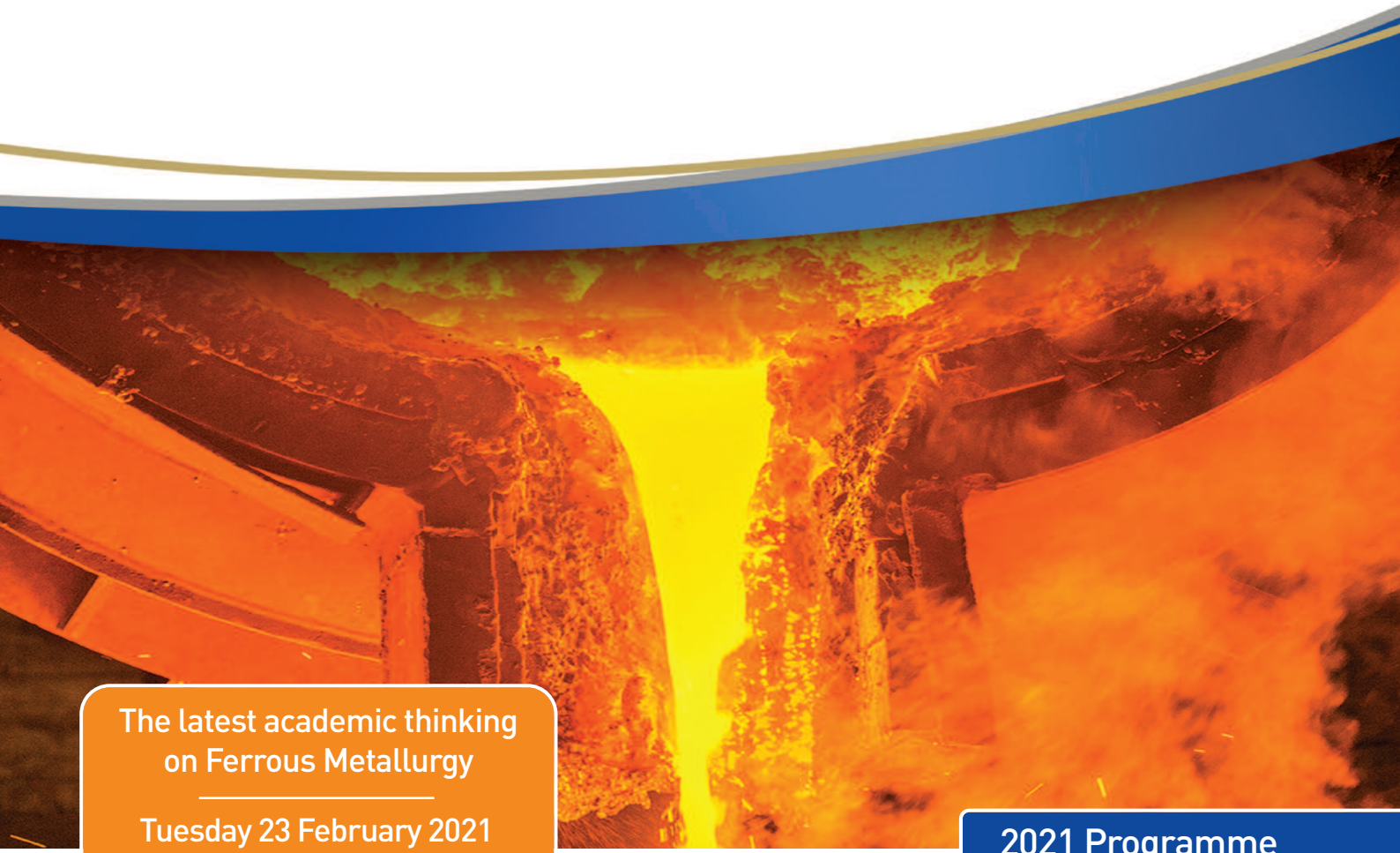
Materials Processing Institute

VIRTUAL EVENT
4th Postgraduate Research Symposium on Ferrous Metallurgy



The latest academic thinking on Ferrous Metallurgy

Tuesday 23 February 2021

#Metallurgy4

2021 Programme

Organised by:

Materials Processing Institute

ARMOURERS & BRASIERS' COMPANY

I·M3

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PRISM

Materials Processing Institute

Foreword by Chris McDonald

Welcome to the fourth annual postgraduate research symposium for ferrous metallurgy. In response to the COVID-19 pandemic, the symposium has moved online this year, which is enabling greater participation, including internationally. The symposium aims to enable PhD and EngD researchers and university departments to showcase their research, to inspire academics and research students to engage in the research challenges of the steel industry, and to enable industry colleagues and academics to form strong and lasting networks. The symposium is now a firmly established part of the UK metallurgy calendar and is more popular than ever, with this year seeing our highest ever level of submissions for papers, posters and delegates. This means that it is now extremely competitive to be accepted for a paper 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 metallurgy 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 and Steel Society and the Company of Armourers and 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 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 & 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 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 are also due to the Iron and Steel Society for their support of this event as co-organising partners and to our sponsors, M2A, and to Dr. Alexander Fleischanderl, for graciously agreeing to deliver the 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 22nd February 2022, when we hope to be able to meet again in person at Armourers' Hall.

