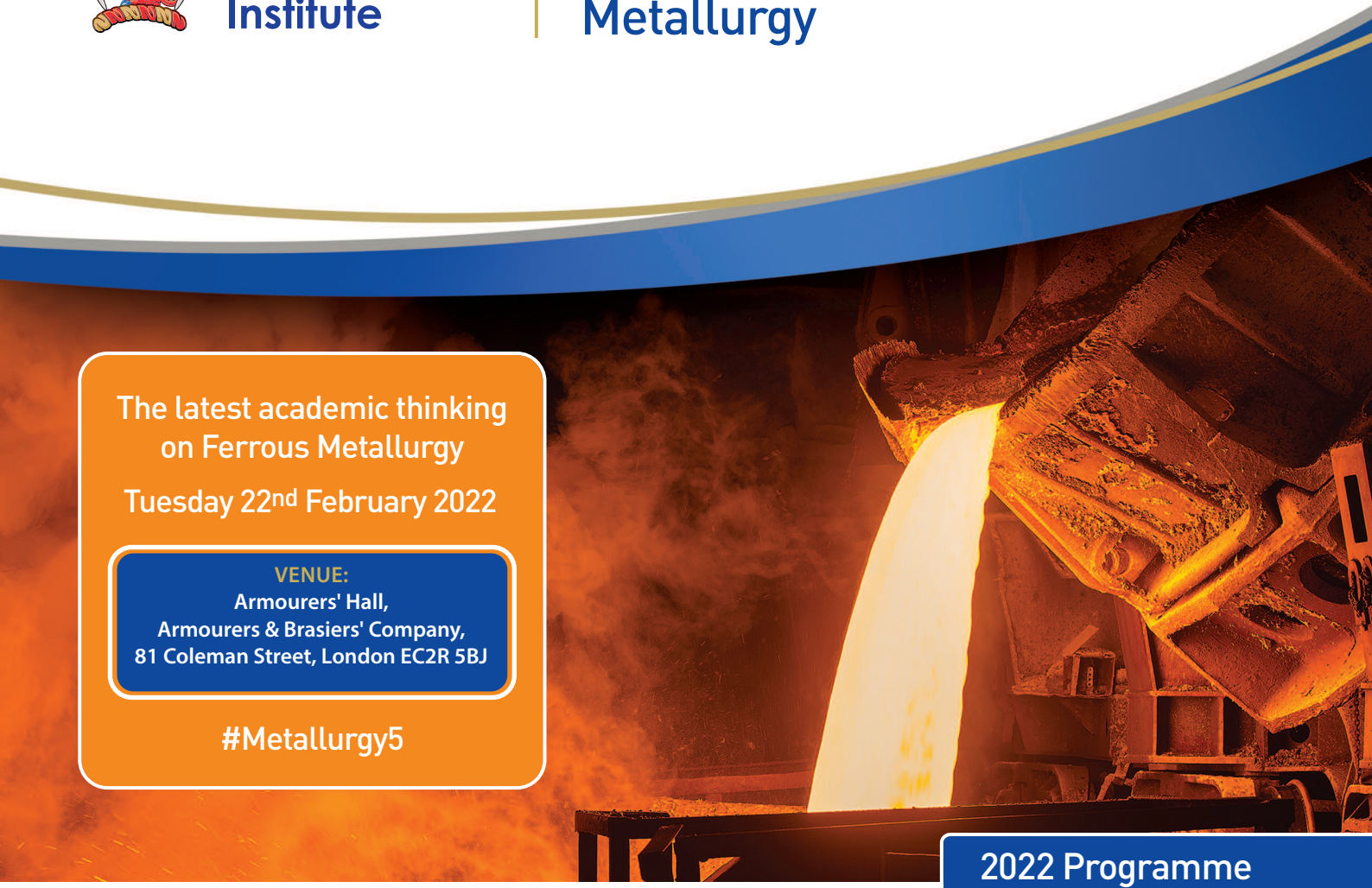
Materials Processing Institute

5th Postgraduate Research Symposium on Ferrous Metallurgy



The latest academic thinking on Ferrous Metallurgy

Tuesday 22nd February 2022

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

#Metallurgy5

2022 Programme

Organised by:

Materials Processing Institute with support from Armourers & Brasiers' Company and the Iron & Steel Group of IOM3.

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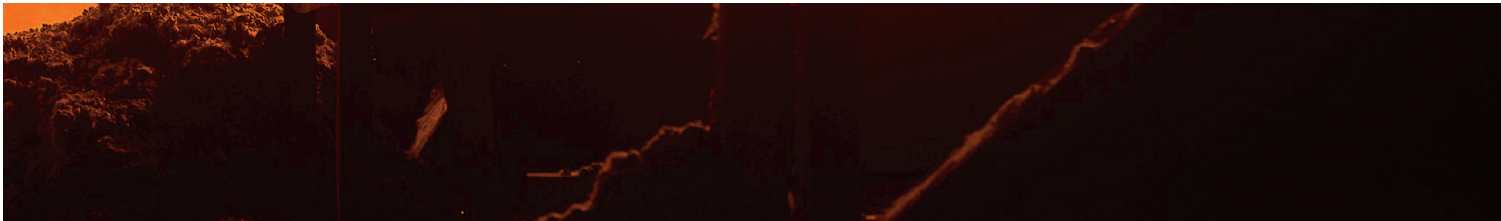


Foreword by Chris McDonald

When this symposium was established in 2018, little did we realise how successful it would be in showcasing the best of UK metallurgical research, providing inspiration to academics and students to engage in the research challenges of the steel industry and enabling industry colleagues and academics to form strong and lasting networks. Now in its fifth year, the symposium continues to go from strength to strength, centred around a core programme of postgraduate research presentations, with a poster exhibition, keynote speech and industrial exhibition. For the first time this year, the symposium includes the awarding of medals and prizes from the Iron & Steel Group of the Institute of Materials, Minerals and Mining. This includes the prestigious annual Bessemer Lecture, to be given by John Ferriola, formerly Chairman, CEO and President of Nucor, USA.

