resistance. Within fusion reactors, structural materials undergo microstructural changes like the formation of precipitates, voids, bubbles, and dislocation loops, caused by high energy neutrons. These microstructural changes generate localised strains within the lattice. To quantify these lattice strains, a nano synchrotron x-ray imaging technique called 3D Bragg Ptychography was utilised on neutron irradiated ODS Fe-Cr steels. In this presentation, I will present the procedures we have developed to prepare samples that are highly irradiated for 3D Bragg Ptychography using a combination of EBSD and FIB-SEM. Then preliminary results collected at the ID01 beamline of ESRF (European Synchrotron Radiation Facility) will be presented.

Presentation 3

Low activation bainite steel: design and microstructure

SPEAKER / LEAD AUTHOR:
Pengxin Wang

INSTITUTION:
University Of Leicester

OTHER AUTHORS:
Dr Gebril El-Fallah, University of Leicester
Professor Hongbiao Dong, University of Leicester

ABSTRACT:
This study introduces Low Activation Bainite Steel (LABS), a novel material designed to address the limitations of Ferritic/Martensitic steels. LABS leverages bainitic microstructures for superior high-temperature mechanical properties and radiation resistance. Machine learning models were developed to predict key properties—creep life, yield strength, tensile strength, and elongation—and integrated with multi-objective genetic algorithms to design ten optimized steel compositions. These compositions were manufactured and validated through dilatometry, thermodynamic modeling (JMatPro, Thermo-Calc), and advanced microstructural characterization (SEM, TEM, EBSD, XRD). Tailored heat treatment schedules were developed, and mechanical testing is underway to evaluate performance. This pioneering work establishes a comprehensive framework for LABS development, offering transformative potential for power generation and advanced energy systems requiring exceptional high-temperature and radiation-resistant materials.

Chair of Session 2

Professor Hongbiao Dong

SESSION 2
Process Improvement

Professor Hongbiao Dong
University of Leicester

Professor Hongbiao Dong is internationally renowned for his work in modelling of metal processing, digital manufacturing, solidification and its application in casting, welding and additive manufacturing of metal. He is Fellow of the Royal Academy of Engineering (FREng), Director of EPSRC CDT in Digital Transformation of Metals Industry, and Director of NISCO UK Research Centre. He successfully led a major EU-FP7 project on modelling of welding, was a recipient of the Metrology for World Class Manufacturing Award and was a Royal Society Industry Fellow at Rolls-Royce Precision Casting Facility.

His team's research aims to bring knowledge-inspired decision making to the production routes of high value-added components, such as single crystal aero-engine turbine components and deep-sea oil and gas transport systems.

Presentation 4

Effects of cold-wire gas metal arc welding (CW-GMAW) process variables on energy input and deposition rate during repair of S275JR structural steel

SPEAKER / LEAD AUTHOR:
Zahraddeen Musa

INSTITUTION:
Cranfield University

OTHER AUTHORS:
Professor Supriyo Ganguly, Cranfield University
Dr Wojciech Suder, Cranfield University

ABSTRACT:
This study investigates the influence of adding a cold wire during gas metal arc welding (CW-GMAW) for the repair of S275JR structural steel. The research is aimed at improving repair productivity.

During weld repair, multiple passes with high energy input induce large number of thermal cycles producing huge thermal gradient on the material. This has an adverse effect on the material's properties. In this work, a systematic approach has been adopted to explore the effects of varying GMAW parameters, including welding current, voltage, travel speed, and specifically cold-wire feed speed on the energy input and deposition rate.

The findings reveal that specific combinations of CW-GMAW parameters can significantly decrease the energy input, minimize production energy, and increase the deposition rate. This suggests that with careful control of these parameters, it would be possible to do faster repair with minimal loss of integrity for critical structural steels.

Presentation 5

The impact of high recycled content on high formability products

SPEAKER / LEAD AUTHOR:
Freya Hamblin

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor Cameron Pleydell-Pearce, Swansea University
Dr Richard Curry, Swansea University
Martyn Dranfield, TATA Steel UK

ABSTRACT:
The switch to electric arc furnaces can enable a higher proportion of scrap steel usage within the melt, however a higher proportion of scrap leads to an increase in residual elements. An exploration of changing temperatures within the industrial process where dynamic and static recrystallisation occur to investigate whether this will negate the impact residual elements: Copper, tin, nickel and chromium. Texture formation during hot rolling and annealing determines end-product formability with a high intensity of {111} grains being the favourable texture. Previous studies have focused on each element and their individual effect on mechanical properties in low carbon steels. This study focuses on the effect of temperature to negate the impact Cu, Sn, Ni and Cr in combination on formability and texture in lab-scale low carbon steel. It is predicted that lowering the reheat temperature and increasing the annealing temperature will inhibit deterioration of {111} texture in low carbon steels. Tensile testing and EBSD techniques will be deployed to illustrate phases, grain orientation and grain size.