Chris McDonald
CEO, Materials Processing Institute

Programme - Morning Session

09:45 - 10:00 Registration, Poster Exposition, Exhibition and Virtual Networking

10:00 - 10:10 **Welcome and Introduction**
Chris McDonald, Chief Executive Officer, Materials Processing Institute

10:10 - 11:30 **Session 1: Process Optimisation**
Chaired by Dr Richard Thackray (University of Sheffield)

10:10 - 10:15 *Introduction by Session Chair*

10:15 - 10:40 ***1.*** *Improving cold spray additive manufacturing with a nozzle designed by the method of characteristics.*
Presenter: *Florentina-Luiza Zavalan (University of Leicester)*

10:40 - 11:05 ***2.*** *Advanced analytics of sinter plant operations to minimise particulate emissions.*
Presenter: *Matthew Thomas (Swansea University)*

11:05 - 11:30 ***3.*** *Automated ladle pouring in the steel industry.*
Presenter: *Ivan Popov (Swansea University)*

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

11:50 - 13:10 **Session 2: Development of Product and Properties**
Chaired by Gill Thornton (Liberty Powder Metals Ltd)

11:50 - 11:55 *Introduction by Session Chair*

11:55 - 12:20 ***4.*** *How low can you go? The medium manganese limbo.*
Presenter: *Thomas Kwok (Imperial College London)*

12:20 - 12:45 ***5.*** *Investigating different rapid alloy prototyping approaches to develop alloys to allow for higher scrap steel content.*
Presenter: *Caroline Norrish (Swansea University)*

12:45 - 13:10 ***6.*** *Understanding the effects of deep cryogenic treatment on precipitation behaviour in En31 bearing steel.*
Presenter: *Kyle Nicholls (University of Leicester)*

13:10 - 13:50 **Lunch Break**
Poster Exposition, Exhibition and Virtual Networking

13:15 - 13:35 *Chris McDonald in conversation with Dr Alexander Fleischanderl, Primetals Technologies Austria GmbH.*

Programme - Afternoon Session

13:50 - 15:35 **Session 3: Understanding Material Performance**
Chaired by Professor Cameron Pleydell-Pearce (Swansea University)

13:50 - 13:55 *Introduction by Session Chair*

13:55 - 14:20 ***7.*** *Role of toughness in abrasion, and impact-abrasion wear.*
Presenter: *Appa Rao Chintha (University of Cambridge)*

14:20 - 14:45 ***8.*** *Effect of Ti microalloying and residual S content on the hot ductility of a boron steel.*
Presenter: *Yaiza Montaña González (CEIT-Basque Research and Technology Alliance, Universidad de Navarra, Tecnun)*

14:45 - 15:10 ***9.*** *Multi-scale investigation of dislocation-assisted carbon migration in ferrite.*
Presenter: *Tigany Zarrouk (King's College London)*

15:10 - 15:35 ***10.*** *Blistering formation in high strength steels (HSS) during hot rolling.*
Presenter: *Rebecca Dewfall (University of Swansea)*

15:35 - 16:00 **Second Perambulation**
Poster Exposition, Exhibition and Virtual Networking

15:40 - 15:55 **Virtual Tour of Armourers and Brasiers' Company**

16:00 - 16:40 **Keynote Speaker**
Dr Alexander Fleischanderl, Primetals Technologies Austria GmbH
Technology Officer Upstream, Head of ECO Solutions

16:40 - 16:50 **Awarding of Prizes by the Armourers and Brasiers' Materials Science Committee**
1. Millman Scholarship
2. Best Poster Winner
3. Best Presentation Runner-up
4. Best Presentation Winner

16:50 - 17:00 **Closing remarks and thanks by Chris McDonald, Chair of the Symposium**

Poster Exposition

1. Initial microstructure characterisation of some castable nanostructured alloys for fission and fusion applications.
James Lennard (University of Manchester)

2. Effect of environmentally friendly additives on Zn-Mn alloys morphology and structure.
Dr Nouha Loukil (National School of Engineering of Sfax ENIS-Tunisia)

3. Steel susceptibility to hydrogen induced failure.
Helena Ferreira (Swansea University)

4. Novel coating solutions for the improvement of scale surface condition.
James Grant (Swansea University)

5. The effect of coal volatile on top gas carbon.
John Lewis (Swansea University)

6. The effect of steel microstructure on damage mechanisms at the wheel-rail interface.
James Ayabina (The University of Sheffield)

7. A review of published models to predict the extent of surface oxidation.
Nicola Beech (University of Warwick)

8. Numerical modelling of thermal-mechanical evolution during high heat input welding of marine steel.
Jun Fu (University of Leicester)

9. Prediction of the mechanical properties of hot rolled steel plates using artificial neural network and statistical method.
Xiaoan Yang (University of Leicester)

10. Exploring the effects of cryogenic treatment on coating-substrate systems.
Christian Chiadikobi (University of Leicester)

Continued on page 5...

Poster Exposition

11. Understanding of ductile fracture mechanisms in nuclear pressure vessel steels under different constraints.
Suleyman Karabal (The University of Manchester)

12. The effect of processing variables on ZnMgAl alloy coating characteristics.
Daniel Britton (Swansea University)

13. Development of improved formability advanced high strength steels.
Talal Said Abdullah (Swansea University)

14. Development of new surface treatments for automotive utilising chemcoater.
Jamie Williams (Swansea University)

15. The role of Chromium Oxide in suppressing filiform corrosion on Cr metal / Cr Oxide coatings for steel used in packaging applications.
Ellen Bluett (Swansea University)

16. The adhesion of protective coatings to novel REACH compliant packaging steel substrates.
Matthew Dodd (Swansea University)

17. Damage tolerance study of a novel maraging steel for aerospace shaft application.
Antony Robinson (Swansea University)

Dr Alexander Fleischanderl

Dr Alexander Fleischanderl is Head of Eco Solutions and Technology Officer Upstream at Primetals Technologies, a joint venture of Mitsubishi Heavy Industries and partners headquartered in London. With a PhD in process engineering and about 100 patents to his name, he is an expert for sustainable iron and steel production. He was Siemens Inventor of the Year 2013 and received the MHI Innovation Award 2019 for Best Environmental Product.

