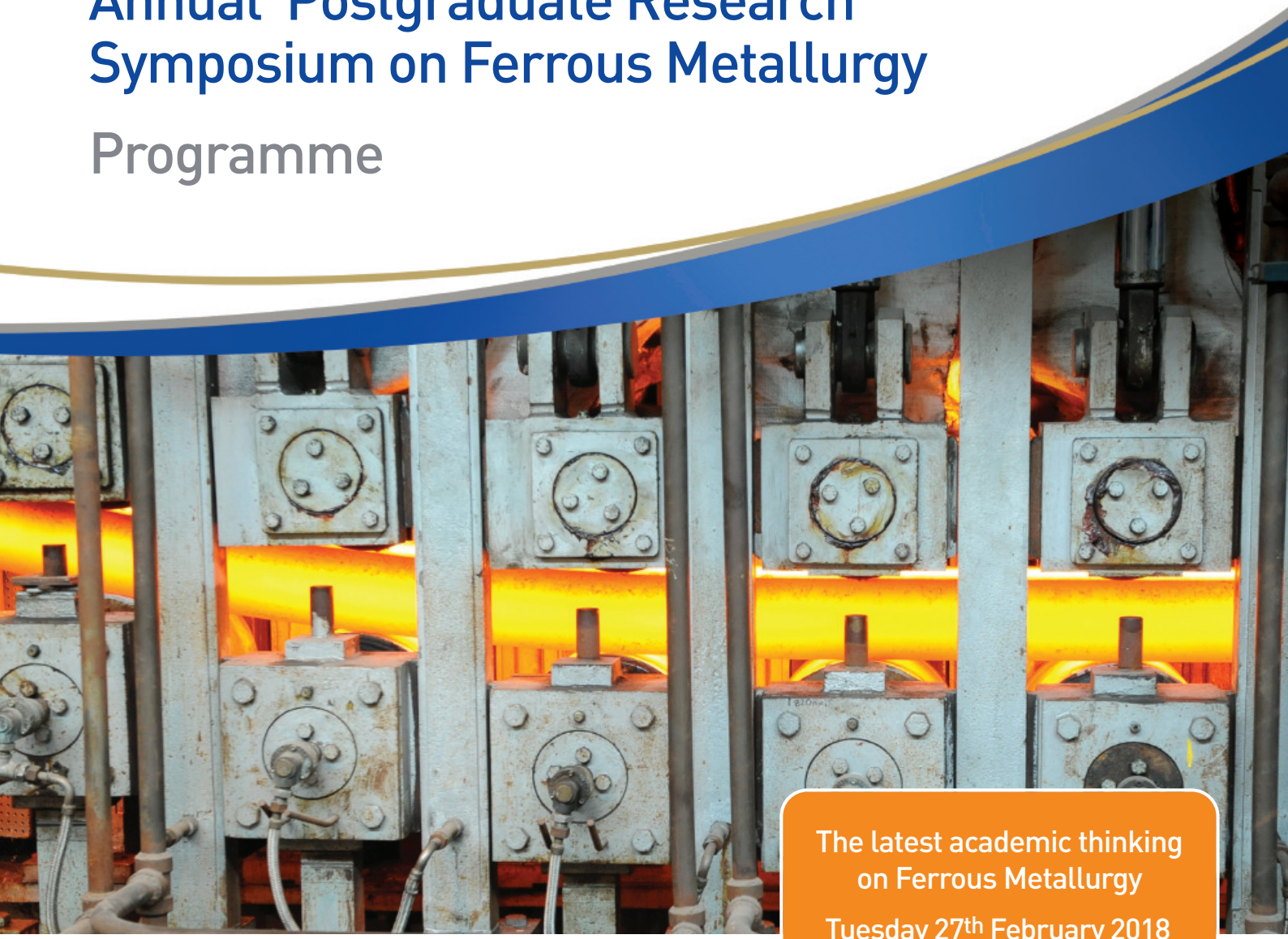
Annual Postgraduate Research Symposium on Ferrous Metallurgy

