Materials Processing Institute

7th Postgraduate Research Symposium on Ferrous Metallurgy

The latest academic thinking on Ferrous Metallurgy

Tuesday 27th February 2024

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

#Metallurgy7

2024 Programme

Organised by:

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Foreword by Chris McDonald

Welcome to the 2024 Symposium – our well established celebration of UK metallurgical research and talented researchers!

As is now the norm for this event, competition for one of the ten speaking slots was fierce and all of those selected to speak can be assured that they have achieved a great deal in making it to the programme. Likewise, we have an extremely high quality poster display and as in previous years we hope to see research students develop through their projects first attending, then presenting a poster and finally presenting a paper at the Symposium. In this way we aim not only to showcase research, but to support the development of research students too. As in previous years, the Symposium will incorporate the presentation of prizes for the best speakers and posters, alongside the Millman Scholarship and Ashok Kumar Fellowship, both of which will be awarded today.

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 and this our 7th Symposium is also the second year in a five year arrangement with Tata Steel as the main sponsor. This ongoing long term commitment from Tata Steel is greatly appreciated, particularly given the challenging economic environment in which all UK steel companies operate. I would also like to thank all our longstanding sponsors and welcome new ones with this Symposium supported by The Henry Royce Centre at the University of Sheffield, The Materials and Design Exchange (MaDE), UK Metals Council, the UKRI Interdisciplinary Centre for Circular Metals and the Cast Metals Federation. I would also like to thank Dr Pam Murrell, Chief Executive of the Cast Metals Federation, for kindly agreeing to be out keynote speaker this year.

Each year we like to introduce a new innovation in the programme and this year is no different as we welcome researchers from the Materials and Design Exchange (MaDE), who will be talking to presenters and delegates during the coffee breaks, about the impact of material developments on aspects of climate change and sustainability.

In particular they are interested in those aspects of technology development that you feel could make a positive impact on climate change and materials sustainability. The information that you offer during these discussions will be used to provide input to other MaDE organised student events during 2024. The MaDE researchers also have information about an upcoming hackathon and they will be pleased to share that with you too.

As in recent years, the Symposium forms part of the dissemination activities of the PRISM programme of research and innovation for the UK Steel & Metals sector, funded by the UK government, through InnovateUK and delivered by the Materials Processing Institute.

This will be my last year introducing and chairing the Symposium and so I would like to make a particular tribute to the people who work so hard throughout the year to make it a success. Most particularly I would like to recognise Andrew Cargill and Andrew Watson from the Materials Processing Institute, Anne-Marie Clift CEO of the Gauntlet Trust, Terry Stefaniw Beadle of the Armourers, and Hall Stewards, Annie Hart, Noel Ragudo and Michale Muzavasi. I would also like to thank our judges and session chairs, most of whom have been with us for every single one of these annual events.

My personal thanks to the Master, Wardens and Company of Armourers and Brasiers, for their consistent and unstinting support of UK materials research and the highly valued partnership and bursary scheme with the Materials Processing Institute. Thanks also to the Iron and Steel Group of IOM3 for their support of this event as co-organising partners.

I hope that you will all enjoy the Symposium today, find new opportunities for research and make new friends from across the community. Please do share your experience with friends and colleagues via social media and do register and encourage others to attend the next version of the Symposium on 25th February 2025.

Chris McDonald
Strategy Consultant, Materials Processing Institute

Keynote Speaker - Dr Pam Murrell FICME

Challenges and opportunities for the UK Castings Industry – can castings be part of the solution for the transition to net zero?

The UK Castings Industry is a key part of the manufacturing and engineering supply chain for many sectors, supplying precision engineered, near-net-shape metal components needed for all aspects of modern life.

An overview of the industry in the UK and further afield will be presented, showcasing some of the newer developments and innovations being taken by foundries and suppliers to the industry, including the use of additive manufacturing techniques, simulation, resource efficiency and process optimisation.

- Can foundries, and the cast components they produce be part of the solution to a lower carbon UK economy, given that the industry is energy intense but is a key part of the circular economy for metals?
- With metal alloys being almost infinitely recycled, and recyclable, can cast components be seen as lower carbon products?
- With a greater focus on local sourcing for supply chains for our critical infrastructure projects and strategic industries, can the wider UK metals sector help the whole economy whilst also supporting the transition to net zero?

By considering some of the challenges for the future competitiveness of the industry in the UK, the answers to some of these questions will be discussed.

The Cast Metals Federation is the Trade Association for the UK casting industry. The Federation represents and supports its members made up from UK foundries and suppliers to the industry.