The popularity of the symposium, combined with the limited number of speaking slots, means that it is now extremely competitive to be accepted for a presentation and so my congratulations to those speakers who have been successful in joining the programme this year. For future years we will continue to look favourably on those applicants who have presented a poster in a previous year.

The great diversity of institutions involved in ferrous metallurgical research in the UK can be seen from today's programme. It is this diversity that makes the case for the symposium and for the same reason, strong, centralised institutions, such as the Materials Processing Institute, the Iron & Steel Group of IOM3 and the Company of Armourers & Brasiers' are more important than ever before. These three organisations have once again worked together to organise, fund and promote this event and remain committed to ensuring it continues as an annual fixture of international importance in the calendar of the UK materials research and the steel industry. The symposium now also forms part of the dissemination activities of the PRISM programme of research and innovation for the UK steel and metals sector, funded by the UK government and delivered by the Materials Processing Institute.

My personal thanks to the Master, Wardens and Company of Armourers & 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 are also due to the Iron & Steel Group for their support of this event as co-organising partners and to our sponsors, Tata Steel, M2A, Liberty Steel, Sheffield Forgemasters, UK Metals Council and the Cast Metals Federation. Thanks also to John Ferriola, Bessemer Laureate, for graciously agreeing to deliver the Bessemer Lecture as our keynote address.

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 encourage others to attend the next version of the symposium on 28th February 2023.

Chris McDonald
CEO, Materials Processing Institute

Programme - Morning Session

09:30 - 10:20 **Registration, Poster Exposition, Exhibition and Networking**

10:20 - 10:30 **Welcome and Introduction**
Chris McDonald, Chief Executive Officer, Materials Processing Institute

10:30 - 11:30 **Session 1: Development of Products and Applications**
Chaired by Professor Hongbiao Dong, University of Leicester

***1.** Characterisation of the effects of oxide dispersion strengthening on the tensile deformation and elastic properties of Eurofer97.*
***Presenter:** Tay Sparks (University of Birmingham)*

***2.** Effect of niobium microstructural and mechanical properties of the heat affected zones of welded marine steel.*
***Presenter:** Jun Fu (University of Leicester)*

***3.** A closer look at the TWIP and TRIP mechanism in medium Mn steels.*
***Presenter:** Thomas Kwok (Imperial College London)*

11:30 - 11:50 **First Perambulation**
Poster Exposition, Exhibition and Networking

11:50 - 12:50 **Session 2: Process Development**
Chaired by Gill Thornton, R&D Manager, Liberty Powder Metals Ltd

***4.** Ladle stirring monitoring for inclusion floatation.*
***Presenter:** William Moncaster (University of Warwick)*

***5.** In situ heat treatment to improve the metallurgy of hot work tool steel alloy H13 fabricated by laser additive manufacturing.*
***Presenter:** Anna Tholen (Loughborough University)*

***6.** The impact of process parameters on blast furnace dust output.*
***Presenter:** John Lewis (Swansea University)*

12:50 - 13:00 **Presentation of Iron & Steel Awards**

1. Adrian Normanton Medal
2. Frank Fitzgerald Medal and Travel Award
3. Dowding Medal and Prize
4. Tom Colclough Medal and Prize
5. Stokowiec Medal and Prize
6. Thomas Medal and Prize
7. Hadfield Medal and Prize
8. Gold Medal

Programme - Afternoon Session

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

14:00 - 15:20 **Session 3: Development Techniques and Fundamental Knowledge**
Chaired by Dr Richard Thackray, The University of Sheffield

7. *Prediction of mechanical properties of low-carbon hot rolled plate based on machine learning method.*
Presenter: *Xiaoan Yang (University of Leicester)*

8. *Development of improved formability interstitial free steels.*
Presenter: *Talal Said Abdullah (Swansea University)*

9. *Rapid characterisation of thermally aged stainless steels for nuclear power applications.*
Presenter: *Oscar Smith (Loughborough University)*

10. *Design of in situ cathodic charging of TMCP steel under flexural loading.*
Presenter: *Sarah Hiew Sze Kei (Imperial College London)*

15:20 - 15:45 **Second Perambulation**
Poster Exposition, Exhibition and Networking

15:45 - 16:00 **Awarding of Prizes by the Armourers & Brasiers Materials Science Committee**
1. Millman Scholarship
2. Ashok Kumar Fellowship
3. Best Poster
4. Presentation Runner-up
5. Presentation Winner

16:00 - 16:50 **Presentation of Bessemer Gold Medal and Bessemer Lecture**

The Sir Henry Bessemer Lecture will be given by John Ferriola, former Chairman, President and CEO of Nucor Corporation, USA