Programme



The latest academic thinking on Ferrous Metallurgy

Tuesday 27th February 2018

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

Organised by:

Materials Processing Institute

ARMOURERS & BRASIERS' COMPANY

IOM3 The Institute of Materials, Minerals and Mining

Materials Processing Institute

Foreword

Welcome to the UK's first annual postgraduate research symposium for ferrous metallurgy. The symposium showcases postgraduate research from across the country, bringing together a diverse range of students, academics and industrialists. The aim of the symposium is to allow doctoral researchers and university departments from across the UK to showcase their research, 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 has been organised by the Doctoral Academy at the Materials Processing Institute, an organisation dedicated to forging strong networks between the UK research and industrial community in ferrous materials. The academy is free to join for researchers, academics and industrialists and benefits include access to bursaries, networks and research support. Details are available from the Institute web page at: www.mpiuk.com/doctoral-academy-overview.

Recent fragmentation in the UK Steel industry has created the need for this 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 brought about this event and are committed to ensuring it becomes an annual fixture of international importance in the calendar of the UK materials research and the steel industry.

My personal thanks to the Master, Wardens and Company of Armourers and Brasiers, for their consistent and unstinting support of UK materials research, which includes the use of Armourers' Hall for the symposium today 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 Bimlendra Jha of Tata Steel, 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 and present next year, when the symposium will be held on 26th February 2019.

Chris McDonald
CEO, Materials Processing Institute

10:00 - 10:20	Registration, Coffee and Networking
10:20 - 10:30	**Welcome and Introduction** *Chris McDonald (CEO, Materials Processing Institute)*
10:30 - 11:50	**Session 1: New Materials Design** *Chair – Dr Richard Thackray (University of Sheffield)* *1. Correlative study of static recrystallization, precipitation and recrystallized texture in cold rolled microalloyed steel. Ishwar Kapoor (University of Warwick)* *2. Recrystallisation kinetics of plain carbon steels containing dilute niobium additions. Bhushan Rakshe (University of Sheffield)* *3. In-situ time-lapse microscopy to elucidate the corrosion mechanism of Zn-4.8wt.%Al galvanising metallic coating; surface and cut-edge. Callum Gallagher (Swansea University)* *4. Damage evolution during the plastic deformation of nanostructured steel. Gebril EL Fallah (University of Cambridge)*
11:50 - 12:10	Coffee, Networking and Poster Display
12:10 - 13:10	**Session 2: Materials Processing** *Chair – Prof Hongbiao Dong (University of Leicester)* *1. Simulation of hydrogen removal in the vacuum arc degasser. Faris Karouni (University of Sheffield)* *2. Novel techniques for controlling heat transfer in a continuous casting mould. Adam Hunt (Materials Processing Institute)* *3. Simulating physical vapour deposition on steel substrate using the Direct Simulation Monte Carlo (DSMC) method. Samuel Minshell (Swansea University)*
13:10 - 14:00	Lunch, Networking and Poster Display
14:00 - 15:20	**Session 3: Materials Performance** *Chair – Dr Steve Ooi (University of Cambridge)* *1. Modelling microstructural alterations under rolling contact fatigue and design of fatigue resistant bearing steels. Hanwei Fu (Lancaster University)* *2. SVET-TLI: a novel combination of scanning vibrating electrode technique and time-lapse imaging for studying the localised corrosion of sacrificial zinc coatings. Rebecca Bolton (Swansea University)* *3. Non-destructive prediction of tensile strength by using an EM sensor. Mohsen Aghadavoudi Jolfaei (University of Warwick)* *4. Effect of hydrogen charging on dislocation multiplication in super duplex stainless steel. Xingzhong Liang (University of Leicester)*
15:20 - 15:40	Tea, Networking and Poster Display
15.40 - 16:00	Awarding of Prizes for Best Paper and Best Exposition - Armourers & Brasiers' Materials Science Committee
16:00 - 16:40	**Keynote Speaker - Bimlendra Jha (CEO, Tata Steel UK)**
16:40 - 16:50	Vote of Thanks - Martin Brunnock (Technical Director, Tata Steel UK)
16:50 - 18:30	Drinks Reception

Keynote Speaker

Bimlendra Jha, present role Chief Executive Officer Tata Steel UK, has been with Tata Steel for nearly three decades. During the last three years he has been actively involved in the restructuring and turning around the steel businesses of Tata Steel in the UK in what is seen as a very difficult environment of the Steel Industry.