Alexander joined Primetals Technologies Austria in 1997 (then VAI and later Siemens VAI) and went on to hold various positions within the company in Technical Sales, project management and R&D for the environmental, steelmaking, and long rolling businesses. With more than two decades of experience in the industry, his expertise covers blast furnace and alternative ironmaking, BOF and EAF steelmaking, waste-gas cleaning, decarbonisation, energy efficiency, by-product management and wastewater treatment.

Dr Alexander Fleischanderl
Primetals Technologies Austria GmbH Technology Officer Upstream, Head of ECO Solutions

His current focus is setting the steel industry on a path toward carbon-neutrality by 2050 - a task for which Primetals Technologies, one of the few globally active full-line providers of technology for the steel industry is well positioned. It will take a mix of carbon direct avoidance with breakthrough technologies, carbon capture and utilisation, as well as increased energy efficiency to achieve the ambitious goals set under the Paris Agreement.

While Alexander believes the technological problems of decarbonisation in the industry are eminently solvable, economic incentives still largely point the other way. There is a considerable gap between the economic feasibility of breakthrough technologies in low-carbon ironmaking (such as hydrogen-based direct reduction) and the amount by which emissions must be reduced within a relatively short timeframe. This is why Alexander has been actively engaging government agencies, producers, as well as international investors to work on regulatory frameworks, the economics, as well as the technological challenges of decarbonisation.

PRIMETALS TECHNOLOGIES

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

Materials Processing Institute

The Materials Processing Institute is a research and innovation centre serving 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 Doctoral Academy at the Institute links with industry and the UK academic research base to support postgraduate and EngD students specialising in materials science disciplines and the SME Technology Centre supports businesses with the development of new technologies and products.

Armourers & Brasiers' Company

The Armourers & Brasiers' 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 changed a number of times. It now exists primarily to promote Materials Science in the United Kingdom. It does by awarding grants through the Armourers & Brasiers' Gauntlet Trust to supports education and research in Materials Science and by organising networking opportunities for the UK's Materials Science community in universities and industry.

Materials Science is the modern discipline most closely aligned to the Armourers and 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.

IOM3

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. IOM3 activities promote and develop all aspects of the Materials Cycle, from exploration and extraction, to characterisation, processing and application, to product recycling, repurposing and reuse.

Chair of Sessions

SESSION 1
Process Optimisation

Dr Richard Thackray
University of Sheffield

Richard is a key member of the University of Sheffield's team for SUSTAIN - the EPSRC funded Future Steel Manufacturing Research Hub. He holds a degree in Materials Science and a PhD in Metallurgy from Imperial College London. Richard joined the University of Sheffield in 2003 as Corus Lecturer in Steelmaking, and his current research interests are related to the production of steel, including development of mould powders for continuous casting of steel, and the role of thermomechanical processing on inclusion behaviours.

Richard is also involved in a number of projects that look at aspects of sustainability in steelmaking, in particular, initiatives to reduce energy consumption in steelmaking, reuse/recycling of waste material, life-cycle assessment of critical elements in steel, and industrial symbiosis in the steel industry. Richard is past chair of the Iron and Steel Society of the Institute of Materials, Minerals and Mining, and a current member of the Sustainable Development Group and Casting Society.

SESSION 2
Development of Product and Properties

Gill Thornton
Liberty Powder Metals Ltd

Gill has a degree in Material Science and an MBA from Warwick Business School. She has worked in the steel industry for 34 years in technical roles including R&D and on plants across the UK. Her most recent work was leading a 4 year multi partner UK government project on creating an advanced manufacturing supply chain for net shape and additive manufactured parts which address the demands of end-users. This has led to Liberty Steel starting a new business; Liberty Powder Metals to vacuum atomise a broad spectrum of high quality steel and nickel-based alloy powders, with bespoke chemistries to enhance properties where required, where her current role is the R&D Manager. Gill is a past president of the Cleveland Institution of Engineers.

SESSION 3
Understanding Material Performance

Professor Cameron Pleydell-Pearce
Swansea University

Professor Cameron Pleydell-Pearce has significant experience of managing industry and academic research collaborations. Before becoming a TATA Steel sponsored lecturer at Swansea University, Cam worked in research at the Rolls-Royce University Technology Centre in Materials, specialising in material characterisation and mechanical metallurgy.

He established the Advanced Imaging of Materials facility and played a leading role in the establishment of the Steel and Metals Institute. He is Deputy Director of the SUSTAIN Future Steel Manufacturing Hub, delivering science and the engineering research to create carbon neutral, resource-efficient UK steel supply chains.

Current research includes topics supporting innovation in the steel industry from product development to process innovation and optimisation of steel making and extractive metallurgy methods. This includes optimisation of ferrous raw material processing, characterisation of refractory materials and rapid alloy development.

Improving cold spray additive manufacturing with a nozzle designed by the method of characteristics

SPEAKER / LEAD AUTHOR:
Florentina-Luiza Zavalan

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Dr Aldo Rona, University of Leicester

ABSTRACT:
Cold spraying is increasingly attractive as an additive manufacturing technique as it retains the original properties of the feedstock and produces oxide-free deposits. Many cold spray facilities use conical convergent-divergent nozzles for accelerating the particles; this typically creates deposits with a triangular profile, rather than an even layer, and can decrease the deposition efficiency. In the current study, this build-up issue is addressed by an axisymmetric profiling of the nozzle walls. This redesign is achieved by application of two aerospace design codes based on the Method Of Characteristics (MOC). By using a coupled Eulerian-Lagrangian Computational Fluid Dynamics (CFD) formulation, the performance of a current commercial cold spray nozzle is compared with that of the redesigned nozzle profile. The numerical predictions show that the new nozzle shape delivers more radially uniform deposit profiles. A higher particle velocity is obtained at the same operating conditions/costs used by the industry standard nozzle.