16:50 - 17:00 **Vote of Thanks and Closing Remarks**
Debojyoti Roy, Director Transformation and Synergy, Tata Steel UK

17:00 - 18:30 **Drinks Reception**

Poster Exposition

1. Minimising particulate emissions of sinter plant operations.
Matthew Thomas (Swansea University)

2. Cohesive zone models of fracture in line-pipe steel.
Pernille Undrum Fathi (Kings College London)

3. Multi-scale in situ studies of deformation mechanism of LPBF 316L stainless steels.
Wanxuan Teng (University of Birmingham)

4. Investigating formability of future steel grades using rapid alloy prototyping.
Liam Moody (Swansea University)

5. Effects of precious metal doping on stainless steels produced by spark plasma sintering.
Natasha Sweeney Fort (The University of Sheffield)

6. Hydrogen diffusion in pipeline steel API 5L X65.
Helena M. Ferreira (Swansea University)

7. Intercritical annealing optimisation in a segregation neutralised dual-phase steel, benchmarked against a commercial DP800.
Pedram Dastur (University of Warwick)

8. The effect of coating weight on the microstructure and performance of Zn-Al-Mg (ZAM) alloy coatings.
Daniel Britton (Swansea University)

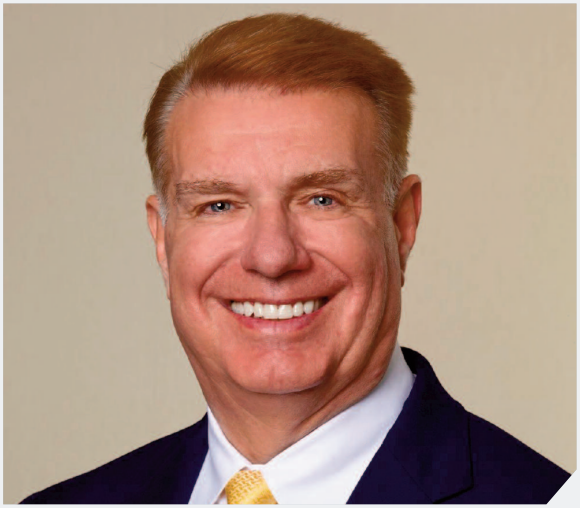
9. Avoidance of hydrogen assisted cold cracking in multi-pass weld metal.
Shaun Smart (TWI Ltd)

10. Size control in pelletisation.
William Kennedy Walls (Swansea University)

Bessemer Lecture by John Ferriola

John Ferriola is a former Chairman, President and CEO Nucor Corporation, USA. He led Nucor from 2011, when he became President, until the end of 2019, when he retired, having served as Chairman, President and CEO. During this time John led the redevelopment of the steel industry in the USA, redefining the role of the mini mill as a high-quality steel producer and serious competitor to the conventional integrated route.

John has also served as Chairman of the World Steel Association in 2016 and 2017, as Chairman of the American Iron & Steel Institute from 2016-2017, Chairman of the Steel Manufacturers Association from 2012-2014 and as a member of the Executive Committee of the National Association of Manufacturers from 2017-2019.



John Ferriola
Former Chairman, President and CEO Nucor Corporation, USA

John joined Nucor Corporation in 1991 as Manager of Maintenance and Engineering at the company's Jewett, Texas bar mill. In 1995, he was named General Manager of Nucor's Grapeland, Texas joist fabrication division. Later that same year, he was named Vice President and General Manager of Nucor's Norfolk, Neb. bar mill. From 1998 to the end of 2001, he served as Vice President and General Manager of the Crawfordsville, Ind. sheet mill. Prior to joining Nucor, John began his career with Bethlehem Steel Corporation in 1974 and worked for 17 years in various operating and engineering management roles.

In 2021 John was awarded the IOM3 Bessemer Gold Medal and has shown himself to be a true successor to Sir Henry Bessemer, bringing to full realisation one of Bessemer's own early patented inventions for efficient steel production.

Organised by the Materials Processing Institute with support from the Armourers & Brasiers' Company and the Iron & Steel Group of IOM3.

Materials Processing Institute

The Materials Processing Institute is a research and innovation centre supporting organisations that work in advanced materials, industrial decarbonisation, digital technologies and the circular economy. The Institute provides a range of technology and R&D based services and consultancy to support industry, government and academia. It has expertise in materials, materials processing and energy; specialising in challenging processes, particularly those involving high specification materials, high temperatures and difficult operating conditions.

The Institute combines the expertise of world-leading scientists, metallurgists and engineers and it has been at the forefront of innovations and process developments for over 75 years. Extensive materials processing knowledge is supported by state-of-the-art facilities, including high specification laboratories, scale-up, prototyping, demonstration and production facilities.

The Institute is delivering PRISM, a programme of research and innovation for the UK steel and metals sector, funded by Innovate UK. Its primary aim is to increase the competitiveness of the sector by funding collaborative projects between industry partners. These projects are all in the areas of decarbonisation, the circular economy and digitalisation.