Mr Bimlendra Jha is a Ceramic Engineer from IT-BHU, Varanasi and has a Post-Graduate Diploma in Business Management from XLRI, Jamshedpur.

He is credited with inventing a comprehensive improvement framework for Tata Steel called ASPIRE that draws from the best practices of Six Sigma, TPM, Knowledge Management and TOC. He was instrumental in introducing TOP in Marketing and TOC at Tata Steel in his previous role as Chief of Aspire and Improvement Groups.

Mr Bimlendra Jha
Chief Executive Officer, Tata Steel UK

As a member of the marketing team of Tata Steel, he has done some pioneering work in the areas of Market Development and Brand Management. This includes the design of new processes in Marketing, Value Selling and Channel Loyalty programme. He has been instrumental in getting Goldratt Schools and TMTC to cooperate and offer courses on TOC to help promote the conception in Tata Group Companies and Indian Industry.

Bimlendra has a variety of experience running hospitals, townships, schools in addition to his regular positions. He is an Executive of TSE, CEO of TS UK, a member of the CBI and CBI Climate Change Board. He has been the Chairman of Indian Value Engineering Society and Convener of Technical Education & Training Panel of CII (Jharkhand) and is a member of the Tata Group Innovation Forum (TGIF).

Mr Jha is deeply passionate about creating economic engagement opportunities for masses and considers quality of life enhancement through economic engagement as the primary purpose of business.

TATA STEEL

Organisers of the 2018 Symposium

Materials Processing Institute

The Materials Processing Institute is a research and innovation centre serving organisations that work in advanced materials, low carbon energy 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 nearly 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 or 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 the medieval Guild charged with overseeing standards in the production of arms and armour. Over the centuries, its purpose has changed a number of times and it now exists primarily to promote materials science in the United Kingdom. It does this through its charitable giving and networking activities.

Materials Science is the modern discipline most closely aligned to the Armourers & Brasiers' ancient craft of working with metals and materials. The Company offers travel grants for research students working towards PhD or EngD to present their work at academic conferences, and grants for undergraduate students on Materials Science degree courses to help with the costs of industrial placements.

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 uninterruptedly since 1346.

The Institute of Materials, Minerals and Mining

The activities of the Institute of Materials, Minerals and Mining (IOM3) encompass the whole materials cycle. IOM3 exists to promote and develop all aspects of materials science and engineering, geology, mining and associated technologies, mineral and petroleum engineering and extraction metallurgy as a leading authority in materials and mining.

The Iron and Steel Society is part of IOM3 and provides value and support to the iron and steel Industry and individual members with a particular interest in iron and steel, to promote exchange and development of technology. The Society supports the iron and steel industry and related industries within the supply chain by providing a focus for the exchange of knowledge on all aspects of steel production, processing and applications. The Society's activities encompass all professional, technical and educational aspects of the steel industry and whole supply chain as well as other strategic considerations of steel.

Chair of Sessions

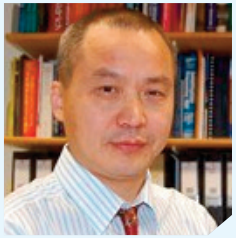
SESSION 1
New Materials Design

Dr Richard Thackray
University of Sheffield

Richard Thackray holds a degree in Materials Science and a PhD in Metallurgy from Imperial College London. He 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
Materials Processing



Professor Hongbiao Dong
University of Leicester

Prof. Hongbiao Dong received a First Class BSc degree and a Masters degree from University of Science and Technology Beijing and obtained his PhD in Materials Science from the University of Oxford in 2000. He joined the Department of Engineering at the University of Leicester in 2004 from Imperial College London, where he worked on modelling microstructure evolution in aero-engine turbine blades. Since October 2006 he has been awarded a Royal Society Industry Fellowship to conduct research at Rolls-Royce plc.