Advanced analytics of sinter plant operations to minimise particulate emissions

SPEAKER / LEAD AUTHOR:
Matthew Thomas

INSTITUTION:
Swansea University

ABSTRACT:
Advanced Analytics of Sinter Plant Operations to Minimise Particulate Emissions (PM). Use of data analysis techniques to improve understanding of the process and correlate process parameters and raw materials to PM emissions and to identify areas of opportunity to decrease PM to the local community. Understand the effects of chemistry upon performance, focusing on reduced chlorides by treatment of reverts, effects on sinter quality and design/implementing new sinter process filter system technology on a laboratory scale to capture and measure PM emissions.

Swansea University Prifysgol Abertawe

Automated ladle pouring in the steel industry

SPEAKER / LEAD AUTHOR:
Ivan Popov

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Grazia Todeschini, Swansea University
Peter Toms, TATA Steel Strip Products UK

ABSTRACT:
Hot metal (HM) pouring can release substantial amounts of flame and fumes. This problem is frequently encountered within the Basic Oxygen Furnace (BOF) steelmaking process.

The pouring process is often manually operated and relies on the skills and precision of the crane operators. Limiting the release of flame during pouring allows extending the lifetime of components in the proximity of the furnace thus reducing the need for frequent maintenance and associated costs.

One way of reducing the release of flame is through process automation, standardising the pouring rate and position of pouring. As part of this research project, video recordings of numerous pours were analysed utilising colour-based image segmentation to evaluate the release of flame. Through this analysis, relationships between pouring rate, scrap metal type amount and flame release were established. Future work will be concentrated on using this data for the optimisation of pouring position and establishing automatic on methodology.

How low can you go? The medium manganese limbo

SPEAKER / LEAD AUTHOR:
Thomas Kwok

INSTITUTION:
Imperial College London

OTHER AUTHORS:
Dr Xin Xu, Imperial College London
Dr Peng Gong, University of Sheffield
Dr Carl Slater, University of Warwick
Professor Claire Davis, University of Warwick
Professor David Dye, Imperial College London

ABSTRACT:
Medium Mn Steel (MMS) with a Mn content of 4-12 wt% has attracted significant research attention as a potential successor to Twinning Induced Plasticity (TWIP) steels for energy absorbing applications. MMS have been found to exhibit a combined twinning and transformation induced plasticity effect (TWIP+TRIP) which provides a high and sustained strain hardening rate that can surpass TWIP steels.

The MMS alloy design and processing concept will be presented, largely based on incrementally lowering the Mn content through a series of alloys while maximising the TWIP+TRIP effect to increase the energy absorption upon deformation. The TWIP+TRIP effect will also be studied in greater detail using electron backscatter diffraction and transmission electron microscopy. Emphasis will also be placed on key learning points to aid future MMS alloy development and scale up.

Investigating different rapid alloy prototyping approaches to develop alloys to allow for higher scrap steel content

SPEAKER / LEAD AUTHOR:
Caroline Norrish

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor Nicholas Lavery, Swansea University
Richard Underhill, Tata Steel Europe
Professor Cameron Pleydell-Pearce , Swansea University

ABSTRACT:
Recycling old steel presents a challenge because of the unwanted residual elements introduced into new steel via the scrap additions. Rapid alloy prototyping presents a way to quickly investigate the effects of varying residual levels in newly made steel. This presentation will discuss three different routes used to investigate this topic focussing on an automotive steel with residual additions.

Initial tests were carried out using 20g synthetic, simplified versions of existing steel grades which lead to small samples with varying composition consistency. The second method also uses synthetic steel but scaled up to 140g to allow for more repeats from each cast. The final route involves remelting industrial steel on the 140g scale to investigate if this might be a better way to get a consistent composition. These samples are then processed on a lab scale to closely replicate an industrial process before determining which route produces more useful results.

UNIVERSITY OF LEICESTER

Understanding the effects of deep cryogenic treatment on precipitation behaviour in En31 bearing steel

SPEAKER / LEAD AUTHOR:
Kyle Nicholls

INSTITUTION:
University of Leicester

OTHER AUTHORS:
Dr Rob Thornton, University of Leicester

ABSTRACT:
Deep cryogenic treatment (DCT) is a commonly applied supplementary treatment step in between hardening and tempering of steel, providing permanent microstructural changes not solely attainable by conventional treatment alone. As often cited, DCT provides ferrous alloys with improved hardness and wear properties.

However, the mechanisms by which DCT alters the microstructure are reported in literature as contradictory in fundamental nature, and often lack correlation to prior thermal history and chemical composition. The inconsistency in the field hinders industrial uptake of the process and fails to optimise DCT cycles for specific ferrous alloy applications.

Therefore, tempering using Calorimetry on En31 bearing steel has been studied after a DCT cycle (93 K, 24 hrs), with varied austenitising temperatures employed prior, to investigate the effects of austenitising temperature and DCT on precipitation behaviour. Activation energies have been determined using a Kissinger analysis where possible, with views to optimise DCT cycles.

Role of toughness in abrasion, and impact-abrasion wear

SPEAKER / LEAD AUTHOR:
Appa Rao Chintha

INSTITUTION:
University of Cambridge

OTHER AUTHORS:
Dr K. Valtonen, Tampere University, Finland
Professor V.T. Kuokkala, Tampere University, Finland
Dr S. Kundu, Tata Steel Ltd., India
Dr M.J. Peet, University of Cambridge
Professor H.K.D.H. Bhadeshia, University of Cambridge

ABSTRACT:
Despite the significant progress in understanding the wear mechanisms and associated factors, steels for components susceptible to wear are developed primarily based on their hardness. Hardness certainly helps to improve the wear properties, but it is known in the context of lifting and excavation equipment that other properties, such as toughness, may also play a role. In any event, it always is necessary to optimise a basket of properties rather than a single parameter, because the manufacture of a component requires a combination of performance criteria.