ARMOURERS & BRASIERS' COMPANY

2022 is the 700th anniversary year of The Armourers & Brasiers' Company. The Armourers' Company started life in 1322 as a medieval guild in the City of London responsible for overseeing standards in the production of arms and armour. Over the centuries its purpose has evolved. It now exists primarily to promote education and research in materials science in the United Kingdom. It does this by awarding grants through the Armourers & Brasiers' Gauntlet Trust and by organising networking opportunities for the UK's materials science community. Materials science is the modern discipline most closely aligned to the Armourers & Brasiers' ancient craft of working with metals and materials. Grant programmes in support of materials science from school to post-doctoral level are described at www.armourershall.co.uk. The Company also offers an annual Venture Prize awarded through a competitive process as an investment to help commercialise innovative research in materials science. The Company exists also to maintain its historic home, Armourers' Hall, a scheduled ancient monument and Grade II listed building, on a site which it has occupied continuously since 1346. To mark it's 700th anniversary the Company has endowed in perpetuity the Armourers & Brasiers' Chair in Materials Science at Imperial College London. The first postholder is Professor Mary Ryan.

IOM3

IOM3 is the global network for the materials cycle, promoting sustainability and greater circularity in the extraction, processing and use of natural resources. IOM3 supports professionals in materials, minerals, mining and associated technical disciplines to become heroes of the transition to a low-carbon, resource efficient society, not villains.

Chair of Sessions

SESSION 1
Development of Products and Applications

Professor Hongbiao Dong
University of Leicester

Professor 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 2
Process Development

Gill Thornton
Liberty Powder Metals Ltd

Gill Thornton has a degree in Materials Science and an MBA from Warwick Business School. She has worked in the steel industry for 36 years in technical roles in R&D and on plants 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 to vacuum atomise high quality steel and nickel-based alloy powders, with bespoke chemistries to enhance properties where required. Gill is currently the R&D Manager for Liberty Powder Metals Ltd. Gill is a 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 alloy.

SESSION 3
Development Techniques and Fundamental Knowledge

Dr Richard Thackray
The 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, and a current member of the Sustainable Development Group.

UNIVERSITY OF BIRMINGHAM

UNIVERSITY OF LEICESTER

Characterisation of the effects of oxide dispersion strengthening on the tensile deformation and elastic properties of Eurofer97

SPEAKER / LEAD AUTHOR:
Tay Sparks

INSTITUTION:
University of Birmingham

OTHER AUTHORS:
Dr Biao Cai, University of Birmingham
Dr Yiqiang Wang, UK Atomic Energy Authority
Dr Michael Gorley, UK Atomic Energy Authority
Dr Thomas Connolley, Diamond Light Source Ltd

ABSTRACT:
Augmentation of the mechanical properties of reduced activation ferritic martensitic steels for structural application in nuclear fusion reactors is an area which attracts a great deal of interest. In the presented work, the effect of temperature on the elastic and microstructural properties of 0.3% wt Y2O3 oxide dispersion strengthened steel Eurofer97 is investigated using synchrotron high energy X-ray diffraction in-situ tensile testing, alongside the non-oxide strengthened base steel as a point of comparison. The single crystal elastic constants of both steels are experimentally determined through analysis of the diffraction peaks corresponding to specific grain families in the polycrystalline samples investigated. Furthermore, the effect of temperature on the evolving dislocation density and character in both materials is interrogated, providing insight as to deformation mechanisms present. Finally, the constitutive flow stress model is used to evaluate the factors affecting yield strength, allowing the strengthening contribution of the oxide particles to be evaluated.

Effect of niobium on microstructural and mechanical properties of the heat affected zones of welded marine steel

SPEAKER / LEAD AUTHOR:
Jun Fu

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Professor Hongbiao Dong, University of Leicester
Dr Qing Tao, University of Leicester
Bogdan Nenchev, University of Leicester
Dr Chinnapat Panwiswas, University of Leicester
Neng Ren Ming Li, China University of Mining and Technology
Biao Tao, Nanjing Iron & Steel United Co, Ltd

ABSTRACT:
The effect of niobium on the heat affected zone of welded E36 marine steel is investigated under different heat inputs from 50kJ/cm to 250kJ/cm during welding. Thermal simulation tests on two E36 steel plates, one with niobium (E36-Nb) and the other without (E36), were conducted by Gleeble 3800. Microstructure and mechanical properties of the welded samples were characterized by optical microscopy (OM), and electron back-scatter diffraction (EBSD), Brinell hardness tests and Charpy impacts tests, respectively. The measured welding thermal cycles in the Gleeble experiments were used as input in a heat transfer-phase transformation model to simulate the thermal process of E36 marine steel. The Leblond-Devaux parameters for phase transformation were evaluated using continuous cooling transformation (SHCCT) diagram. The quantitative correlation among thermal cycle, microstructure and mechanical properties during welding process were analysed using a combined physical simulation by Gleeble 3800 and numerical simulation by COMSOL.

Imperial College London

A closer look at the TWIP+TRIP mechanism in medium Mn steels

SPEAKER / LEAD AUTHOR:
Thomas Kwok

INSTITUTION:
Imperial College London

OTHER AUTHORS:
Dr Peng Gong, University of Sheffield
Professor David Dye, Imperial College London

ABSTRACT:
Medium Mn (medMn) steels have gained significant academic and industrial attention due to their low cost, high strain hardening rates (>1.5 GPa) and large elongations to failure (>40%). This is achieved by adjusting the stacking fault energy and stability of the austenite phase, thereby activating a combined Twinning Induced Plasticity and Transformation Induced Plasticity (TWIP+TRIP) effect. While the TWIP+TRIP effect has been studied extensively in stainless steels, little is known about how to control it in medium Mn steels. This presentation aims to shed some light on the TWIP+TRIP effect in medMn steels, especially on how microstructure affects the twinning and transformation responses.