SESSION 3
Materials Performance

Dr Steve Ooi
University of Cambridge

Dr Steve Ooi is a senior research associate based in the University of Cambridge. He obtained his BEng, MPhil and PhD from Swansea University. His work specialises in alloy and process design in the context of steels for complex engineering applications where component failure can lead to significant consequences. Much of his research has therefore been focused on critical components in aeroengines, automobiles, stress-cancelling welding alloys, deep-ocean structures and bearings. He holds three international patents for the ferrous alloy he designed.

Correlative study of static recrystallization, precipitation and recrystallized texture in cold rolled microalloyed steel

SPEAKER / LEAD AUTHOR:
Ishwar Kapoor

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Dr Yongjun Lan, Tata Steel, Coventry Technology Centre
Rolf Arjan Rijkenberg, Tata Steel, IJmuiden
Dr Zushu Li, WMG, University of Warwick
Dr Vit Janik, Coventry University and WMG, University of Warwick

ABSTRACT:
In present study, cold rolled high strength low-alloy steel (HSLA) is annealed at a constant heating rate inside of a heated stage SEM-EBSD microscope to different target temperatures. Role of Mn and Ti addition on the kinetics of static softening process is studied by in-situ EBSD. At lower temperature almost no recrystallization is observed and microstructure resembles the as-received deformed material. With increase in temperature and dwell time, recrystallization is much more pronounced and effective. At lower temperature, drag force via solute atom or pinning force via precipitates is dominated and seems to retard recrystallization process. Detailed texture analysis is performed including analysis of the recrystallization behaviour of various texture components such as alpha and gamma fibre.

Recrystallisation kinetics of plain carbon steels containing dilute niobium additions

SPEAKER / LEAD AUTHOR:
Mr Bhushan Rakshe

INSTITUTION:
Advanced Metallic Systems CDT,
University of Sheffield

OTHER AUTHORS:
J Patel, CBMM Technology Suisse S.A., Geneva, Switzerland
E J Palmiere, University of Sheffield

ABSTRACT:
There is lack of systematic studies on recrystallisation behaviour of carbon steel long products (C > 0.20 wt %). It could be due to low solubility of niobium in austenite. However, there is anecdotal evidence in literature on beneficial effect of small Nb (< 250 ppm) additions in improving mechanical properties of such steels in some industrial trials.

The laboratory cast heats of 0.20 and 0.80% C base steel composition with three different Nb levels (50, 100 and 200 ppm) were investigated for recrystallisation and precipitation behaviour. The recrystallisation simulation were carried out using the double-hit deformation technique in PSC testing machine at UoS. The effect of pre-strain and deformation temperature on recrystallisation was evaluated for interpass holding of 5 and 20s. The analysis of fraction softening and microstructure showed that even dilute addition of Nb has ability to influence the static recrystallisation behaviour through pinning of grain boundaries.

In-situ time-lapse microscopy to elucidate the corrosion mechanism of Zn-4.8wt.%Al galvanising metallic coating; surface and cut-edge

SPEAKER / LEAD AUTHOR:
Callum Gallagher

INSTITUTION:
Swansea University

OTHER AUTHORS:
Nathan Cooze, TATA Steel
James Sullivan, TATA Steel
Patrick Dodds, TATA Steel
Peter Barker, TATA Steel

ABSTRACT:
The fundamental corrosion mechanisms on the surface and cut-edge of Zn-4.8wt.%Al galvanising coating have been investigated using an in-situ time-lapse microscopy technique that permits the investigation of the initiation and propagation of corrosion in alloys at a microstructural level. This alloy coating had a microstructure comprised of Zn rich primary dendrites and a lamellar Zn-Al binary eutectic phase. The coating was metallurgically prepared for optical light microscopy and immersed in 1 wt.% NaCl at pH 7 and left for 24 hours with images of the alloy captured every 2 minutes. The images, then rendered into a video, show the initiation of anodic and cathodic sites on the alloy's surface at specific phases within the microstructure and their progression with time providing new insights into the corrosion mechanism.