Dr Murrell is a Fellow of the Institute of Cast Metals Engineers, FICME, a Board member of the European Investment Casters' Federation, a Trustee of the Foundry Training Trust, and Chair of the ISO Technical Committee for Cast Irons. She is also a Liveryman of the Worshipful Company of Founders, chairing their Industry Committee. She completed a PhD on Fracture and Fatigue at Cranfield University following a BSc Hons Degree in Metallurgy and Materials Science from Cardiff University.

Dr Pam Murrell FICME
Chief Executive of the Cast Metals Federation

Chair of Sessions

SESSION 1
Process Development

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.

SESSION 2
New Approaches for Future Manufacture

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 Research Chair of the Royal Academy of Engineering/TWI, Science Director of EPSRC CDT in Innovative Metal Processing, 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.

SESSION 3
Characterisation and Properties

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.

Programme

09:30 - 10:30 **Registration, Poster Display, Exhibition and Networking**

10:30 - 10:40 **Welcome and Introduction**
Chris McDonald, Strategy Consultant, Materials Processing Institute

10:40 - 11:40 **Session 1: Theme – Process Development**

1. *Optimisation of next generation galvanising pot hardware*
Presenter: *Giovanni Alparone (Swansea University)*

2. *The influence of composition on the cast microstructure for different casting technologies*
Presenter: *Ajitesh Sharma (University of Warwick)*

3. *Development of formable steel grades through alternative steelmaking technologies*
Presenter: *Hannah Clarke (Swansea University)*

11:40 - 12:00 **First Perambulation**
Poster Display, Exhibition and Networking

12:00 - 13:00 **Session 2: Theme - New Approaches for Future Manufacture**

4. *Rationalisation of steel grades and specifications*
Presenter: *Sadegh Jalalian (Brunel University)*

5. *Challenges in wire-arc additive manufacturing (WAAM) of Fe-Co-V alloy using metal powder-cored wire*
Presenter: *Soumyajit Koley (Cranfield University)*

6. *Augmenting the thermodynamic oxidation data of dual phase steels using synthetic data*
Presenter: *Nicola Beech (University of Warwick)*

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

14:00 - 15:20 **Session 3: Theme - Characterisation and Properties**

7. *Hydrogen embrittlement of L-PBF manufactured 316L Stainless Steel*
Presenter: *Yixiang Jin (Southampton University)*

8. *The effect of inconsistent casting on the mechanical performance of cast iron wind turbine components*
Presenter: *Obey Suleyman (Strathclyde University)*

9. *In situ synchrotron radiography investigation of graphite nodule evolution during solidification in ductile cast iron*
Presenter: *Xiangmei Ding (University of Leicester)*

10. *Characterising reheated microstructures of microalloyed multipass C-Mn steel welds*
Presenter: *Enn Veikesaar (University of Manchester)*

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

15:50 - 16:30 **Keynote Speaker**
Dr Pam Murrell, FICME, Chief Executive, Cast Metals Federation
Presentation Title: Challenges and opportunities for the UK castings industry - can castings be part of the solution for the transition to net zero?

16:30 - 16:40 **Vote of Thanks**

16:40 - 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**

Presentation 1

Optimisation of next generation galvanising pot hardware

SPEAKER / LEAD AUTHOR:
Giovanni Alparone

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor David Penney, Swansea University
Professor James Sullivan, Swansea University
Dr Christopher Mills, Tata Steel
Dr James Edy, Tata Steel

ABSTRACT:
Galvanising lines must comply with stringent quality requirements and the performance of the pot hardware affects production and quality of galvanised steel sheet. The pot roll bearings are subjected to severe deterioration due to the reaction of the bearing materials with the galvanising bath. Limiting the so-called 'down days' for maintenance leads to an increased production yield and financial interests for the industry. Ceramics are inert in many molten metals and their use as bearing materials can increase the duration of a galvanising campaign. The present study investigates on the performance of ceramics for use as galvanising bearing materials. Static immersion testing was performed to assess the corrosion behaviour in liquid zinc alloy followed by material characterisation to analyse the interactions with the molten metal bath. The results showed that ceramics remained unreactive in liquid zinc-aluminium and, therefore, they can be potentially used as bearing materials in continuous galvanising lines.