In the present work, a remarkable new steel has been studied to reveal the role of toughness on a particularly dramatic wear scenario involving both abrasion and impact. It is demonstrated with clarity that toughness becomes incredibly important in impact-abrasion, though not during abrasion on its own. Detailed microscopy and other characterisation techniques have revealed explanations for these observations. Based on the laboratory test results, full scale trials were undertaken in an integrated steel plant and the performance of a novel steel has been satisfactory thus far.

Effect of Ti microalloying and residual S content on the hot ductility of a boron steel

SPEAKER / LEAD AUTHOR:
Yaiza Montaña González

INSTITUTION:
CEIT-Basque Research and Technology Alliance (BRTA), Universidad de Navarra, Tecnun

OTHER AUTHORS:
Jon Arruabarrena Teruelo, CEIT-Basque Research and Technology Alliance (BRTA). Universidad de Navarra, Tecnun.

ABSTRACT:
The hot ductility of a boron steel with different Ti addition is evaluated by hot tensile testing. Hot tensile tests were carried out at different temperatures in the range 800-1100ºC at a constant strain rate of 0.001 s-1, in order to simulate the conditions at which bending/unbending is conducted during continuous casting. The addition of Ti improves the hot ductility by reducing the width and depth of the ductility trough, yet mixed results are obtained depending on the TI/N ratio. An optimal Ti addition corresponds to a proportion close to the stoichiometric with respect to the nominal N.

The FEG-SEM analyses performed on samples quenched at different temperatures in the range of interest show that the improved hot ductility for the stoichiometric Ti/N relation is due to the confluence of the inhibition of BN formation at austenite grain boundaries and the reduced size of TiN particles.

Multi-scale investigation of dislocation-assisted carbon migration in ferrite

SPEAKER / LEAD AUTHOR:
Tigany Zarrouk

INSTITUTION:
King's College London

ABSTRACT:
Martensitic bearing steels undergo subsurface microstructural decay, forming Dark Etching Regions, which promote failure through rolling contact fatigue.

Dislocation-assisted carbon migration is thought to be the underlying mechanism, yet empirical studies have been inconclusive as to how dislocations move carbon and where excess carbon from martensite migrates to upon transformation to ferrite. We detail a multi-scale modelling approach to elucidate carbon transport by dislocations.

Quantum-mechanical tight-binding simulations found that carbon stabilises the 1/2<111> hard screw dislocation core in agreement with ab-initio calculations. Equilibrium carbon concentrations, estimated from solute-dislocation interaction energies, suggest all dislocations are pinned in this hard-core configuration, under typical conditions. A dislocation line tension model found kink-pair formation enthalpies to decrease with both carbon content and stress. Kinetic Monte Carlo simulations incorporating solute diffusion will complete the multi-scale description, showing potential mechanisms for dislocation-assisted carbon migration.

Blistering formation in high strength steels (HSS) during hot rolling

SPEAKER / LEAD AUTHOR:
Rebecca Dewfall

INSTITUTION:
Swansea University

ABSTRACT:
Blistering is the detachment of scale at high temperature, producing bubble-like features in high strength steels (HSS) which cause surface defects in rolled product. A high Si GOES (grain oriented electrical steel), and a high Mn steel was examined to discern the influence of chemical composition on the formation mechanism.

Samples were oxidised in a thermo-gravimetric analyser (TGA,) with an air velocity of 10litres 〖min〗 ^(-1), over a temperature range of 750-1200℃ and held at temperature in an argon atmosphere for 10minutes, then oxidised in air for 600s, 60s, 30s, 15s and 4s respectively. The conditions were selected to simulate hot rolling with the approximate formation of secondary and tertiary scales in the finishing mills. Blisters were characterised using EBSD, EDX, Raman Spectroscopy, nanoindentation, FIB and FEG-SEM imaging. The thermodynamics and kinetics of these reactions were shown to differ greatly between the two steel grades, producing blistering regimes unique to each grade.

Poster 1

Initial microstructure characterisation of some castable nanostructured alloys for fission and fusion applications

AUTHOR OF POSTER:
James Lennard

INSTITUTION:
University of Manchester

OTHER AUTHORS:
Dr Huw Dawson, Culham Centre for Fusion Energy
Professor Grace Burke, University of Manchester
Professor Eric Palmiere, University of Sheffield
Dr Enrique Jimenez-Melero, University of Manchester

ABSTRACT:
Castable nanostructured alloys (CNAs) are a new class of ferritic/martensitic (FM) F-9Cr steels offering high creep resistance for high temperature applications such as structural components in nuclear power stations.

This makes CNAs desirable for Gen III+ fission and DEMO-class fusion reactors, as well as non-nuclear plants. They feature an increased volume fraction of thermally stable MX-type nanoprecipitates compared to traditional FM grades such as commercial P91, enabling mechanical properties to rival recent ODS grades while retaining ductility, fracture toughness and scalable manufacture.

Their development could lead to superior radiation tolerance over existing grades as demanded by advanced nuclear systems, as well as increased operating temperatures up to 650 °C. This poster presents some initial microstructural characterisations of two CNAs in the as-austenitised condition which was performed at 1250 °C to promote maximum dissolution of carbonitride formers.