Damage evolution during the plastic deformation of nanostructured steel

SPEAKER / LEAD AUTHOR:
Gebril El Fallah

INSTITUTION:
University of Cambridge

OTHER AUTHORS:
H. K. D. H. Bhadeshia, University of Cambridge

ABSTRACT:
There have been many previous studies of bainitic nanostructured steels that can be made in bulk form. This work reports two different novel alloys, one of which is rich in nickel (Alloy B), and another that is more conventionally like nanostructured bainite (Alloy A). Both of the alloys have been transformed at a low temperature in order to produce a fine mixture of bainitic ferrite and retained austenite. In the present work, alloy A, containing 0.72wt% carbon and 3.87 wt% silicon displayed unrivalled combinations of strength and ductility with around 8% total elongation and 0.2% proof strength of 1516MPa when tested at ambient temperature. The other alloy, containing 0.45 wt% carbon and 13.20 wt% nickel, had a 12.6% total elongation with 0.2% proof stress of 1036MPa. These alloys are subjected in the present work to tensile testing to demonstrate their level of strength and toughness.

Simulation of hydrogen removal in the vacuum arc degasser

SPEAKER / LEAD AUTHOR:
Faris Karouni

INSTITUTION:
University of Sheffield

OTHER AUTHORS:
Professor Bradley Wynne, University of Sheffield
Professor Jesus Talamantes-Silva, Sheffield Forgemasters International Ltd.
Stephen Phillips, Sheffield Forgemasters International Ltd.

ABSTRACT:
Removal of hydrogen from molten steel in the vacuum arc degasser (VAD) is modelled using computational fluid dynamics. The dynamic flow field produced by the interaction of the slag, steel and argon phases in the ladle are predicted using Eulerian transport equations. These are coupled to a mass transfer model, where the concentration of hydrogen in the melt in equilibrium with that of the gas phase is expressed via Sievert's Law. The model predictions demonstrate good agreement with industrial measurements from a VAD unit at Sheffield Forgemasters International Ltd. for a series of melts of varying initial hydrogen content. In order to identify the optimal conditions for the degassing process, a range of processing (argon flowrate, vacuum pressure) and design (number of argon plugs, plug positions, ladle aspect ratio) parameters are subsequently simulated.

Novel techniques for controlling heat transfer in a continuous casting mould

SPEAKER / LEAD AUTHOR:
Dr Adam Hunt

INSTITUTION:
Materials Processing Institute

OTHER AUTHORS:
Dr Bridget Stewart, Materials Processing Institute

ABSTRACT:
When casting steel grades in the peritectic range, it is critical to control horizontal heat flux in the mould to minimise longitudinal crack defects. Cuspidine (3CaO.2SiO2.CaF2) is seen as the most effective crystal phase to control heat flux due to a high crystallisation temperature and low incubation time. However, the presence of fluoride creates various environmental and operational problems. Research into fluoride-free mould powder for peritectic steel grades has so far not yielded a fully effective substitute, as the crystallisation thermodynamics of cuspidine cannot be reproduced by other phases.

The current research investigates whether heat flux in the mould can be controlled by introducing porosity into the mould flux film. Laboratory scale measurements have shown that one particular technique can meet and exceed the thermal requirements to cast peritectic steel grades with a glassy mould flux. Trials were completed on the most promising technique using the "copper-finger" test.

