Materials Processing Institute

MANUFACTURING R&D AT THE MATERIALS PROCESSING INSTITUTE

A Speech given at a Meeting of the Association of British and Chinese Professors

Friday 2 July 2021

Introduction to the Materials Processing Institute

Professor Qin, thank you for your introduction and for the kind invitation to speak here at this 2nd Annual Conference of the Association of British and Chinese Professors. I was particularly pleased to receive the invitation to speak today, from my good friend Professor Hong, as I believe it is essential that we work to strengthen links between Britain and China, improving understanding and seeking opportunities where we can work together. The Association of British and Chinese Professors is an important organisation in developing this understanding and identifying areas for future work. Having visited China myself on several occasions, I do hope that it will be possible to come together in person again in time for the next iteration of this conference.

My background is in the steel industry, where I have worked in a variety of roles, in manufacturing, strategy and technology. However, I have spent most of my career in technology and innovation and for the last 6 years I have been the Chief Executive Officer of the Materials Processing Institute.

The Institute is the UK's national centre for innovation for metals, having been established more than 75 years ago, to support the development of the UK steel industry. Over that time, researchers at the institute have worked in collaboration with industry and academia, to develop many technologies that are in standard practice in the steel industry globally, but in recent years our focus has broadened beyond steel to encompass the full metals supply chain. We are currently delivering the first year of a five year programme of research and innovation support for the UK Steel and Metals sector, known as PRISM, on behalf of the UK government.

We have achieved this success in innovation by the application of the in depth academic and industry knowledge of our talented research team, supported by a unique range of specialist research equipment, the centre piece of which is our pilot scale steelmaking and casting facilities, including an electric arc furnace, continuous casting machine and both induction and vacuum induction melting.

At the Institute our aim is to apply our expertise and facilities, to support industry and the economy in addressing the major societal challenges of our age. To achieve this we have four areas of research focus:

> **Advanced Materials:** This area of research primarily involves the development of new steel alloys, of improvements in the efficiency of metals processes, to improve quality and productivity. Key facilities include our Advanced Materials Characterisation Centre, which has world leading, state of the art characterisation facilities, including for high temperature metallography. Future developments include an Advanced Materials Development Facility, building on our unique pilot plant facility, expanding capability into metals beyond steel and downstream processes.

> **Industrial Decarbonisation:** Sustainable metals manufacture that does not involve damaging climate emissions is the greatest challenge facing our industrial economy. We need to find ways to decarbonise our steel production, both to make this industry sustainable and to ensure that we can provide the essential steel to underpin the new technologies we need for the rest of the green economy, such as offshore wind, nuclear energy and electric vehicles. We have developed significant expertise in this area and I will speak about this in more detail later in this speech.

> **The Circular Economy:** Another aspect of sustainability is resource efficiency and whilst this can be about minimising the amount of material that we use in a particular application, it is also about ensuring that at end of life, materials are extracted and recycled back into the supply chain. This is particularly important for many rare, or critical metals, such as lithium, cobalt, platinum and palladium, that are essential for modern technologies, such as smart 'phones, or electric vehicle batteries. Our role in this area is in developing

extraction and recycling processes, drawing on our vast metals processing expertise in both pyro- and hydro-metallurgy, alongside mechanical separation technology.

> Our 4th area of innovation underpins the others and it is **Digital Technologies.** Across metals manufacturing we are identifying opportunities for major leaps in productivity, of as much as five times, that are enabled by new digital technologies. Our role here is not in the invention of these new technologies, but in demonstrating their application within a steel and metals environment. Sometimes this can be about ensuring that the technologies can survive in a hostile environment, or developing new instruments and sensors that can provide the essential data input to a digital architecture. Often this also involves application of our detailed processing knowledge to enable transfer of a digital technology from one environment to another. We are currently working on advanced data analytical techniques, AI enabled process control, wearable technology, robotics and blockchain for supply chain management, amongst others. We are also in the process of investing in a new robotics laboratory.

Steel Decarbonisation

Perhaps the greatest of these four challenges is decarbonisation of the steelmaking process and so I would like to focus on this area in more detail.

We know that the steel industry is the largest industrial emitter of carbon dioxide and so measures to reduce those emissions will require a wholesale change in the technology of steel production. Fortunately, we already know what the technologies to decarbonise will be a combination of electric arc furnaces, hydrogen, and carbon capture and storage.

Electric arc furnaces are a proven technology for melting and refining steel. In the mind of many people, these furnaces are intrinsically linked with the recycling of scrap steel and indeed the UK has a big opportunity, as one of the world's largest exporters of scrap steel, to recycle more at home, for our own manufacturing and infrastructure. This means that our route to decarbonisation is very closely linked to our work in the circular economy.