Two medMn steels with an equiaxed and lamellar microstructure were produced using the same composition. Interrupted tensile specimens were characterised using Electron Backscatter Diffraction (EBSD) and Transmission Electron Microscopy (TEM) to examine the evolution of deformation structures with strain.

Ladle stirring monitoring for inclusion floatation

SPEAKER / LEAD AUTHOR:
William Moncaster

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Paul Kitson, Materials Processing Institute

ABSTRACT:
Within production of bearing and aerospace steels, consistency of ladle stirring is critical for inclusion floatation. This a process occurring at the end of steelmaking aiming to encourage detrimental inclusions to float out of the liquid steel. An effective inclusion floatation operation is closely linked to superior mechanical properties and has thus far satisfactorily been controlled by the experience of steelmakers allowing for steels to provide exemplary performance in service. Recently, a great effort has been expended researching ladle stirring monitoring using sound, vibration and video based technologies, with an aim to quantify stirring so that it can be even more closely and consistently controlled.

This project looked at implementing ladle vibration monitoring technology at Liberty Speciality Steels with a view to linking vibration and process data to a number of product quality measures in order to link the gentle stirring during inclusion floatation to product performance.

In situ heat treatment to improve the metallurgy of hot work tool steel alloy H13 fabricated by laser additive manufacturing

SPEAKER / LEAD AUTHOR:
Anna Tholen

INSTITUTION:
Loughborough University

OTHER AUTHORS:
Dr Rebecca Higginson, Loughborough University
Dr Lewis Jones, Loughborough University
Professor John Tyrer, Loughborough University
Nick Jones, Renishaw Plc
Dr Ravi Aswathanarayanaswamy, Renishaw Plc
Robert Brown, Renishaw Plc

ABSTRACT:
Laser powder bed fusion (LPBF) additive manufacturing (AM) is a promising manufacturing process for high wear resistance alloys, such as tool steels. The mitigation of subtractive processing means that a tool steel fabricated component does not need to be machined in a softened state followed by hardening heat treatments to enable the high wear resistance characteristics required for tooling applications.

Following the fabrication of H13 fabricated by LPBF AM, stress relieving heat treatments are necessary to reduce residual stresses. This adds time and cost to the process, as well as being reactive rather than preventative to the formation of catastrophic defects in the fabricated material.

This research uses dilatometry to investigate the potential of utilising in-situ laser heat treatments, to restore the microstructure of H13 during fabrication in the LPBF AM process. The opportunities to incorporate these preventative in-situ heat treatments into the LPBF AM process are also discussed.

The impact of process parameters on blast furnace dust output

SPEAKER / LEAD AUTHOR:
John Lewis

INSTITUTION:
Swansea University

ABSTRACT:
To assess the combustion efficiency of coal injected into the blast furnace, dust samples have been analysed for various analytes and carbon type differentiation techniques applied. The dust output of the furnace has been measured using a suspended solid meter in the water flume and trended against live process parameters. The dust output is not influenced one parameter, but more a combination of parameters. The live dust measurements have been validated by a manual suspended solid technique and the dust analysed for carbon type via the Canmet method. A recognised method for carbon type differentiation. With increase in dust output, we see a decrease in the difference between carbon types. The data can be influential in optimising a process for combustion efficiency with minimal influence on the product. The impact of the project is dependent on the outcome of the work and actual impact of the change in process parameters.

Prediction of mechanical properties of low-carbon hot rolled plate based on machine learning method

SPEAKER / LEAD AUTHOR:
Xiaoan Yang

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Dr Jenny Shepherd, University of Leicester
Dr Qing Tao, University of Leicester
Professor Hongbiao Dong, University of Leicester

ABSTRACT:
Prediction of mechanical properties as a function of chemical composition and hot rolling process parameters is important to the steel metallurgy industry; this is especially true for the yield to tensile ratio, a clear predictor for plastic collapse. In this study, a series of machine learning methods including shallow neural networks and decision tree approaches are applied to consider yield to tensile ratio using industrial datasets.

Sensitivity analysis (feature learning) is applied at the initial stages of building machine learning models and this allows the importance of features, not merely in terms of linear correlations to be ranked. As a result of sensitivity analysis the key impact features to control the yield to tensile ratio could be derived from massive industrial inputs. With the integration of statistical methods and data-driven models, prediction of yield to tensile ratio could be achieved and the key influential parameters Mn and Nb concentration identified.

Development of improved formability interstitial free steels

SPEAKER / LEAD AUTHOR:
Talal Said Abdullah

INSTITUTION:
Swansea University

ABSTRACT:
Improving the formability of Interstitial Free steels is the project's aim and rapid alloy prototyping (RAP) is an effective way of tackling this endeavour. Miniaturised test samples of DX57 will be subjected to tensile testing with intentions of being able to extract the R-value in a repeatable fashion. The aim is to see if measurements are representable to that of its standard samples. The idea is to be able to roll out 200g RAP strip in the rolling mill, and to have several Mini 2 bars sampled and tensile tested for mechanical properties. Running experiments with large amounts of material on an industrial plant is slow and expensive. If small scale production of alloys showing representative structures and giving realistic results from miniature testing could be achieved, then this would represent a major improvement and acceleration in novel steel grade design.