Swansea University
Prifysgol Abertawe

Simulating physical vapour deposition on steel substrate using the Direct Simulation Monte Carlo (DSMC) method

SPEAKER / LEAD AUTHOR:
Samuel Minshell

INSTITUTION:
Swansea University

OTHER AUTHORS:
James Paolo Carlos, Swansea University

ABSTRACT:
Physical Vapour Deposition (PVD) is being developed as a coating process for steel substrates and is undertaken in high vacuum conditions to minimise contaminants mixing with the zinc vapour. The low-pressure conditions in the vacuum chamber, equates to large Knudsen numbers for the flow, due to this, continuum CFD methods tend to become invalid.

For dilute or rarefied gases, the Direct Simulation Monte Carlo (DSMC) method is the prevalent method to analyse such flow conditions. A DSMC solver called dsmcFOAM from an open-source software is used. Existing research from K. Hencken uses dsmcFOAM to investigate copper vapour condensation in a vacuum interrupter1). Current research at Swansea University benchmarks and adapts the modelling steps taken in work by K. Hencken, to simulate zinc vapour deposition onto a moving steel substrate. Preliminary simulations show that the species are colliding and impinging on the steel substrate and shows that the vacuum locks limits evacuation in the chamber.

Modelling microstructural alterations under rolling contact fatigue and design of fatigue resistant bearing steels

SPEAKER / LEAD AUTHOR:
Hanwei Fu

INSTITUTION:
Lancaster University

OTHER AUTHORS:
Wenwen Song, RWTH Aachen University
Enrique I. Galindo-Nava, University of Cambridge
Pedro E.J. Rivera-Díaz-del-Castillo, Lancaster University

ABSTRACT:
Bearings are amongst the most vital steel components in modern machinery, finding their application in a wide range of fields such as vehicles, wind turbines and aerospace crafts. Although high-strength martensitic steels are typically used for bearings, subsurface-initiated rolling contact fatigue (RCF) cannot be avoided. Despite great efforts devoted from the 1940s on characterising microstructural transitions due to contact fatigue, their formation mechanisms remain unclear. In the present work, a unified novel theory is proposed to model three major such alterations in bearing steels: dark etching regions (DERs), white etching bands (WEBs) and white etching areas (WEAs). The models, for the first time, yield accurate predictions of formation, progress and corresponding mechanical properties evolution with respect to the number of cycles. The proposed theory promotes the understanding of strain-induced damage of bearing steels and leads to the tailoring of novel bearing steels with outstanding fatigue resistance.

SVET-TLI: a novel combination of scanning vibrating electrode technique and time-lapse imaging for studying the localised corrosion of sacrificial zinc coatings

SPEAKER / LEAD AUTHOR:
Rebecca Bolton

INSTITUTION:
Swansea University

OTHER AUTHORS:
Dr. Justin Searle, Swansea University
Prof. Geraint Williams, Swansea University

ABSTRACT:
The integration of in-situ time-lapse imaging with a scanning vibrating electrode technique (SVET) has been successfully achieved by attaching a waterproof camera to the SVET probe assembly via a custom 3D printed friction clamp. The resulting data reveals a strong correlation between the visual evolution of corrosion features with the relevant current density distribution maps obtained via SVET. This paper will compare the corrosion mechanisms of pure zinc coatings produced via traditional hot-dip galvanising, electrogalvanising and physical vapour deposition using this method. It is shown that hot-dip galvanised zinc coatings promote strong focal anodes with rapid initiation and steady, radial growth. In contrast, anodic features on both electrogalvanised and physical vapour deposited coatings occupy larger areas, with lower anodic current density values. However, systematically varying the concentration of NaCl within the electrolyte promotes significant changes in localised corrosion propagation and physical nature of observed corrosion features for all three coatings.