Presentation 2

The influence of composition on the cast microstructure for different casting technologies

SPEAKER / LEAD AUTHOR:
Ajitesh Sharma

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Professor Claire Davis, University of Warwick
Dr Carl Slater, University of Warwick

ABSTRACT:
Next generation casting technologies such as thin slab, belt or strip casting have gained popularity due to the reported energy saving, which can be as high as 1.6 GJ/tonne when compared to conventional thick slab casting. However, these casting approaches result in changes in cooling rate during solidification and in thickness reduction to the required product geometry, both affecting the final microstructure and properties.

In this work the secondary dendrite arm spacing (SDAS) and micro-segregation levels for the range of cooling rates relevant for different casting technologies (1 to 10 °C/s) have been assessed using Confocal Laser Scanning Microscopy (CLSM). SEM-EDX line scans have been used to characterise micro-segregation levels. An S275 and a DP800 steel grade have been chosen as baseline materials before residual elements are added (Cu and Sn). The segregation ratio is calculated from the elemental spatial distribution values as 95th % percental value / 5th % percental value.

Swansea University Prifysgol Abertawe

Presentation 3

Development of formable steel grades through alternative steelmaking technologies

SPEAKER / LEAD AUTHOR:
Hannah Clarke

INSTITUTION:
Swansea University

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

ABSTRACT:
Steelmaking using an Electric Arc Furnace (EAF) has many environmental benefits compared to the traditional Blast furnace/Basic oxygen furnace (BF/BOF) steelmaking route, particularly a significant reduction in CO_2 emissions. However, steel made in the EAF route typically has higher carbon and nitrogen levels. Interstitial free (IF) steel requires very low levels of carbon and nitrogen, making it a particular challenge for transitioning to EAF steelmaking. For this reason, the focus of my project is looking at ways to produce IF steel in an EAF. This study aims to investigate the impact of increasing nitrogen levels on the product performance of formable strip steels. Laboratory scale casts of IF steel with varying nitrogen content have been created, with the InTRAP technique, in which smaller lab casts are inserted into a larger transfer bar before hot rolling, used to allow processing parameters more representative of those at an industrial scale.

SAVE THE DATE 2025

8th Postgraduate Research Symposium on Ferrous Metallurgy

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81 Coleman Street, London EC2R 5BJ

Contact the organisers about attending or presenting:
e: academy@mpiuk.com
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Presentation 4

Rationalisation of steel grades and specifications

SPEAKER / LEAD AUTHOR:
Sadegh Jalalian

INSTITUTION:
Brunel University

ABSTRACT:
This project will aim to provide an expert system for reclassification of steels into a significantly smaller number of grades, to improve recyclability without compromising performance and production costs.

Presentation 5

Challenges in wire-arc additive manufacturing (WAAM) of Fe-Co-V alloy using metal powder-cored wire

SPEAKER / LEAD AUTHOR:
Soumyajit Koley

INSTITUTION:
Cranfield University

OTHER AUTHORS:
Kuladeep Rajamudili, Cranfield University
Professor Supriyo Ganguly, Cranfield University

ABSTRACT:
Fe-49Co-2V alloy is suitable for high power density electrical machines owing to its high magnetic permeability, saturation magnetisation and electrical resistivity. An attempt has been made to produce Fe-49Co-2V alloy using the wire-arc additive manufacturing (WAAM) route. A conventional plasma arc torch with cold wire feeding attachment was used in the process. A metal powder-cored wire with Co sheath and Fe and V powder filled inner core was used as feedstock.

Several challenges must be overcome to deposit the alloy. Firstly, controlling the oxygen content in the deposition atmosphere below 500 ppm was essential as V gets preferentially oxidized otherwise. Secondly, the orientation and geometry of the substrate plays a pivotal role in mitigating cold cracking of the deposit. A vertical plate type substrate with horizontal slots parallel to deposit was engineered to get crack free deposit. Thirdly, melting of V particle in plasma/arc column is still a challenge.

Presentation 6

Augmenting the thermodynamic oxidation data of dual phase steels using synthetic data

SPEAKER / LEAD AUTHOR:
Nicola Beech

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Dr James Edy, Tata Steel Europe
Dr Didier Farrugia, Tata Steel Europe
Professor Michael Auinger, University of Warwick

ABSTRACT:
Dual Phase (DP) steels have excellent mechanical properties but lack corrosion resistance. Consequently, they require galvanising, which directly follows annealing in a modern plant. Under annealing conditions (around 800^{0}C and up to 100% hydrogen), the alloying elements, typically 1.5-2wt% Mn and 0.5-1.0wt% Si, are prone to selectively oxidise. If non-wettable surface oxides form, such as MnO and SiO2, liquid zinc may not adhere, resulting in coating defects. Internal oxide formation is therefore preferred to keep the steel surface clean. While oxidation studies can inform the manufacturing route of these complex steels, the thermodynamic databases they often utilise may be incomplete. To resolve this issue, the databases could be augmented using synthetic data, data generated to replicate the statistical properties of real data. This work explores the advanced machine learning techniques of synthetic thermodynamic data generation to augment oxidation data for greater insight into DP steel oxidation near critical limits.