Presentation 6

Ferrite grain size control via two-stage cooling for structural steel tubes

SPEAKER / LEAD AUTHOR:
Nathan Dixon

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Professor Claire Davis, University of Warwick
Dr Carl Slater, University of Warwick
Dr Jinlong Du, Tata Steel UK

ABSTRACT:
In this work, ferrite grain size control during the manufacture of S355 steel tubes is investigated. Recent changes to standards, allow for accelerated cooling, replacing natural cooling. Annealed tubes are cooled with a two-stage process: rapid water cooling followed by slower natural cooling. Various amounts of ferrite are formed during each cooling stage. The aim of this work is to identify the levels of grain size refinement capable using two-stage cooling.

Dilatometry tests have been completed to simulate transformation and microstructure changes with varying industrial and hypothetical cooling regimes. Results show that by increasing the cooling rate from 1°C/s to 50°C/s reduces the ferrite grain size from 5.72µm to 2.60µm, with the grain size being "locked in" within the first 35% of ferrite formation. Fast cooling during the first 35% of ferrite formation maximizes grain refinement by forming stable ferrite nuclei at high undercoolings that are retained in final microstructure.

Institute of Materials, Minerals & Mining

Designing steel for a sustainable low carbon future.

Synopsis

1892 million tonnes of crude steel were produced last year, with 21GJ of energy consumed per tonne of steel produced and 1.91 tonnes of CO2 emitted, contributing 7-9% of the world's CO2 emission. This position is not sustainable and the move towards "green steel" is gathering considerable pace, with some consumers (e.g. automotive) demanding a green steel supply. This is not just a challenge of emission, but also we face major future challenges as key elements that will be increasingly in short supply with the current price volatility getting much worse. The availability and sustainability of green steel is critical in delivering a low-carbon energy economy through applications such as wind turbines, the hydrogen economy, fusion power, EV transport, construction and so on. Addressing sustainability in steel production and use requires that steels be designed specifically to reduce reliance on strategic and scarce elements, for recycling and for disruptive manufacturing technologies that minimise waste.

Professor Mark Rainforth, *University of Sheffield*
Winner of the Bessemer Gold Medal for 2024

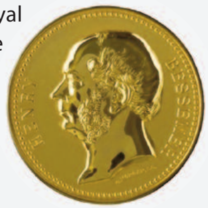
In this lecture I will address the major challenges and success stories in green steel production. The talk will take examples of how, by taking sustainability as a starting point, steels can be designed to give improved properties, but with less reliance on critical elements and lower CO2 emissions in their manufacture. Specific case studies will come from designing lean steels for ultra-high strength to give weight saving technologies in automotive, the challenges in steel quality in switching from BOS steel to EAF steel making, designing steel for Fusion Power Reactors and designing steels for the hydrogen economy.

Biography

Professor Mark Rainforth took a first class BMet degree from the Department of Metallurgy in Sheffield in 1984 then joining British Steel in Rotherham and later at TI Research Hinxton Hall. After a PhD in 1990, he was appointed Lecturer in the Department of Materials in Sheffield in 1989, was promoted to a Personal Chair in 2000, was Head of the Department of Materials Science and Engineering between 2011-15 and was appointed the POSCO Professor of Iron and Steel in 2021.

Professor Rainforth led the £3m EPSRC grant "Designing Alloys for Resource Efficiency" (DARE) and co-investigator on the EPSRC Programme Grants £5m "Hydrogen in Metals (HEmS)". He is currently Sheffield PI on the EPSRC Future Steel Manufacturing Hub, SUSTAIN (£10.6m). He has published over 400 ISI journal papers, publishing extensively in the top journals, including Nature, Science, Science Advances, Acta Materialia, Scripta Materialia, Scientific Reports and Proc Royal Soc (attracting over 1000 citations per year), one textbook and numerous invited presentations at leading international conferences around the globe.

Professor Rainforth was elected a Fellow Royal Academy of Engineering (FREng) in 2016. He is the winner of the IOM3's 2024 Bessemer Gold Medal, Verulam Medal and Prize and the Rosenhain Medal.