Non-destructive prediction of tensile strength by using an EM sensor

SPEAKER / LEAD AUTHOR:
Mohsen Aghadavoudi Jolfaei

INSTITUTION:
University of Warwick

ABSTRACT:
In order to obtain accurate quality control of steel products, it is desirable to be able to monitor the mechanical properties non-destructively. This study proposes using an electromagnetic (EM) sensor, suitable for use on strip samples, as a tool for non-destructive steel characterisation and strength. It is known that the low-frequency inductance measured using an EM sensor depends on the relative permeability of the sample and that the permeability is affected by phase fraction and, to a lesser extent, grain size. The aim of this project is to study the link between the dual phase microstructures (using commercial DP600, DP800 and DP1000 grades and a heat treated DP600 grade) with the EM sensor signal, taking into account the effect of strip thickness. The ability to model the EM system to develop a calibration curve for thickness was carried out to account for the effect of thickness on the EM signal, allowing the permeability of any thickness to be determined from the sensor measurement. This paper also reports on the relationship between the ferrite fraction and tensile strength. The ability of the EM sensor to determine the tensile strength with 90% accuracy for dual phase steels.

Effect of hydrogen charging on dislocation multiplication in super duplex stainless steel

SPEAKER / LEAD AUTHOR:
Xingzhong Liang

INSTITUTION:
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T.L. Lee, ISIS Neutron Source, Science and Technology Facilities Council
H.B. Dong, Department of Engineering, University of Leicester

ABSTRACT:
The effect of hydrogen charging on dislocation multiplication in super duplex stainless steel was investigated. Steel samples were pre-strained and charged with hydrogen for 10 days. Dislocation density was then measured using neutron diffraction. It is found that dislocation density multiplies by about one order of magnitude in samples with less than 5% pre-strain, but remains the same level in samples with pre-strain level of 10% and above.

Functionally graded components for nuclear applications

AUTHOR OF DISPLAY / POSTER:
Emmanouil Stavroulakis

INSTITUTION:
University of Manchester

ABSTRACT:
The application of functionally graded components is considered for the next generation nuclear reactors, where two dissimilar metals are needed to operate together in the framework of a single component. Currently, dissimilar metal welds are used in such joints, which are inherently weak spots in terms of mechanical properties, due to residual strains and stresses. In the present work, the materials studied are the austenitic 316L stainless steel and the ferritic low-alloyed SA508 steel grade 2. Functional grading was realised by mixing the two metals in powder form in various compositions to create a transition zone from 316L to SA508. The powders were then consolidated via the Hot Isostatic Pressing (HIP) process and the microstructure development was studied for different stages of HIP processing. The aim of the project is to optimise the initial composition profile of the two metals to achieve improved properties across the transition zone.

Inspection of as cast steel slabs using EMAT arrays

AUTHOR OF DISPLAY / POSTER:
Jozef Tkocz

INSTITUTION:
University of Warwick

OTHER AUTHORS:
Steve Dixon
David Greenshields

ABSTRACT:
Electromagnetic acoustic transducers (EMATs) are devices capable of generating and detecting ultrasound in conducting samples without the requirement for acoustic contact between the transducer and the test specimen. EMATs are therefore suited for application in high temperature environments on rough, moving samples, however their reliance on the Lorentz force mechanism makes them inherently inefficient, and thus achieving practicable signal to noise ratios in thick, coarse-grained as-cast steel products is challenging. This research concerns the development of a novel EMAT array system as a means of generating bulk ultrasound wave modes in as-cast steel with improved signal amplitudes. Experimental data is presented which demonstrates the ability to use EMAT-generated ultrasound to detect vertical cracking defects and to localise artificial side-drilled holes with diameters comparable to the 6mm ultrasound wavelength. The design of this system has been consistent with eventual adaptation for high temperature online measurement.

UNIVERSITY OF CAMBRIDGE

Materials Processing Institute

Mitigation of high temperature hydrogen attack

AUTHOR OF DISPLAY / POSTER:
Mohammed Alshahrani

INSTITUTION:
University of Cambridge

OTHER AUTHORS:
Dr. Steve Ooi, University of Cambridge

ABSTRACT:
High temperature Hydrogen attack is a mechanism that deteriorates the mechanical properties in the steel operating in critical equipment (i.e. high temperature and high pressure). This occurs due to hydrogen diffusion into the steel and reacting with carbon or carbides to form methane bubbles which accumulate in the steel. Damage at first is microscopic and cannot be detected with advanced NDE techniques. Once the damage is possibly detectable optically then mechanical properties are partially deteriorated. After that, mechanical properties rapidly deteriorate with rapid fissure growth. Carbon in solid solution is then reduced leading to cracking occurrence. The main idea of this project is to develop a steel that can mitigates the methane formation at temperature up to 500C in order to tackle the issue of high temperature hydrogen attack.