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Presentation 7

Hydrogen embrittlement of L-PBF manufactured 316L stainless steel

SPEAKER / LEAD AUTHOR:
Yixiang Jin

INSTITUTION:
University of Southampton

OTHER AUTHORS:
Professor Pedro Rivera, University of Southampton
Dr Briony Holmes, TWI Ltd

ABSTRACT:
316L stainless steel (SS) can be employed as high-pressure or liquid hydrogen containers due to its good low-temperature performance and high corrosion resistance. However, the influence of additive manufacturing on the hydrogen embrittlement of 316L SS is still unclear. Laser powder bed fusion (L-PBF) manufactured samples and wrought samples of 316L SS were tested using slow strain rate tensile test and in-situ neutron diffraction. The deformation mechanisms of both materials were considered to be changed by hydrogen, but no significant changes in mechanical properties were found in L-PBF manufactured materials.

Presentation 8

The effect of inconsistent casting on the mechanical performance of cast iron wind turbine components

SPEAKER / LEAD AUTHOR:
Obey Suleyman

INSTITUTION:
University of Strathclyde

ABSTRACT:
Currently, there is a lack of end-of-life solutions for wind turbine components, with many items being disposed of in landfill. To reduce material waste and carbon emissions, end-of-life solutions must be advanced. Approximately 5000 offshore wind turbines are due to undergo decommissioning in the UK by 2050, additionally, the ever-increasing demand for new wind turbines means there are substantial requirement projections for cast iron, specifically spheroidal graphite iron (SGI).

SGI is cast in compliance with standards such as ASTM A536 and has a broad leeway on how to attain the target grades, leading to casting inconsistencies and differences between components. This study focuses on preliminary metallurgical investigation and mechanical assessment of two turbine components, the yaw planetary gear and yaw brake calliper. These will be analysed and benchmarked against each other, with the aim of correlating differences in composition, cooling parameters, microstructure to their mechanical performance.

UNIVERSITY OF LEICESTER

Presentation 9

In situ synchrotron radiography investigation of graphite nodule evolution during solidification in ductile cast iron

SPEAKER / LEAD AUTHOR:
Xiangmei Ding

INSTITUTION:
University of Leicester

OTHER AUTHORS:
X. Ding, University of Leicester
Dr J Shepherd, University of Leicester
Dr M. A. Azeem, University of Leicester
Dr T. Wigger, University College London
Professor P.D. Lee, University College London
Associate Professor N.S. Tiedje, University of Denmark
Professor J.H. Hattel, University of Denmark
Professor Y Hideyuki, Kyoto University
Assistant Professor N. Taka, Kyoto University

ABSTRACT:
The size distribution and morphology of graphite nodules are critical for mechanical properties of ductile cast iron (DCI). High-speed synchrotron radiography was used to investigate the nucleation, floatation and growth kinetics of graphite nodules during solidification in DCI. The motion of inoculants before nucleation was examined, including their velocity changes and travelling distances. Three distinct nucleation waves were identified. For each nucleation wave, the growth behaviour, encompassing growth rate, size distribution, and nucleation site distribution, was studied. Additionally, the evolution of the global size distribution and sphericity was analyzed. In the later stages of solidification, the merging behaviour of graphite nodules was investigated.

MANCHESTER 1824
The University of Manchester

Presentation 10

Characterising reheated microstructures of microalloyed multipass C-Mn steel welds

SPEAKER / LEAD AUTHOR:
Enn Veikesaar

INSTITUTION:
University of Manchester

OTHER AUTHORS:
Professor John Francis, University of Manchester
Dr Ed Pickering, University of Manchester
Dr Miguel Yescas, Framatome
Dr Glyn Evans, Consultant

ABSTRACT:
The Charpy performance of C-Mn steel welds can vary significantly due to variations in the concentrations of trace elements, such as Ti, B, Al and N, which are often not measured or controlled by electrode manufacturers. This can result in unpredictable shifts in the ductile-to-brittle transition temperature and potentially lead to unexpected brittle fracture. We aim to develop an understanding of the effects of the Ti-B-Al-N system on absorbed energies for multipass C-Mn HSLA steel welds, by characterising a set of welds in which the concentrations of these elements are systematically varied. To date, microstructural analysis has focused on establishing whether the concentrations of Ti, B, Al and N affect the reheated grain structures in multipass weld metals, and preliminary results suggest that these regions do not change significantly. Ongoing work will seek to determine whether chemical segregation is a driver for the Charpy performance of the aforementioned alloys.