Chair of Session 3

Dr Richard Thackray

SESSION 3
Structure Measurement and Property Prediction

Dr Richard Thackray
University of Sheffield

Dr Richard Thackray holds a degree in Materials Science and a PhD in Metallurgy from Imperial College London. Richard joined the University of Sheffield in 2003 as Tata (Corus) Lecturer in Steelmaking and is a key member of the University of Sheffield's team for SUSTAIN - the EPSRC funded Future Steel Manufacturing Research Hub. His current research interests are related to the production of steel, including development of mould powders for continuous casting of steel, inclusion engineering in steels, and using novel powder metallurgical techniques for the production of stainless steel components.

Richard is also involved in several projects that look at aspects of sustainability in steelmaking, in particular, initiatives to quantify and reduce energy consumption in steelmaking, reuse and recycling of waste material, life-cycle assessment of critical elements in steel, and alternative materials for ironmaking. Richard is a past chair of the Iron & Steel Group of IOM3, Gold Medal Winner in 2021 and a current member of the Sustainable Development Group.

Brunel University London

Presentation 7

Correlation between electrical resistivity, ultrasonic measurements and microstructural changes in SS316 under high-cycle fatigue

SPEAKER / LEAD AUTHOR:
Maryam Izadi

INSTITUTION:
Brunel University

OTHER AUTHORS:
Dr Ebad Bagherpour Jahromi, Brunel University
Professor Isaac Chang, Brunel University
Professor Zhongyun Fan, Brunel University

ABSTRACT:
Most of the metal's failure happens because of the fatigue which is associated with metal that is subjected to cyclic loading over time. Undetected fatigue damage can lead to catastrophic failures in critical components like those in aerospace, automotive and infrastructure. Early detection enables timely maintenance, enhances safety, reduces costs and supports the circular economy by minimizing resource extraction and promoting efficient resource utilization. Fatigue typically progresses through stages such as pre-crack nucleation, crack formation and crack growth. While many techniques detect fatigue damage after crack formation, early detection during the pre-crack nucleation stage remains less explored. This stage involves increased dislocation density, changes in dislocation features and slip band formation, which act as crack initiation sites. Non-destructive testing (NDT) methods, including electrical resistivity and nonlinear ultrasonic testing, effectively identify early fatigue damage. Significant changes in electrical resistivity and nonlinear parameters were observed at three distinct stages before 10% of fatigue life of SS316, validated by TEM and destructive methods.

Presentation 8

University of Strathclyde Glasgow

Investigation of fatigue and fracture mechanics properties of structural steels in adverse environments

AUTHOR OF POSTER:
Monisha Manjunatha

INSTITUTION:
University of Strathclyde

OTHER AUTHORS:
Dr Tugrul Comlekci, University of Strathclyde
Dr Yevgen Gorash, University of Strathclyde
Professor Donald Mackenzie, University of Strathclyde

ABSTRACT:
With the growing demand for lighter and stronger structures, high-strength steels such as S700, S690, and S960 are gaining prominence due to their superior yield strength. These materials offer the potential for weight reduction while maintaining structural integrity, contributing to sustainability. However, the higher strength grades of steel have higher costs compared to the medium strength steels like S275 and S355. Additionally, higher yield strength does not necessarily translate to improved fatigue and fracture properties, and available literature on the fatigue performance of these steels is sparse, primarily due to the high cost of testing.

This research presents a comprehensive comparative analysis of the total fatigue life of several steel grades, ranging from low to high strength. The study assesses both crack initiation and crack propagation phases. Crack initiation is investigated using an ultrasonic fatigue testing machine, while crack propagation is examined with a servo-hydraulic Instron machine. Moreover, the study evaluates the impact of corrosion on the fatigue properties of these steels. Fractographic analysis is also conducted to provide insights into failure mechanisms across the tested grades. Concluding with the comparison of medium and high strength steels in terms of fatigue properties. This research aims to bridge the knowledge gap in fatigue performance and corrosion resistance of steels, offering valuable data for their broader application in industry.