The effects of coal particle swelling during blast furnace coal injection

AUTHOR OF DISPLAY / POSTER:
Ian Moore

INSTITUTION:
Materials Processing Institute

OTHER AUTHORS:
Sridhar Seetharaman, Warwick University
Zushu Li, Warwick University
Stephen Spooner, Warwick University
Colin Atkinson, Materials Processing Institute

ABSTRACT:
Blast Furnace Pulverised Coal Injection (PCI) is the injection of pulverised coal into the ironmaking Blast Furnace to act as a reducing agent in reduction of iron ore to iron. The use of coal as a reducing agent decreases the dependency upon coke. This has numerous advantages including:

- Environmental e.g. reduced emissions from cokemaking
- Economic e.g. increased production rate
- Technical e.g. increased operational flexibility

Coal particles swell when heated above ~400 °C yet the effect of swelling upon Blast Furnace operations is not well researched. The degree of swelling is dependent upon coal type therefore understanding the swelling behaviour of a coal and the impacts upon the process may be an important consideration in selecting cost-effective coals.

The Confocal Scanning Laser Microscope (CSLM) allows direct observation of coal particles during heating, revealing the swelling behaviours of particles and enabling measurement of differences between coal types. This project aims to improve our understanding of how coal particle swelling impacts Blast Furnace performance.

Welding of carbide free bainitic steels for the railway industry

AUTHOR OF DISPLAY / POSTER:
Marta Muniz-Mangas

INSTITUTION:
University of Sheffield

OTHER AUTHORS:
Eric J. Palmiere, Department of Materials Science and Engineering, The University of Sheffield
Sandra Fretwell-Smith, British Steel, Rail Technologies Consultant
Lindsey Smith, British Steel, Senior Consultant

ABSTRACT:
In recent years, there has been a limited scope for the future development of pearlitic grades on railway applications, which is necessary due to its continuous advancement. For this reason, carbide-free bainitic steels were first developed during the late 90s, showing greater performance in some fatigue deformation mechanisms such as head checks.

Nevertheless, problems were encountered when welding carbide-free bainitic grades. The heat affected zone (HAZ) of pearlitic steels is well understood, and the microstructural evolution can be identified by an examination of the iron-iron carbide phase diagram. However, the microstructural evolution associated with bainitic steels is much more challenging, as bainite tempers more readily, and also over a much wider range of temperatures.
An extensive work of characterization was performed in this research, using a portion of a flash butt weld (FBW) carbide-free bainitic grade. Tensile behaviour of dissimilar regions of the HAZ, SEM examination and hardness techniques were used in order to better understand the microstructural evolution of the HAZ.

Influence of composition and processing on strain ageing in high strength pearlitic wires

AUTHOR OF DISPLAY / POSTER:
Benjamin Jones

INSTITUTION:
University of Sheffield

OTHER AUTHORS:
W M Rainforth, University of Sheffield
S Hobson, British Steel

ABSTRACT:
Strain ageing is responsible for an undesirable change of mechanical properties in pearlitic wires. The project focuses on high carbon (~0.80 wt.%) wires. Dissolution of cementite contributes to the large increase in interstitial carbon atoms found in the ferrite during service. Interstitial carbon atoms interact with dislocation substructures in the ferrite to produce an increase in hardness, and an associated reduction in toughness. This can lead to wires failing prematurely in service. The project aims to reduce the effect of strain ageing via the addition of alloying elements or processing parameters. The project also aims to increase current understanding of the mechanisms responsible for strain ageing.

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