Poster Index

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12. Capture and reduction of carbon emissions to maximize circularity in the steelmaking process
13. Characterisation of a quenched, quenched & tempered AISI M2 HSS subjected to deep cryogenic treatment

UNIVERSITY OF BIRMINGHAM

Poster 1

Characterisation of nuclear fusion materials

AUTHOR OF POSTER:
Lucy Fitzgerald

INSTITUTION:
University of Birmingham

OTHER AUTHORS:
Dr Biao Cai, University of Birmingham,
Dr Slava Kuksenko, UK Atomic Energy Authority
Dr Duc Nguyen, UK Atomic Energy Authority
Dr Yiqiang Wang, UK Atomic Energy Authority

ABSTRACT:
Iron-chromium (FeCr) based ferritic and ferritic-martensitic steels are among top candidates being developed as structural materials for future nuclear fusion reactors, including the UK designed Spherical Tokamak for Energy Production (STEP). One important property of these steels is the ductile-brittle transition temperature (DBTT). Radiation increases this temperature, which could then affect the structural integrity of the reactor. This poster will present the initial data on using in situ x-ray synchrotron tensile testing techniques to study the DBTT of Eurofer97 steel.

Poster 2

Effect of 304L stainless steel cladded thickness with Q345R steel on mechanical properties and microstructure

AUTHOR OF POSTER:
Ali Fahem

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Dr Gebril El-Fallah, University of Leicester
Dr Gauri Mahalle, University of Leicester
Dr Shiladitya Paul, University of Leicester
Professor Hongbiao Dong, University of Leicester

ABSTRACT:
The combination of 304L stainless steel with Q345R steel alloy is widely utilized in welded clad pipes, processing vessels, and heat exchangers due to its exceptional corrosion resistance and mechanical properties.

This study investigates the microstructural and mechanical properties of Q345R Carbon steel (approximately 18 mm) with 304L Stainless Steel Cladding (approximately 3mm). Microhardness mapping assesses the impact of the cladding interface on hardness. Tensile tests reveal distinct mechanical properties, with ultimate tensile strengths of 691 MPa for 304L SS, 654 MPa for cladded, and 451 MPa for Q345R steel. The cladded sample exhibits higher ductility than 304L SS and greater strength than Q345R steel.

The optical microstructure shows variations of nickel and chromium within the parent alloy, influencing mechanical properties and hardness across cladding regions. The highest hardness occurs in the cladding interface due to martensite phase formation and carbon-chromium dilution, providing valuable insights into cladding's microstructural and mechanical behaviour.

Poster 3

Steps towards sustainability & decarbonisation: The impact of high recycled content on high formability products

AUTHOR OF POSTER:
Freya Hamblin

INSTITUTION:
Swansea University

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

ABSTRACT:
There is an increasing desire to shift towards low energy, low carbon steel manufacturing via various methods including carbon capture, near net shape casting utilising thin slab casting technology and electric arc furnaces (EAFs) moving away from the more traditional basic oxygen furnaces-blast furnaces (BOF-BF). There are many benefits for a steel industry to advance towards EAF technology including reduced energy usage, lower carbon emissions and a higher proportion of recycled steel as the iron bearing charge resulting in a reduction in costs. The more recent steel manufacturing, rolling and further processing technology has created obstacles in generating steels with high formability. The challenges posed in this study comprise of undesirable residual elements, Cr as the primary culprit from stainless steels in scrap, with the adverse effects on downstream processes and high formability coated applications leading to split and cracked products, which is highly unattractive to any customer base. A range of annealing temperatures ranging from 800-900°C were explored with increasing Cr to determine whether this negated the negative impact had on the formability properties of IF steel through determining the r-value through tensile testing.