Poster 2

Effect of environmentally friendly additives on Zn-Mn alloys morphology and structure

AUTHOR OF POSTER:
Dr Nouha Loukil

INSTITUTION:
National School of Engineering of Sfax ENIS-Tunisia

ABSTRACT:
Pure Zn coating commonly used for the protection of steel is not sufficient in some industrial applications due to its high dissolution rate. There is a growing interest in Zn-Mn coatings owing to the highest corrosion resistance compared to that of pure zinc coatings. However, Mn-rich alloys electrodeposition is a difficult issue since there is a gap between standard redox potentials of the two alloying elements Zn ($E°$ (Zn^{2+}/Zn) = - 0.76 V/HSE) and Mn ($E°$ (Mn^{2+}/Mn) = - 1.18 V/HSE). Besides to that, hydrogen evolution reaction is a concurrent reaction that inhibits Mn co-deposition as the two potentials are notably more negative than that of hydrogen evolving. Mn-rich deposits that require high current densities are burned, powdery and non-adherent. To overcome these difficulties, fundamental research in this work has been made to develop the Zn-Mn electroplating process. Stringent environmental concerns have restricted the complexing agent regularly incorporated in the bath as they induce serious problems related to wastewater treatment. In this work, new electroplating formulations containing effective and environmentally friendly additives have been developed. These additives facilitate Zn-Mn co-deposition. Thus, Zn-Mn alloys were successfully electrodeposited with suitable properties. The Mn content reaches 20% under low current density. SEM data reveal that Zn-Mn exhibits fine morphology.

Poster 3

Steel susceptibility to hydrogen induced failure

AUTHOR OF POSTER:
Helena Ferreira

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Hollie Cockings, Swansea University,
Dr Douglas Figueroa-Gordon, Tata Steel Europe

ABSTRACT:
Strict sustainable development agreements are driving a profound decarbonisation of the energy sector. A low-carbon alternative currently under debate is the 'hydrogen economy', in which H2 will be used as an energy vector in several applications.

However, its large-scale implementation will require an update and expansion of the current gas transportation and storage infrastructure, in which steel pipelines and pressure vessels play a crucial role. The aim of this project is to understand how these unique service conditions (e.g. hydrogen sources, temperature and pressure variations) influence the susceptibility of several high strength steel grades produced by Tata Steel to hydrogen induced failure.

A deep understanding of the chemical composition, microstructure, mechanical properties, corrosion resistance and hydrogen susceptibility of these steels will be acquired. The outputs of this project will allow Tata Steel to develop an optimum steel alloying, manufacturing processes and microstructural design strategy for the service conditions considered.

Poster 4

Novel coating solutions for the improvement of scale surface condition

AUTHOR OF POSTER:
James Grant

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Amit Das, Swansea University

ABSTRACT:
TATA Steel's low carbon steel conveyance tubes undergo a 900°C normalisation to remove an undesirable heat affected zone caused by high frequency induction welding. This reheating, however, generates significant surface conditioning issues and instigates severe processing inefficiencies due to the parent hollow's insufficient protection from high temperature oxidation.

This poster highlights the kinetics of the scale grown by normalisation and will further characterise the key oxide layers; FeO, Fe3O4, Fe2O3, permeating on the steel surface. In addition, the research details the trialling of novel preventative coatings using phosphate based technology.

Inexpensive and commercially viable, these coatings aim to increase yield and surface quality of TATA Steels' Tube products. Techniques for analysis and characterisation include Raman Spectroscopy, Energy-Dispersive Spectroscopy, Simultaneous Thermal Analysis and X-Ray Diffraction.

Poster 5

The effect of coal volatile on top gas carbon

AUTHOR OF POSTER:
John Lewis

INSTITUTION:
Swansea University

ABSTRACT:
Dust is a by product of blast furnace ironmaking. The dust exits the furnace in the gas stream which can be problematic from a gas recycling perspective.

The dust consists of material blown from the top of the burden during charging and non gasified material exiting the furnace. It is believed that coal injected at the bottom of the furnace leaves in the gas stream as char or unburnt coal. Optimising the conditions for injection and considering the properties of the coal injected, will improve fueling efficiency and reduce the quantity of dust exiting the furnace.

A TGA technique has been implemented to quantify the degree of low order carbon present within the blast furnace dust. Following this will be a comprehensive investigation into the most influential operating parameters which effect the quantity of low order carbon present within the flue dust.

Poster 6

The effect of steel microstructure on damage mechanisms at the wheel-rail interface

AUTHOR OF POSTER:
James Ayabina

INSTITUTION:
The University of Sheffield

OTHER AUTHORS:
Professor Roger Lewis, The University of Sheffield
Professor Klaus Six, Virtual Vehicle Research Institute, Austria

ABSTRACT:
The microstructure of the steel at the wheel-rail interface plays an important role in the way wear and rolling contact fatigue occurs. The extreme loading experienced over a contact patch area that is about the size of a twenty pence coin leads to contact pressures occurring locally in the wheel material that are above the yield strength of the steel.

This combined with shear as a result of friction in the contact leads to the creation of a highly plastically deformed layer up to about 100 microns thick on the surface. It is here that wear and rolling contact fatigue mechanism are initiated. Layers are hard to extract from the actual in service material, so laboratory methods using a high pressure torsion (HPT) approach are being developed in this work to create layers in a more controlled way that can then be machined to very small specimens for FCG testing.

Poster 7

A review of published models to predict the extent of surface oxidation

AUTHOR OF POSTER:
Nicola Beech

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Michael Auinger, University of Warwick

ABSTRACT:
Advanced High Strength Steels (AHSS) are widely used in car structures to reduce vehicle weight, thus lowering fuel consumption and CO2 emissions. While these steels possess excellent mechanical properties such as yield strength and elongation, their corrosion resistance is poor.

AHSS therefore require the application of a zinc coating, which corrodes preferentially and protects the base material. Prior to galvanising, these steel grades are annealed at temperatures of around 800°C in atmospheres containing up to 100% hydrogen. Under these conditions, AHSS-alloy additions (e.g. Mn, Si, Al and Cr) can oxidise and form an external oxide layer that liquid zinc may fail to adhere to. Consequently, surface quality issues such as bare spots can arise.