Presentation 9

Swansea University Prifysgol Abertawe

A computational approach towards proactive scale management for steel pipelines

SPEAKER / LEAD AUTHOR:
Megan Kendall

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Elizabeth Sackett, Swansea University
Dr Chris Owen, TATA Steel UK
Dr Michael Auinger, University of Warwick

ABSTRACT:
Conveyance tube manufacturing via a hot-finished, welded route is an energy-intensive process which promotes surface oxidation. During normalisation to homogenise the post-weld microstructure, an oxide mill scale layer grows on tube outer surfaces. Following further thermomechanical processing, there is significant yield loss and surface degradation. Delaminated scale is also liable to contaminate and damage plant tooling. The computational thermochemistry software, Thermo-Calc, and its diffusion module, DICTRA, was explored for its potential to investigate oxidation kinetics on curved geometries representative of conveyance tubes. A model was developed using the Stefan problem, bespoke thermochemical databases, and a numerical solution to the diffusion equation. Oxide thickness predictions, and subsequent mechanical analysis, for representative curved surfaces revealed the significance of the radial term in the diffusion equation and that the effects of a cylindrical coordi nate system on oxidation cannot be neglected if oxidation on curved surfaces is to be fully understood and controlled.

Presentation 10

University of Strathclyde Glasgow

Influence of iron oxide corrosion on hydrogen uptake and susceptibility to embrittlement in pipeline steels

SPEAKER / LEAD AUTHOR:
Anthony Reilly

INSTITUTION:
University of Strathclyde

ABSTRACT:
Hydrogen is pivotal to achieving net-zero energy goals, with strategies focusing on repurposing natural gas networks for hydrogen transport. However, hydrogen embrittlement (HE) impacts the mechanical integrity of pipeline steels, creating significant uncertainties about their performance in service conditions and challenging the transition to hydrogen as an energy carrier.

This study investigates how surface conditions and microstructural variations in vintage pipeline steels, typical of national gas transmission networks, influence hydrogen uptake and HE susceptibility. Novel technologies to mitigate HE are also introduced, offering pathways to enhance pipeline resilience and safety.

By addressing critical challenges and advancing practical solutions, this work supports the integration of hydrogen into existing infrastructure. The findings contribute to robust strategies for mitigating HE in aging pipelines, aligning with energy transition goals and enabling the development of a sustainable hydrogen economy.

Keynote Speaker
Dr David Bowden, UK Atomic Energy Authority

Increasing the heat: Developing next-generation high-temperature steels to deliver commercial fusion energy.

As the UK nuclear 'renaissance' continues apace, steels continue to demonstrate incredible versatility and performance, particularly as we consider next-generation structural materials to use in the most demanding environments ever developed. Proposed commercial fusion powerplants contain plasmas ten times hotter than the sun, with materials witnessing extreme levels of radiation damage. This is coupled with challenging mechanical loads, and other environmental factors such as corrosion. Yet nano-structuring and carefully designed steel microstructures can be tuned to manage these effects.

A UK consortium, NEURONE (Neutron Irradiation of Advanced Steels), operating across academia, national labs and industry are tackling the challenge of developing steels to use in fusion plants, and utilising existing national infrastructure to deliver the tonnages of material required by the end of the decade.

This talk will explore some of the key challenges we face within this programme, as well as the science behind the steels being developed. Importantly, the opportunity for the UK to lead the charge in this emerging sector will be outlined.

UK Atomic Energy Authority

Dr David Bowden is the Materials Science and Engineering Group Leader at the UK Atomic Energy Authority. He has a varied background, initially studying aerospace engineering before working in the maritime sector where he was introduced to nuclear materials development. In 2012, he started his PhD in advanced metallics at the University of Manchester, investigating new wear-resistant steels for pressurised water reactors. After his PhD he continued at Manchester, working as a post-doctoral researcher, investigating the irradiation and corrosion performance of MAX phases developed as potential nuclear fuel cladding materials.

Since joining UKAEA in 2019, David has led materials teams in both Fusion Technology and the Spherical Tokamak for Energy Production (STEP) programme. Now, in the Materials Division, he leads the £12.5m NEURONE programme and the wider metallics development portfolio.

Dr David Bowden, *Materials Science and Engineering Group Leader, UK Atomic Energy Authority.*

Poster Index

Poster 1

Swansea University Prifysgol Abertawe

Coating network and barrier property design strategies for protection against hydrogen embrittlement

AUTHOR OF POSTER:
Ehsan Akbari Kharaji

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Shirin Alexander, Swansea University
Dr Elizabeth Sackett, Swansea University
Dr John Wood, AkzoNobel

ABSTRACT:
As society moves towards net zero, hydrogen offers an alternative approach to heating, transport, and industrial processes. The 'hydrogen economy' to succeed being dependent upon current and new infrastructure for storage and supply. Hydrogen is of course known to cause embrittlement in some metals. Careful materials selection and the application of appropriate surface coatings may be the key to safe and economical solutions.

This project aims to develop design criteria for polymeric and / or inorganic coating linings, to offer protection against hydrogen embrittlement. Additionally, methods to measure hydrogen permeation, and the impact of such permeation on tensile properties of the substrate material, will be considered.