Poster 4

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

AUTHOR OF POSTER:
Sophie Barwick

INSTITUTION:
University of Sheffield

OTHER AUTHORS:
Professor Russell Goodall, University of Sheffield
Dr Katerina Christofidou, University of Sheffield
Dr Jack Haley, UK Atomic Energy Authority
Professor Amy Gandy, UK Atomic Energy Authority
Dr David Bowden, UK Atomic Energy Authority

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. This work produces and investigates Fe-based model alloys with varying levels Mn and Si. Mn and Si have been found to contribute to irradiation induced degradation and enhance clustering effects. Transmission electron microscopy (TEM) and atom probe tomography (APT) will be used to determine the formation location and size of these clusters, particularly their vicinity to irradiation induced defects and dislocation loops. Upon irradiation, the impact of Mn and Si clusters on embrittlement at low temperatures and swelling at high temperatures will be analysed. Verification of critical contents of Mn and Si will then allow compositions to be developed further into more complex and industrially applicable materials.

Poster 5

Assessment and development of antimicrobial coated steels for indoor use

AUTHOR OF POSTER:
Rupika Gulati

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Dr Freya Harrison, University of Warwick
Dr Nicole Robb, University of Warwick
Dr Stuart Coles, University of Warwick
Dr Christopher Mills, Tata Steel UK

ABSTRACT:
Steel is one of the most common materials in the world and can be used as a substrate for antimicrobial coatings. A combination of the COVID-19 pandemic and rise in healthcare associated infections has resulted in a heightened interest into infection prevention control measures. Studies have shown a link between contaminated surfaces and infection transmission rates, with some bacteria surviving for months at a time. Antimicrobial coatings have shown to reduce microbial transmission.

Infection prevention has led to research into antimicrobial alternatives, such as metals like copper and bismuth. These antimicrobial metals could then be embedded into coated steels. Metals in different forms were assessed using various techniques. Initial findings have confirmed the antimicrobial activity of various forms of metal such as copper acetate and silver. Colloidal silver however has shown no effects within this project. These findings provide an insight into the future research direction for antimicrobial coated steels.

Poster 6

Ensemble learning for BOF Steelmaking end-point temperature prediction: A comparative analysis with neuron network

AUTHOR OF POSTER:
Jianbo Zhang

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Maryam Khaksar Ghalati, University of Leicester
Professor Hongbiao Dong, University of Leicester

ABSTRACT:
Basic oxygen furnace (BOF) process is a global technique in the steelmaking industry. Optimising the BOF process is crucial for reducing carbon emissions, improving energy efficiency, and enhancing product quality. Machine learning became a strong tool to be attempted in industries recent years. Ensemble learning is a technique in machine learning that combines multiple models to improve the accuracy, robustness, and reliability of predictions. In this study, five machine learning models were established to predict BOF end-point temperature on a vast dataset comprising over 10,000 heats. These models were based on one neuron network algorithm which is multilayer perceptron and four ensemble learning algorithms including boosting algorithms (XGboost, lightGBM, Catboost) and bagging algorithm (Random Forest). A comprehensive comparison of all models was conducted, and the results showed that boosting algorithms performed better than other algorithms.

Poster 7

An investigation of the high strength structural steel mechanical properties

AUTHOR OF POSTER:
Monisha Manjunatha

INSTITUTION:
University of Strathclyde

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

ABSTRACT:
The use of low alloy steels increased over the years for manufacturing heavy industrial machines and structural steel constructions to achieve lighter structures with a focus on sustainability. However, the literature for high strength steels (HSS) is limited in terms of fracture mechanics properties such as the fatigue crack propagation rates and fracture toughness compared to the low to medium strength grades of structural steels. This research aims to provide insights of crack propagation tests on the HSS. The methodology followed for test procedure is based on the ASTM E647 standard and a compact tension (CT) test sample design. The experimental results are used to validate finite element analysis (FEA) for crack propagation based on the ANSYS SMART (separating, morphing and adaptive remeshing tool) technology. Additionally, the tensile testing and Charpy impact testing results are presented and SEM fractography analysis is discussed.

Poster 8

Weathering around the world: Discovering new market opportunities for sustainable organic coatings

AUTHOR OF POSTER:
Courteney Peart

INSTITUTION:
Swansea University

ABSTRACT:
Tata Steel Shotton is home to Tata Steel Colours, which is one of the largest producers of pre-painted steel in Europe. Tata Steel Colours produces top of the range products that are specified throughout Europe and are primarily used in the construction industry. To maintain this position, Tata Steel Colours are continuously seeking to improve the current product range and explore new market opportunities to support sales growth, in addition to their current customer base. In some regions of Tata Steel's current market, warranties are offered on their products of up to 40 years. In order to expand their market base outside of Europe, an investigation is required to determine the polymer performance of the organic coatings, which will include factoring the climatic conditions in these new markets, to determine the working lifespan of the organic coatings to identify how the product can withstand varied climates whilst maintaining the desired properties.