If the critical conditions leading to external oxide formation were known, manufacturers could strategically avoid their occurrence by encouraging internal oxidation. This poster presents a review of published models to predict the extent of surface oxidation.

Poster 8

Numerical modelling of thermal-mechanical evolution during high heat input welding of marine steel

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OTHER AUTHORS:
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ABSTRACT:
The high heat input welding method can improve the efficiency of manufacturing, but the impact toughness of heat-affected zone (HAZ) is reduced seriously during the welding process. Thermal profile evolution in HAZ is the key factor affect microstructures and resulting mechanical properties of welded joints.

In this study, we coupled heat transfer, solid mechanics and solid-state evolution to simulate the electro-gas welding (EGW) process of ultra-high strength marine steel plate using COMSOL multiphysics software. The real welding geometry, process variables and materials are used with a three-dimension heat source as a sinusoidal function with various heat input up to 200kJ/cm. The simulation results reveal that microstructure can be optimized by varying the welding source movement path and the cooling rate of sliding copper shoe, to improve the properties of HAZ.

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Poster 9

Prediction of the mechanical properties of hot rolled steel plates using artificial neural network and statistical method

AUTHOR OF POSTER:
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University of Leicester

OTHER AUTHORS:
Dr Jenny Shepherd, University of Leicester
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Stefan Stein, University of Warwick
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ABSTRACT:
Steel manufacturing is a long and complicated process involving iron-making, refining, casting, rolling, etc.; the result, hundreds of processing parameters all with a potential influence on the mechanical properties of the final product. This complexity results in significant challenges in the correlation of input parameters with output mechanical properties.

In this work, we applied both a neural network based model and a statistic method in order to predict yield strength, ultimate tensile strength, elongation and impact toughness of hot rolled steel plates using chemical composition and process parameters (including finish rolling temperature and reduction ratio). The influential process parameters recognized by the neural network model were compared with the key features selected by the statistical method, initial Guided Analytics for parameter Testing and control band Extraction or iGATE. The differences between predicted results using iGATE and neural network were discussed and the effect of the input parameter, including chemistry and process variables investigated.

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Poster 10

Exploring the effects of Cryogenic treatment on coating-substrate systems

AUTHOR OF POSTER:
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INSTITUTION:
University of Leicester

OTHER AUTHORS:
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Dr Dave Weston, University of Leicester

ABSTRACT:
Owing to the growing demand in production industries to employ materials that will last longer and more efficient as well as reduced cost, focus has now been shifted to employ materials and strategic treatment geared towards addressing the above demands. Thus, Cryogenic treatment (CT) is being proposed geared towards enhancing engineering materials. CT is a novel approach that relates to the behaviour of materials typically below 193K, thus causing microstructural change; which in turn enhances the behaviour of the material e.g. hardness, fatigue life, dimensional stability. For some applications CT materials are also coated as the have been found to work well and improves wear resistance.

Nevertheless, in the literature the topic is still under much discussion due to consistency of results and appropriate experimental evidence. For coating – substrate systems, the driving force responsible for the microstructural change undergone have not been fully investigated to assess their significance. Therefore, it is of importance to explore the effects of CT on materials as well as on coated - substrate systems through destructive, slightly destructive and non-destructive techniques with sole aim to improve the understanding in the field.

Poster 11

Understanding of ductile fracture mechanisms in nuclear pressure vessel steels under different constraints

AUTHOR OF POSTER:
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The University of Manchester

OTHER AUTHORS:
Professor Philip Withers, The University of Manchester
Dr Tim Burnett, The University of Manchester
Professor Andrew Sherry, The University of Manchester

ABSTRACT:
Specimens of SA508 grade 3 steel with different notch geometries have been subjected to tensile straining while simultaneously imaged using high-resolution, in-situ synchrotron computed tomography.

Site-specific post-mortem metallographic sectioning analysis was performed using scanning electron microscope. These methods are used for the direct observation of ductile fracture mechanisms, namely void nucleation, growth and coalescence.

It was found that the interfacial strength between inclusions and matrix material is zero, therefore inclusions nucleate cavities at zero plastic strain. Conversely, sub-micron carbides require larger strain and high triaxial stress to nucleate cavities, which are concentrated within 350 μm of the necked region. Interestingly, internal microcracks are formed by coalescence of small cavities, while large cavities play no role in microcrack initiation. The results of Xray CT data was used to calibrate the parameters of Gurson- Tvergaard-Needleman (GTN) model for SA508 grade 3 steel.

Poster 12

The effect of processing variables on ZnMgAl alloy coating characteristics

AUTHOR OF POSTER:
Daniel Britton

INSTITUTION:
Swansea University

ABSTRACT:
An abundance of research on ZnMgAl metallic coatings has shown a great improvement on corrosion protection compared to traditional galvanising, whilst also providing numerous advantages during automotive manufacturing.

To compete with worldwide innovation, UK steel manufacturers are currently looking to further improve the coating; in particular the quality of surface finish, formability and corrosion resistance. This novel research will look to identify the effect of processing variables on the characteristics of ZnMgAl coatings using material from a continuous hot dip galvanising line and Swansea University's new state-of-the-art hot dip simulator.

Poster 13

Development of improved formability advanced high strength steels

AUTHOR OF POSTER:
Talal Said Abdullah

INSTITUTION:
Swansea University

ABSTRACT:
Improving the formability of AHSS through yielding enhanced R-values by use of miniaturised samples in the RAP route, is the premise of this research.

The development of improved mechanical properties will also be supported by building a 2D hot rolling simulation, as the rolling mill possesses the ability to influence desired microstructures complementary to the required mechanical properties. Experiments commence with the DX57, the idea is to validate and develop the suitable techniques required to not only produce data replicas from miniaturised samples, but also garner thermo-compressive material properties from the Gleeble.