Rapid characterisation of thermally aged stainless steels for nuclear power applications

SPEAKER / LEAD AUTHOR:
Oscar Smith

INSTITUTION:
Loughborough University

OTHER AUTHORS:
Sarah Spindle, EDF Energy
Mike Spindler, EDF Energy
Jacob Knight, EDF Energy
Dr Simon Hogg, Loughborough University
Dr Rebecca Higginson, Loughborough University

ABSTRACT:
During thermal aging in stainless steels intermetallics and carbides form. These phases may reduce the mechanical and corrosion properties of stainless steels. In some cast austenitic stainless steels, delta ferrite is present within the austenitic matrix. These regions of delta ferrite were observed to transform rapidly during thermal aging, initially forming $M_{23}C_6$ carbides at the interface between ferrite and austenite within ~24hrs at 750°C and with sigma phase then forming within ~48hrs. The formation of these phases coincides with the formation of secondary austenite and can be described as $\delta \leftrightarrows \sigma + \gamma'$, $\delta \leftrightarrows M23C6 + \gamma'$. Methods of phase identification and quantification such as Electron Backscatter Diffraction (EBSD) paired with Energy Dispersive Spectroscopy (EDS) can allow rapid assessment of these phases across large areas of material. However, when phases have similar crystal structures and are in the order of ~100nm EBSD analysis can be challenging. This presentation discusses the details of the techniques used for phase detection in these complex systems and our ability to accurate map the phases. This presentation presents the research conducted on thermally aged stainless steels and the characterisation of carbides and intermetallics using EBSD.

Design of in situ cathodic charging of TMCP steel under flexural loading

SPEAKER / LEAD AUTHOR:
Sarah Hiew Sze Kei

INSTITUTION:
Imperial College London

OTHER AUTHORS:
Bostjan Bezensek, Shell Global Solutions UK
Steve Paterson, Shell Global Solutions UK
Willem Maarten van Haaften, Shell Global Solutions International BV
Dr Thibaut Dessolier, Imperial College London
Dr Stella Pedrazzini, Imperial College London
Dr Ben Britton, The University of British Columbia

ABSTRACT:
Thermo-Mechanical Control Process (TMCP) steels are used in oil and gas production because of good cost-performance ratio. However, they may be at risk of premature failures in low pH environments. These environments may promote hydrogen formation and ingress into, leading to embrittlement of, the steel, potentially resulting in failure via associated with Sulphide Stress Cracking (SSC). In this work, we are developing in situ methods to charge with hydrogen while loading TMCP samples mechanically to understand these mechanisms. We have designed a three-point bend rig to enable flexural loading of single-edged notched bend sample within an electrochemical cell. The rig design work has included in situ electrochemical charging and crack monitoring. Crack monitoring is being performed using crack tip opening displacement (CTOD) measurements with a clip gauge, potential drop measurements, and 2D digital image correlation. In this presentation, we will explore the design process and preliminary results from this study.

Poster 1

Minimising particulate emissions of sinter plant operations

AUTHOR OF POSTER:
Matthew Thomas

INSTITUTION:
Swansea University

ABSTRACT:
The principal for the long-term future of the Tata Steel integrated steel plant in Port Talbot is reliant on efficient and stable operations. However, increased production levels and stringent environmental demands have pushed the sinter plant main stack to its limits with respect to particulate emissions.

Sinter is a critical feedstock for the blast furnaces to aid the production of liquid iron for the conversion to steel. The objective is to understand the effects of chemistry of the sinter blend upon performance, product output and environment emissions. Laboratory simulation with current and modified blends with the aim to optimise accelerants and raw materials will be analysed. Full scale plant trials that results in minimised particulate emissions to comply with the new emission limit value of 40mg/Nm3 will determine if this project is successful.

Poster 2

Cohesive zone models of fracture in line-pipe steel

AUTHOR OF POSTER:
Pernille Undrum Fathi

INSTITUTION:
Kings College London

ABSTRACT:
There is a keen motivation to use existing domestic pipelines to carry hydrogen as a replacement to natural gas. The issue of hydrogen embrittlement arises and we are involved in a project at SINTEF Industry in Norway to make finite element based cohesive zone models of fracture in steel. Our remit is to enquire into the fundamental principles behind these models and to suggest how a traction separation law may be implemented in a transparent way.

Poster 3

Multi-scale in situ studies of deformation mechanism of LPBF 316L stainless steels

AUTHOR OF POSTER:
Wanxuan Teng

INSTITUTION:
University of Birmingham

OTHER AUTHORS:
Professor Moataz Attallah, University of Birmingham
Dr Biao Cai, University of Birmingham

ABSTRACT:
An understanding of deformation mechanisms of laser powder bed fusion (L-PBF) 316L stainless steels was important for further optimization of LPBF processing and the in-service applications of L-PBF 316L steel. In this study we used in situ synchrotron characterization to study the formation of corrugated surface in L-PBF 316L stainless steel during mechanical loading. In situ tomography analysis was carried out revealing the surface morphology and porosity evolution. The pores elongate and reaching the surface during loading. A corrugated surface was formed after plastic deformation. Ex situ characterizations including optical microscopy and electron microscope revealed the microstructures contributed to the mechanical performance. The findings show the further needs to optimize the mechanical performance of additive manufactured alloys through tailoring the microstructure.