Poster 2

Rationalisation of steel grades and specifications

AUTHOR OF POSTER:
Sadegh Jalalian

INSTITUTION:
Brunel University

OTHER AUTHORS:
Professor Hamid Assadi, Brunel Univeristy
Professor Isaac Chang, Brunel University
Professor Zhongyun Fan, Brunel University

ABSTRACT:
This study introduces a multi-step approach to classification of steel grades with a primary motivation to facilitate reducing the existing number of grades and enhancing recyclability. The relationship between chemical composition and mechanical properties are investigated initially for the case of carbon and stainless steels using the artificial neural network technique. In addition, the examined group of steels are classified into four distinct subgroups based on their properties, by using the Principal Component Analysis (PCA) and k-means clustering methods. Moreover, we utilise the Shapley Additive Explanations (SHAP) method to identify the most influential features within each group. Finally, we outline an algorithmic method of reclassification that can be applied to steel grades, as well as any other datasets, where the aim is to minimise the number of classes while maintaining the coverage of the property space.

Poster 3

Ferrous electrode materials for battery-electrolyser systems

AUTHOR OF POSTER:
Abubakar Sadiq Abdullahi

INSTITUTION:
Loughborough University

OTHER AUTHORS:
Professor Dani Strickland, Loughborough University
Professor Benjamin Buckley, Loughborough University
Lee Marston, Fibre Technology Ltd
Dr John Barton, Loughborough University

ABSTRACT:
The battery-electrolyser is a technological innovation that efficiently stores energy and produces hydrogen, making it an ideal future engineering solution for storing excess renewable energy and helping decarbonisation. However, existing chemistries face material challenges, particularly corrosion of electrodes, which affects their durability.

This Knowledge Transfer Partnership (KTP) between Loughborough University and Fibre Technology Ltd focuses on developing low-cost, durable porous metal fibre network electrodes for battery-electrolyser systems using innovative rapid solidification technology and fibre bonding. The project investigates ferrous materials, specifically stainless steel (SS304, 314) and other iron alloys, to improve corrosion resistance, electrochemical performance, and durability of the battery-electrolyser electrodes using widely available materials.

The research aims to overcome barriers to commercialising this innovative technology by combining material science, chemistry, and advanced manufacturing techniques. This interdisciplinary engineering project advances the role of ferrous metallurgy in developing sustainable energy solutions, paving the way for scalable, efficient hydrogen production systems that align with global decarbonisation goals.

Poster 4

Swansea University Prifysgol Abertawe

Emissivity and oxidation in the reheat furnace

AUTHOR OF POSTER:
Cadyn Robinson

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Ian Mabbett, Swansea University
Dr Hollie Cockings, Swansea University
Jonathan Richards, TATA Steel UK

ABSTRACT:
Understanding of steel emissivity and the oxide formation on its surface is vital within the reheat furnace for mass production of steel. Oxidation is the process where iron-ions react with oxygen in the furnace atmosphere forming scale on a slab's surface, reducing steel yield and requires descaling. Emissivity is the fraction of radiation energy a material will re-emit after absorbance raises temperature and is important when considering energy exchanges within reheat furnaces. Since emissivity is dependent on surface chemistry, the presence of scale, an oxidised-surface chemistry, is likely to impact emissivity. Tests including furnace heating, cooling and thermogravimetric analysis are underway to investigate the emissivity change due to temperature change and oxidation. Three grades are being tested to simulate these effects within the reheat furnace at an industrial scale. Aiming to contribute to the steel industry by reducing energy consumption during reheating and build reheat models specified to steel grade.

Poster 5

MANCHESTER 1824 The University of Manchester

Retained austenite decomposition in low alloy steels

AUTHOR OF POSTER:
Grace Fidler

INSTITUTION:
University of Manchester

OTHER AUTHORS:
Dr Ed Pickering, University of Manchester
Dr Kun Yan, University of Manchester
Dr Matthew Dear, University of Manchester

ABSTRACT:
Low alloy steels are used in a variety of engineering applications as structural materials. They are often heat treated to form microstructures comprising hard microconstituents such as bainite and martensite. Typical heat treatment usually comprise austenitisation, quenching and tempering steps. Following quenching, it is often found that small amounts of austenite remain untransformed at room temperature, called retained austenite. This retained austenite can be found as carbon-enriched austenite blocks, or films which are stabilised between martensite laths. While the amount of this is small, it may influence the final microstructure and properties of the final component after tempering. The presented work uses XRD with rietveld refinement, EBSD and dilatometry to measure the amount of retained austenite in the samples prior to and post tempering. Additionally, SEM imaging is used to understand the decomposition products and start temperatures for both the block and film retained austenite.