The properties are to be built in to an Ansys thermo-mechanical model supported by the Hansell-Spittle equation to represent the flow stress of the material under hot rolling conditions. The blueprint of the overall process is to then be implemented on to AHSS grades, where improving its R-value for up-scale production will finalise the completion of this research.

Poster 14

Development of new surface treatments for automotive utilising chemcoater

AUTHOR OF POSTER:
Jamie Williams

INSTITUTION:
Swansea University

ABSTRACT:
Automotive steel products are manufactured in the UK by Tata Steel and sold globally. A typical product consists of an annealed steel strip with an applied zinc coating. Subsequent organic and inorganic coatings can be applied to the steel following annealing or galvanizing using a roller coating system known as the chemcoater.

These products are applied in order to add value to the steel or make the product more attractive to the customer. Coatings that can be applied might include those that prevent corrosion, improve lubricity, enhance surface passivation or add a smart functionality, with the ultimate aim of adding value to the steel product.

This poster presentation will expand on this by exploring some potential coatings that could be applied to the steel using the chemcoater system.

Poster 15

The role of chromium oxide in suppressing filiform corrosion on Cr metal / Cr oxide coatings for steel used in packaging applications

AUTHOR OF POSTER:
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INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr Nat Wint, Swansea University, Professor Neil McMurray Swansea University, Dr Arnoud de-Vooys, Tata Steel Europe

ABSTRACT:
This paper describes a study into the filiform corrosion (FFC) of Cr(III) electroplated steel used for packaging applications. A bilayer Cr metal/Cr oxide coating is applied to low carbon steel via an electroplating process.

The coating weight of the Cr layer is kept constant whilst the Cr oxide layer is varied in coating weight between samples. FFC is initiated by introducing an artificial scribe into a model organic coating, polyvinyl butyral. The scribe defect is filled with 2µl 0.005M FeCl2 and the sample placed into a humidity chamber. Samples were removed to obtain photographs and carry out computerized image analysis to calculate the area of FFC.

The rate of FFC is shown to increase with decreased Cr oxide coating weight. This may be caused by an increase in substrate exposure at the holes and micropores observed in lower oxide samples. Evidence of FFC filaments tapering and chloride entrapment is observed.

Poster 16

The adhesion of protective coatings to novel REACH compliant packaging steel substrates

AUTHOR OF POSTER:
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INSTITUTION:
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OTHER AUTHORS:
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Dr Natalie Wint, Swansea University
Dr Arnoud de-Vooys, Tata Steel Europe

ABSTRACT:
This research examines various subject areas pertaining to packaging steel and its ubiquitous use, specifically by exploring how protective coatings adhere to novel chrome plated packaging steel substrates which conform to REACH regulations (substrates which have not been produced using Chrome VI).

It is necessary to insulate both packaging steel substrates and their contents from each other as corrosion and contamination may occur. Packaging steels are usually coated with a protective lacquer, although other protective coatings such as polymer-based laminates are also being used as an alternative due to their chemical stability.

It is the aim of this research to investigate the adhesion and failure mechanisms of lacquered coatings applied to chrome plated substrates which have been passivated, or indeed produced using trivalent chromium as means of depositing chrome metal and inert chrome oxide layers onto the surface of packaging steel substrates.

Swansea University
Prifysgol Abertawe

Poster 17

Damage tolerance study of a novel maraging steel for aerospace shaft application

AUTHOR OF POSTER:
Antony Robinson

INSTITUTION:
Swansea University

OTHER AUTHORS:
Professor Mark Whittaker, Swansea University

ABSTRACT:
A novel maraging steel has been developed as a potential solution for shafts on future engine architectures where it offers a combination of improved strength, temperature capability and corrosion resistance compared with historic materials used for shaft applications. In addition, the maraging composition and associated heat treatment requirements offer greater flexibility in shaft geometry over conventional quenched and tempered steels due to the significant increase in Limited Ruling Section (LRS).

The aim of this program is to characterise the material and attain crack propagation and fatigue threshold data over a wide variety of R-ratios and temperatures, simulating possible in flight conditions, in order to deliver information that can be used to make damage tolerance lifting predictions for future components. This will be achieved by cyclically loading Corner Crack (CC) and Double-Edge Notched (DEN) specimens with live current, coupled with optical and electron microscopic analysis of fracture surfaces.

M2A

The Materials and Manufacturing Academy (M2A) which incorporates the Centre for Doctoral Training in Functional Industrial Coatings, facilitates collaboration between academia and industry through industrially focused postgraduate research in the fields of Materials, Manufacturing and Functional Coatings. Based at Swansea University's College of Engineering, industrial project partners benefit from access to world leading facilities and academics. Offering funded research degrees of Engineering Doctorate (EngD) and Master by Research (MSc), our scheme produces highly skilled graduates ready to enter the workplace and drive the knowledge economy. By focussing our research on relevant industry problems, we deliver impact through innovation and provide real economic benefits to the business. Students fully engage with their sponsoring business, take up placement opportunities and immerse themselves in the business culture. This gives them a platform from which to begin their career, enhance the skillset of industry and drive the long-term success of the sector.

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KEYNOTE SPEAKER

2018	Bimlendra Jha, Chief Executive Officer, Tata Steel UK
2019	Ron Deelan, Chief Marketing Officer, British Steel
2020	Jon Bolton, Senior Adviser, Liberty Steel Group (UK)

MILLMAN SCHOLAR

2019	Ben Napier, Durham University
2020	Robert Hillier, The University of Sheffield

Prize Winners

BEST PRESENTATION

2018	Faris Karouni, The University of Sheffield
2019	Daniel Stewart, Swansea University
2020	Benjamin Poole, Imperial College London

BEST POSTER

2018	Benjamin Jones, The University of Sheffield
2019	Cameron Bee, University of Warwick
2020	Rebecca Dewfall, Swansea University

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