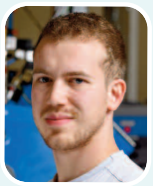
Poster 9

Assessing the environmental impact of recovery, retention and scrap sorting strategies in steelmaking

AUTHOR OF POSTER:
William Robertson

INSTITUTION:
University of Sheffield

OTHER AUTHORS:
Dr Richard Thackray, University of Sheffield



ABSTRACT:
Increasing the use of steel scrap in steel production has become a strategic decision for the UK steel industry as part of the move towards decarbonisation and the pivot from BOS to EAF steelmaking. Impurities in scrap can strongly influence the processing and properties of products, however. There are mechanisms for removal or recovery of these residuals, but the environmental impact of these is uncertain. Strategies for improved scrap efficiency exist but potential environmental benefits need to be assessed. In addition, several related issues that involve BOS steelmaking operations exist. These involve recovery of expensive elements from steelmaking slag, and the environmental impact of strategies for retaining critical elements in the loop. Results from a feasibility study into zinc removal/recovery from EAF dust mechanisms will be discussed, along with preliminary LCA/environmental assessment results of the most promising mechanisms for removal/recovery of zinc and recovery of manganese from BOS slag.

Poster 10

Development of a digital twin framework for the steel bending process

AUTHOR OF POSTER:
Amir Cheshmehzangi

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Dr Michael Auinger, University of Warwick
Dr Sumit Hazra, University of Warwick

ABSTRACT:
Digital twinning technology has gained prominence by transforming physical space into a measurable digital space through analytics, modelling, simulation, and other information technologies. It enables descriptive analysis, diagnosis, prediction, and decision-making while establishing interactive mapping and closed-loop control between digital and physical spaces, maximizing its value in diverse industrial and engineering settings. This research focuses on defining a manufacturing-focused digital twinning framework, specifically addressing challenges in integrating physical and digital spaces, with a particular focus on the 3-point bending forming process. The aim is to create a closed-loop control process adjusting output, like the predicted bending angle or springback, based on input parameters such as material properties, tooling, and process parameters. A mathematical model will be developed to establish the input-output relationship, followed by analytical or numerical solutions and verification. To ensure reliable results and data accuracy over time, multiple measurement systems, techniques, performance metrics, and trade-offs are carefully considered.

Poster 11

Experimental investigation of the effects of cryogenic treatments on the corrosion and tribocorrosion resistance of structural steels

AUTHOR OF POSTER:
James Kelly

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Professor Rob Thornton, University of Warwick
Dr Jenny Shepherd, University of Leicester
Dr David Weston, University of Leicester

ABSTRACT:
Tribocorrosion is a significant cause of material degradation, necessitating an effective approach to enhance a material's resistance and protection. Current approaches rely on surface modification, which, while promising, is complex to implement and susceptible to premature damage, requiring ongoing maintenance - an additional financial burden. Cryogenic treatment, a well-established technique for enhancing steel wear resistance, offers a compelling solution, as recent studies have independently highlighted its potential to improve corrosion resistance. Our research aims to investigate the supposed improvement in corrosion resistance and subsequent tribocorrosion resistance. One such promising steel is SA508-4N, a nuclear pressure vessel steel. If successful, cryogenic treatment could be a cost-effective and straightforward alternative for tribocorrosion protection. We will utilise potentiodynamic polarisation techniques to study the corrosion behaviour, SEM imaging to characterise the corrosion surface and XRD to analyse the microstructure, providing valuable insights into potential microstructural alterations that could enhance corrosion resistance.

Poster 12

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

AUTHOR OF POSTER:
Azita Etminan

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor Peter Holliman, Swansea University
Professor Ian Mabbett, Swansea University
Dr Ciaran Martin, Tata Steel UK

ABSTRACT:
Emissions of carbon monoxide and carbon dioxide from Blast Furnace Gas, Basic Oxygen Furnace Gas, and Coke Oven Gas are significant sources. Shifting to a circular economy involves converting these gases into renewable fuels. This research introduces an innovative thermodynamic analysis, evaluating hydrogenating CO2/CO-rich gases along with steel-off gases.

Process design: As synthetic natural gas can be used in integrated steelworks, substituting for natural gas, the direct carbon capture and utilisation using BFG and BOFG as a carbon source and H2-rich COG as a hydrogen source is the focus of this research.