Poster 4

Investigating formability of future steel grades using rapid alloy prototyping

AUTHOR OF POSTER:
Liam Moody

INSTITUTION:
Swansea University

ABSTRACT:
This research focuses on optimising a proprietary software to improve the efficiency of the runout table during the steel making process. This optimisation is achieved by inputting microstructural and temperature data collected from onsite measurements. A fully optimised mathematical model of the hot mill will allow for a comprehensive understanding of the thermomechanical aspects that need to be incorporated and therefore improve the manufacturing process by reducing wastage. The model is also being adapted to work at a laboratory scale. The optimisation of this model will benefit future steel making processes and save both energy and resources by reducing the amount of waste material. Optimised simulations of a full size and lab scale runout tables will assist in facilitating the scale up of novel alloys, produced using the Rapid Alloy Prototyping Process.

Poster 5

Effects of precious metal doping on stainless steels produced by spark plasma sintering

AUTHOR OF POSTER:
Natasha Sweeney Fort

INSTITUTION:
The University of Sheffield

ABSTRACT:
The corrosion resistance of stainless steels can prove inadequate in particularly aggressive environments leading to reduced service life and poor performance. Research shows that cathodic modification with precious metals by alloying and coating can improve the corrosion resistance of stainless steels. Research which explores the use of spark plasma sintering (SPS) to produce stainless steels cathodically modified by precious metals remains lacking. This project aims to incorporate precious metals into stainless steels by functional grading using SPS. The metal powders used have been characterised by particle size analysis and SEM. The sintered parts have been analysed using SEM to investigate grain size and elemental segregation. Indentation testing and density measurements of the sintered samples was also carried out.

Poster 6

Hydrogen diffusion in pipeline steel API 5L X65

AUTHOR OF POSTER:
Helena M. Ferreira

INSTITUTION:
Swansea University

ABSTRACT:
Climate change is driving a transition in the energy sector, with low-carbon energy vectors such as hydrogen (H2) emerging as an alternative to fossil fuels. However, hydrogen is known to cause premature failure of components. Therefore, it is imperative to evaluate to what extent will hydrogen induced failure limit the service conditions of steel pipelines, which are essential components for the future H2 transportation infrastructure.

This poster will review important fundamentals of hydrogen entry and diffusion in steels, in particular similarities and differences expected to occur between gaseous and electrolytic hydrogen charging and the influence of microstructural features in the hydrogen mobility throughout the material. This work focuses on a specific steel grade commonly used in pipelines - API 5L X65 – and it aims to investigate the hydrogen diffusivity of this steel grade under different electrolytic charging conditions, using hydrogen permeation testing (ISO 17081:2014).

Poster 7

Intercritical annealing optimisation in a segregation neutralised dual-phase steel, benchmarked against a commercial DP800

AUTHOR OF POSTER:
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Bharath Bandi, University of Warwick
Professor Claire Davis, University of Warwick

ABSTRACT:
Dual phase (DP) steels are typified by their ferrite and martensite microstructure, where the martensite is banded in the rolling direction due to micro-segregation of Mn during solidification. The banding results in anisotropy in mechanical properties, and reduced ductility in DP steels. The concept of neutralizing the effect of Mn segregation on the second phase distribution has been employed to remove the banded martensite distribution. To achieve this the steel composition has been redesigned to balance the austenite (Mn) and ferrite (Si) stabilising elements in micro-segregation to introduce a new grade of DP steel named as 'segregation-neutralised (SN)' DP steel. In this report a systematic approach has been used to compare the inter-critical annealing parameters required for the SN-DP compared to a commercial DP steel and the sensitivity of the microstructure to variations in these parameters. The tensile properties, and anisotropy in properties, of the two grades have been compared. It has been found that the commercial DP grade showed higher sensitivity to heating rate in terms of volume fraction of martensite formed compared to the SN-DP steel. However, the SN-DP steel was more sensitive to cooling rate to achieve the desirable ferritic-martensitic microstructure. The SN-DP steel showed negligible anisotropy in strength and elongation achieving the alloy design aim for more uniform properties.

Poster 8

The effect of coating weight on the microstructure and performance of Zn-Al-Mg (ZAM) alloy coatings

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Professor James Sullivan, Swansea University
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Professor Geraint Williams, Swansea University

ABSTRACT:
Zinc magnesium aluminium (ZAM) galvanised coatings have found increasing popularity over the past two decades due to their reported superior corrosion protection. However, ZAM coatings exhibit a complex microstructure, which is influenced by a range of processing parameters, making consistent coatings very difficult to produce. This work concentrates specifically on the effect of coating weight on microstructure and subsequent corrosion performance.

Use of the Scanning Vibrating Electrode Technique on three different coating weights showed a steady decrease in metal loss as the coating weight is increased. The use of sequential polishing found that the average volume fraction of zinc dendrites in the coating decreased as coating weight increased. This resulted in a higher volume fraction of the aluminium and magnesium eutectic phases present in the thicker coatings, leading to greater protection through the promotion of stable Al and Mg corrosion products.