Poster 6

University of Strathclyde Glasgow

Investigation of fatigue and fracture mechanics properties of structural steels in adverse environments

AUTHOR OF POSTER:
Monisha Manjunatha

INSTITUTION:
University of Strathclyde

OTHER AUTHORS:
Dr Tugrul Comlekci, University of Strathclyde
Dr Yevgen Gorash, University of Strathclyde
Professor Donald Mackenzie, University of Strathclyde

ABSTRACT:
With the growing demand for lighter and stronger structures, high-strength steels such as S700, S690, and S960 are gaining prominence due to their superior yield strength. These materials offer the potential for weight reduction while maintaining structural integrity, contributing to sustainability. However, the higher strength grades of steel have higher costs compared to the medium strength steels like S275 and S355. Additionally, higher yield strength does not necessarily translate to improved fatigue and fracture properties, and available literature on the fatigue performance of these steels is sparse, primarily due to the high cost of testing.

This research presents a comprehensive comparative analysis of the total fatigue life of several steel grades, ranging from low to high strength. The study assesses both crack initiation and crack propagation phases. Crack initiation is investigated using an ultrasonic fatigue testing machine, while crack propagation is examined with a servo-hydraulic Instron machine. Moreover, the study evaluates the impact of corrosion on the fatigue properties of these steels. Fractographic analysis is also conducted to provide insights into failure mechanisms across the tested grades. Concluding with the comparison of medium and high strength steels in terms of fatigue properties. This research aims to bridge the knowledge gap in fatigue performance and corrosion resistance of steels, offering valuable data for their broader application in industry.

Poster 7

Swansea University Prifysgol Abertawe

Paint recycling for end-of-life construction cladding

AUTHOR OF POSTER:
Anna Voytyukova

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor Matthew L Davies, Swansea University
James Smith, Beckers Group

ABSTRACT:
The annual global production of pre-painted metal reaches 1.5 billion square meters, with 76% of it utilised in the building industry, particularly for construction cladding. At the end of life, the cladding is recycled, and the metal is recovered. However, the organic coating is typically incinerated, resulting in material waste and increased greenhouse gas emissions. This project aims to develop methods for recycling the organic coating from pre-painted metal, thereby reducing the carbon footprint and promoting the circular economy.

The research investigates various paint removal techniques, including cryogenic treatment and induction heating, while evaluating their impact through life cycle assessment (LCA). The initial results show that the cryogenic treatment promotes the decoating of the PVC plastisol from steel, while the polyester coating exhibits cracking without delamination. The second project goal is the recovery of paint constituents, primarily titanium dioxide, which significantly contributes to the carbon footprint associated with organic coatings.

Recycling organic coatings from pre-painted metal can reduce the reliance on virgin raw materials. The environmental impact of the coatings industry can be reduced while the efficiency of steel recycling can be enhanced.

Poster 8

Understanding cold work needed for recrystallization of 316L LPBF material and its effect on the material's performance in PWR primary water

AUTHOR OF POSTER:
Sydney Coates

INSTITUTION:
University of Manchester

OTHER AUTHORS:
Professor Fabio Scenini, University of Manchester
Dr Ed Pickering, University of Manchester
Timothy Watkins, Rolls Royce
Karen Perkins, Rolls Royce

ABSTRACT:
316L austenitic Stainless Steel (SS) is used within the structural components and main circuits of Pressurized Water Reactors (PWR) due to its good corrosion resistance and machinability. Due to Additive Manufacturing's (AM) benefits of more complex geometries and shorter manufacturing times, there is a need to understand AM material's performance within PWR primary water environments. Laser Powder Bed Fusion (LPBF) is a specific type of AM that allows for the more complex geometries through melting layers of powder metal together. Previous research has shown LPBF 316L SS has slower recrystallization kinetics leading to partial recrystallization, creating an anisotropic microstructure that can lead to reduced mechanical and corrosion performances therefore different levels of induced cold work (0%, 5%, 7%, and 10%) and solution annealing temperatures (1000°C, 1050°C, 1100°C), were evaluated, and their subsequent mechanical and corrosion performances tested to determine the most beneficial microstructure.