Thermodynamic analysis: The HSC Chemistry software is applied for process simulations of steel-off gas reforming without a catalyst. The study utilised a thermodynamic equilibrium analysis to identify optimal process parameters and reaction conditions. The objective was to enhance CO2 hydrogenation and minimize carbon formation. The findings highlight variations in process gas characteristics, with the most effective operational parameters for maximising methane production involving Coke Oven Gas, CO2-rich gas flow, and a specific temperature range.

Poster 13

Characterisation of a quenched, quenched & tempered AISI M2 HSS subjected to deep cryogenic treatment

AUTHOR OF POSTER:
Christian Chiadikobi

INSTITUTION:
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OTHER AUTHORS:
Professor Rob Thornton, University of Warwick
Dr Dimitrios Statharas, University of Leicester
Dr David P. Weston, University of Leicester

ABSTRACT:
AISI M2 HSS are well known for their wide industry usage due to its strength, and ability to retain red hardness at high temperature. To further enhance the mechanical properties relevant to its applications, deep cryogenic treatment is often applied as an extension to bulk heat treatment process, aimed at improving the mechanical properties and performance (hardness, wear resistance). AISI M2 HSS were investigated following different heat treatment processing sequences, such as Q, Q+DCT, Q+T, Q+T+DCT, Q+DCT+T, and characterised using a range of techniques. By varying the processing routes, the mechanical properties can be tailored to fit the relevant applications. For all DCT samples, analysis from SEM examination suggests an increase in the number of secondary carbides. XRD showed that these carbides are the type M6C and MC carbide type, beneficial for the materials strength and resistance to wear. It was also shown that amount of retained austenite was found to be low for all DCT samples, with lowest reduction (3.1%) obtained for Q+DCT+T samples. Hardness test results revealed that an increase in hardness could be obtained following DCT. Nevertheless, the level of increase was dependent on the processing sequence employed. A clear trend found suggests that employing DCT between conventional prepared Q & T gave an increased hardness of approximately 4.1 %, with p value ($p<0.05$), suggesting the values obtained are significant (0.009).


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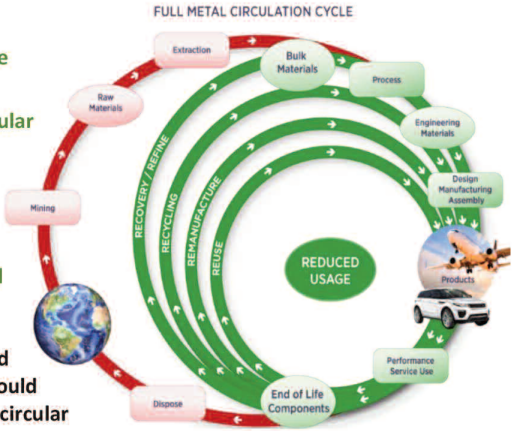
CircularMetal aims to accelerate the transition from the current largely take-make-waste linear economy to full metal circulation by 2050 and make UK the first country to realise that. We have assembled a truly interdisciplinary academic team with a wide range of academic expertise, and a strong industrial consortium involving the full metal supply chain.

- 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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UK Metals Council

The UK Metals Council, UKMC, works to advance the profile of the UK metals sector, supporting the development of policy as a UK Government recognised Sector Council.

With input and collaboration from business leaders spanning the full supply chain, from primary manufacturing to recycling, our vision is for a modern, sustainable and progressive UK metals sector, supplying high-quality, innovative and competitively priced products into the UK & global manufacturing and infrastructure supply chains, as a fundamental part of the circular economy for metals in the UK.

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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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KEYNOTE SPEAKER

2023	Professor Rob Boom, Retired
2022	John Ferriola, Former Chairman, Nucor Corporation
2021	Alexander Fleischanderl, Primetals Technologies Austria GmbH
2020	Jon Bolton, Liberty Steel Group (UK)
2019	Ron Deelan, British Steel
2018	Bimlendra Jha, Tata Steel UK

BEST PRESENTATION

2023	Joshua Collins, University of Manchester
2022	Thomas Kwok, Imperial College London
2021	Rebecca Dewfall, Swansea University
2020	Benjamin Poole, Imperial College London
2019	Daniel Stewart, Swansea University
2018	Faris Karouni, University of Sheffield

BEST POSTER

2023	Anna Tholen, Loughborough University
2022	Daniel Britton, Swansea University
2021	Matthew Dodd, Swansea University
2020	Rebecca Dewfall, Swansea University
2019	Cameron Bee, University of Warwick
2018	Benjamin Jones, University of Sheffield

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2023	Lauren Skidmore, Teesside University
2022	Sam Brown, University of Sheffield
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2020	Robert Hillier, University of Sheffield
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