Poster 9

Avoidance of hydrogen assisted cold cracking in multi-pass weld metal

AUTHOR OF POSTER:
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ABSTRACT:
Many challenges still remain regarding the mechanism of hydrogen assisted cold cracking (HACC). Historically, heat affected zone (HAZ) HACC has been the predominant failure mode, its causes and mitigation have been studied extensively and are generally well understood. However, with the development of lean composition steels, along with the use of high strength, highly alloyed welding consumables, a shift from HAZ cracking to weld metal (WM) cracking may also commonly occur. So far, industrial techniques for avoidance of HACC are still focused on HAZ cracking and do not consider the difference between the mechanism resulting in HAZ or WM HACC. Thus, a need has arisen to define the cracking mechanism and techniques for the avoidance of WM HACC.

In this study a condition that results in both WM and HAZ HACC has been developed on U-groove S690QL grade steel samples, welded with a multi-pass technique and flux-cored welding wire. In-depth microstructural investigation was undertaken to characterise HACC morphology in both WM and HAZ, and the bulk diffusible hydrogen of the deposited WM was quantified. Following this, HACC avoidance techniques were applied to the cracking condition in order to understand the effectiveness of different procedural techniques for avoidance of WM HACC.

Poster 10

Size control in pelletisation

AUTHOR OF POSTER:
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ABSTRACT:
Pelletisation is a one of a variety of methods of converting fine ferrous materials into a form suitable for use in the blast furnace. The carbon released in pelletisation of fines is much lower than that for sintering, making it a valuable tool in the toolbox of carbon reduction.

One of the main weaknesses of pelletisation is that controlling the size of the pellets has been historically difficult to manage, and performed through analysis of the growth rate.

This poster will cover simulating the process of pelletisation and the novel analytical theory which it uses.

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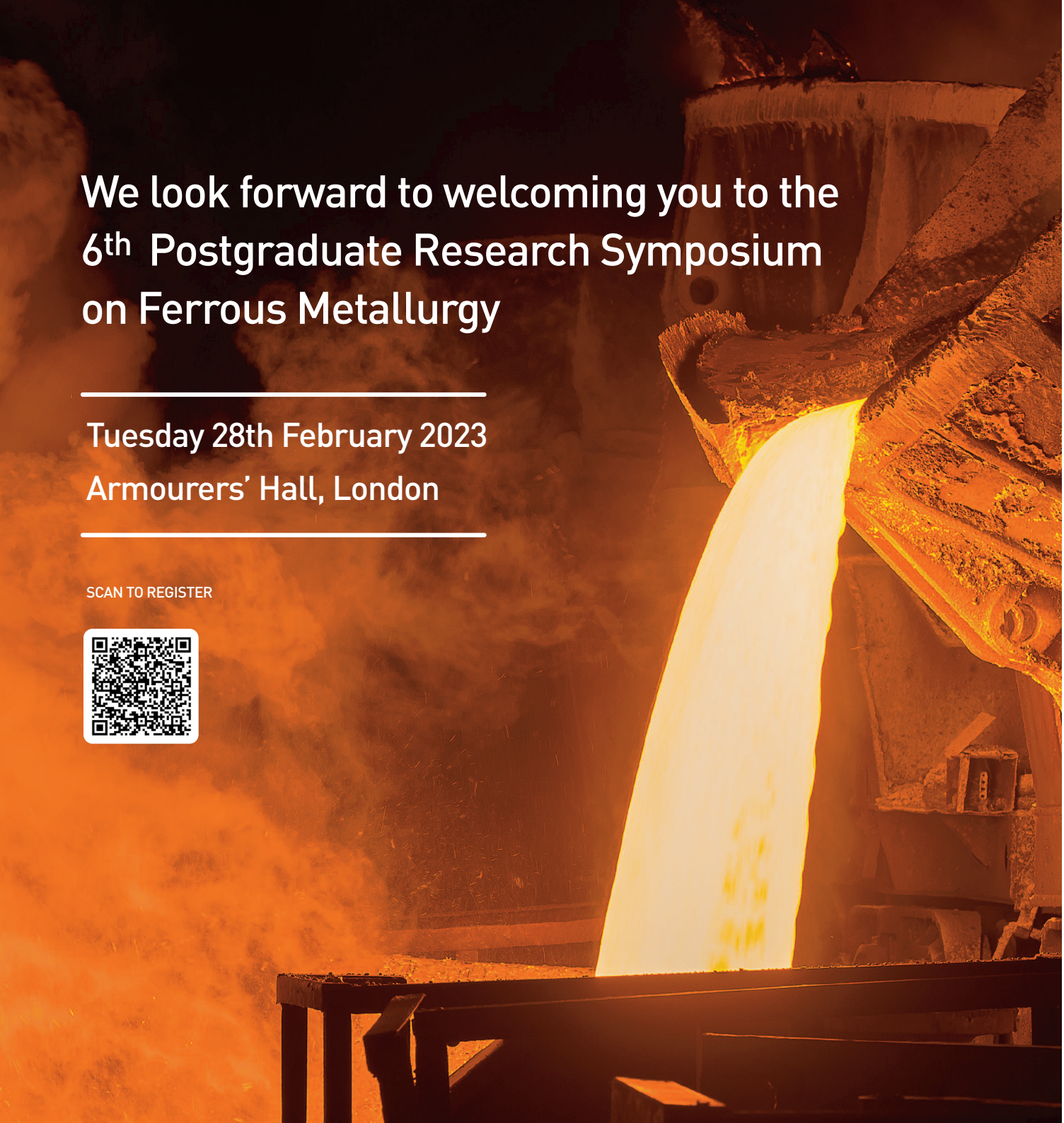
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