Poster 9

A novel finite element model for 2D induction heating based on the bound preserving method

AUTHOR OF POSTER:
Katherine MacKenzie

INSTITUTION:
University of Strathclyde

OTHER AUTHORS:
Dr Gabriel Barrenechea, University of Strathclyde
Dr Aurik Andreu, University of Strathclyde

ABSTRACT:
In induction heating, it is important to understand the temperature profile within the material for maximum throughput, efficiency and control, but also to avoid overheating and melting of workpieces. However, due to high temperatures strongly affecting materials properties and shallow skin-depths, it is difficult, time-consuming, and expensive to accurately measure the temperature evolution. Therefore, numerical models are useful to predict the temperature profile for different shapes of materials, different types of steels and alloys, and different system setups.

In this poster, I will present a novel 2D model for induction heating. This model is built using the freely available python software FEniCSx, makes use of adaptive meshes, and employs a new finite element method called the Bound Preserving Method. I will present results that compare the model output to experimental data and to output from industry-standard DEFORM software and show that this model could be useful in certain applications.

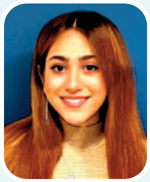
Poster 10

Capture and reduction of carbon emissions to maximize circularity in the steelmaking process

AUTHOR OF POSTER:
Azita Etminan

INSTITUTION:
Swansea University

OTHER AUTHORS:
Peter J. Holliman, Swansea University
Ian Mabbett, Swansea University
Ciaran Martin, TATA Steel UK
Chay Davies-Smith, TATA Steel UK



ABSTRACT:
Our research work investigates an innovative approach for methane synthesis from steelmaking off-gases (CO and CO_2) using hydrogen derived from the pyrolysis of waste plastic (polypropylene (PP)). Employing the Gibbs free energy minimization method, we conducted a simulation-based analysis to optimize thermodynamic parameters and evaluate the energy and exergy efficiencies of the integrated process. The study identifies optimal conditions for hydrogen production and methanation while addressing critical challenges, such as coke formation and catalyst deactivation. By ensuring efficient carbon utilization and high conversion rates, this approach offers a sustainable pathway for methane production. Our findings underscore the potential of integrating steelmaking off-gas conversion with polymer pyrolysis to reduce greenhouse gas emissions and enhance energy efficiency, paving the way for more sustainable industrial applications.

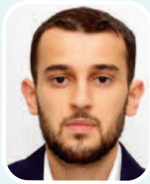
Poster 11

Simulation of high frequency induction welded thick-walled line pipe products

AUTHOR OF POSTER:
Sami Elkabbani Alhouh

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Professor Claire Davis, University of Warwick
Dr Carl Slater, University of Warwick
Dr Jinlong Du, TATA Steel UK



ABSTRACT:
This research aims to develop a computational model to replicate the High-Frequency Induction (HFI) welding process used at Tata Steel for thick-walled line pipe products. A COMSOL-based model has been created to simulate induction heating of the tube, incorporating temperature-dependent material properties, the influence of an impeder, the V-shaped geometry where the edges of the strip meet, and the dynamic motion of the tube moving forward while its edges converge. Samples and data from Tata Steel are used to validate the results from the simulation. Future work will focus on simulating the contact pressure at the edges to ensure the correct amount of material is removed, expelling manganese silicates from the bond line to improve weld quality.

UNIVERSITY OF BIRMINGHAM

Poster 12

Additive manufacturing and characterisation of topologically designed porous 316L stainless steels

AUTHOR OF POSTER:
Shuyi Li

INSTITUTION:
University of Birmingham

OTHER AUTHORS:
Dr Julan Wu, Cooksongold
Dr Parastoo Jamshidi, Cooksongold
Dr Selassie Dorvlo, Cooksongold
Dr Biao Cai, University of Birmingham

ABSTRACT:
Porous metals are multifunctional materials, widely used in catalysis, biomedical implants, and filtration due to their unique properties. Additive manufacturing (AM), particularly Laser Powder Bed Fusion (LPBF), provides precise control over the design and fabrication of porous metals. In this study, by using topological design principles, we designed, and additive manufactured Triply Periodic Minimal Surface (TPMS) porous structures out of 316L stainless steel. These porous structures, known for their high interconnectivity and favourable mechanical properties, were optimised for enhanced performance. To evaluate printed porous 316L components, advanced characterisations including electron microscopes and X-ray computed tomography were employed, providing essential data such as porosity, surface area, wall thickness distribution, and internal structural integrity. The results highlight the advantages of using AM to produce topology optimisation porous materials.

UNIVERSITY OF LEICESTER

Poster 13

CFD modelling of electric arc furnace process for sustainable steelmaking

AUTHOR OF POSTER:
Mohammed Siddiqui

INSTITUTION:
University of Leicester

ABSTRACT:
Electric Arc Furnace (EAF) is integral to ferrous metallurgy, offering a sustainable route for steelmaking through scrap recycling. However, challenges such as production quality, operational capacity, energy consumption and CO_2 emissions continue to hinder its full potential. This research focuses on developing a Computational Fluid Dynamics (CFD) model to optimise the EAF process by simulating fluid flow, heat transfer and chemical reactions. The study emphasises the fundamental principles of multi-physics interactions within the furnace and their impact on EAF performance and sustainability. By aligning with circular economy principles, the research aims to provide actionable insights for improving process efficiency, reducing energy consumption and minimising CO_2 emissions. This work contributes to advancing the field of ferrous metallurgy by establishing a solid foundation for EAF digital twin model and facilitating the industry's transition towards more sustainable steelmaking.

Poster 14

Development of refractory systems to support the steelmaking process

AUTHOR OF POSTER:
Patrick Mayne

INSTITUTION:
Swansea University

ABSTRACT:
Refractory linings are commonly used in the steel industry and perform a critical role with regards to energy conservation and product quality. An industrial study is presented in which thermocouples have been installed into the refractory linings of in-service steel plant assets. Temperatures of linings under normal operating conditions were monitored in real time using Long Range Radio Wide Area Network (LoRa WAN) wireless communications technology and correlated with non-contact thermography measurements. This data is being used to validate and inform the output of a three-dimensional FEM model of the same refractory lined asset, enabling the model to better simulate the impact any changes involving refractory material selection might have on the asset's overall effectiveness.

Poster 15

Development of novel coatings of steel for the hot-stamping process

AUTHOR OF POSTER:
Luke Lewis-Jones

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor David Penney, Swansea University
Professor James Sullivan, Swansea University

ABSTRACT:
The project is mainly focusing on designing a alternative coating for use in the hot stamping industry that can provide galvanic protection for the steel while still being viable for use on boron steels while they are heated through the austenitic region, currently used coatings are typically based on barrier protection of the steel which works until any damage to the coating occurs through scratches during any of the transport or processing steps. Galvanic protection that can survive the heat treatment process could allow for less processing steps and become more economically viable for manufacture while also increasing service life of formed parts.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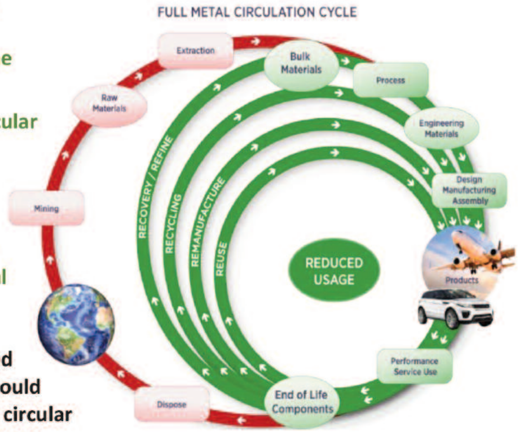
- **We conduct macro-economic analysis of metal flow to identify circularity gaps in the metals industry and to develop pathways, policies and regulations to bridge them.**
- **We develop circular product design principles, circular business models and circular supply chain strategies to facilitate the transition to full metal circulation.**
- **We develop circular alloys and circular manufacturing technologies to enable the transition to full metal circulation.**
- **We engage actively with the wider academic and industrial communities, policy makers and the general public to deliver the widest possible impact of full metal circulation.**



The CircularMetal centre is providing the capability and pathways to eliminate the need for metal extraction. The estimated accumulative economic contribution to the UK could be over £100bn in the next 10 years. The metallurgical, business, economics and circular economy research communities will all benefit from the development of this programme.

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IMAGE: ARCAST ARC 200 - ARC MELTER at the RDC in Sheffield

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The Interdisciplinary Centre for Circular Metals aims to make the UK the first country to realise full metal circulation for high-volume metals by 2050. To facilitate this, we have assembled a truly interdisciplinary academic team with a wide range of expertise, and a strong industrial consortium.

Our work includes:

Conducting macro-economic analysis of metal flow to identify circularity gaps in the metals industry and to develop pathways, policies and regulations to bridge them.

Developing circular product design principles, circular business models and circular supply chain strategies.

Developing circular alloys and circular manufacturing.

Engaging with academic and industrial communities, policy makers and the general public to deliver the impact of full metal circulation.

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2019	Ron Deelan, British Steel
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