It is true that the electric arc furnace still lacks some quality capability, but this is an innovation challenge for Institutes like my own to resolve, rather than a barrier to the technology being introduced. Indeed, we are already advanced in the development of a new refining process to produce steel with a very low nitrogen level, via the electric arc furnace route. However, for reasons of both steel quality and quantity, the UK cannot survive on recycled steel alone and so we need to be able to use raw materials derived from iron ore.

The electric arc furnace is not capable of dealing with iron ore in its raw form. Currently the task of smelting ore into iron is carried out by the blast furnace, which relies on coking coal and is the major emitter of carbon dioxide. This is where hydrogen has a role to play. By replacing the blast furnace with a Direct Reduction furnace, we can replace coking coal with a gas, such as hydrogen, and produce a raw material that can be fed, alongside scrap, directly into the electric arc furnace. Making this switch will require innovation and we can see this progressing now in other nations around the world, including in China, where the world's first hydrogen reduction furnace will be commissioned this year.

While electric arc furnaces and hydrogen can be quite readily understood, the use of carbon capture presents some choices. Carbon capture could be applied to the electric arc furnace, the direct reduction furnace, hydrogen production and the blast furnace. Emissions from the electric arc furnace are around 15% that of the blast furnace, but nonetheless they will need to be dealt with. There is currently no available technology to do this, but it is something we are considering at the Materials Processing Institute, where we have a pilot scale electric arc furnace.

International Competition

In this race to net zero, we can see countries around the world competing hard to be the global leader and that race is now accelerating. Sweden has been long regarded as the leading nation, with their flagship HYBRIT project, a collaboration of three industrial groups, aiming to introduce hydrogen produced Green Steel to the market in 2026. This project was joined in February this year, by a new start up steelmaker, H2GreenSteel[1], which aims to build a brand new, 'fully integrated, digitalised and automated greenfield steel plant', in Northern Sweden, to start up production in 2024 and be fully operational by 2030.

Until recently the HYBRIT project was the front runner, but on 25th June this year China raced into the lead as HBIS, the world's third largest steelmaker, announced that as well as starting the World's first hydrogen direct reduced iron (DRI) plant in 2021, they will have a full scale hydrogen plant up and running by 2025[2].

Whilst this international competition between nations is understandable and productive, it is also true that all of us face this same enormous challenge together and so there are great opportunities to be realised by collaboration. By combining the academic, industrial, research and innovation expertise, such as that present in this conference, Britain, China and other nations around the world, and their people, will benefit from a steel industry that is green and supports our transition to a zero carbon world.

Thank you.

[1] https://www.h2greensteel.com/

[2] https://www.steelguru.com/steel/hbis-unveils-plan-for-low-carbon-steel-development-in-china

Materials Processing Institute

Chris McDonald is the Chief Executive Officer of the Materials Processing Institute. The Institute carries out industrial research and innovation in advanced materials, industrial decarbonisation, digital technologies and the circular economy supporting the materials, processing and energy sectors for over 75 years. Chris led the divestment and return to independent, not-for-profit ownership of the Institute in 2014.

Chris's background is in industrial research and manufacturing, where he has worked internationally. A graduate of Cambridge University, Chris is a Fellow the Institute of Chemical Engineers and of the Institute of Materials, Minerals and Mining. He sits on industrial advisory boards at a number of universities, including Oxford and Sheffield.

Chris has an interest in innovation management and industry dynamics and in addition to leading the Institute, he provides expert opinion and consultancy support to companies, institutes, Governments and public bodies in innovation and technology strategy and management. He also advises on the technical due diligence aspects of mergers and acquisitions.

Chris is prominent in the development of public policy, around innovation, steel, SMEs, where he works to support growth and inward investment. Chris is the policy chair for Innovation and Enterprise for the Federation of Small Businesses, a member of the CBI Regional Council and Shadow Monetary Policy Committee for the North East, the Chair of the UK Metals Council and a member of the Steel Advisory Board for UK Steel (EEF).

Chris is often called to commentate in the media on innovation leadership and the steel industry.

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Chris McDonald
Chief Executive Officer
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The Materials Processing Institute is an independent, open access and not-for-profit technology and innovation centre working with industry, government and academia worldwide. Support ranges from small scale, site based investigations, through to long term collaborative research programmes.

The Materials Processing Institute is expert in advanced materials, industrial decarbonisation, digital technologies and the circular economy, specialising in challenging processes, particularly those involving high specification materials, high temperatures and difficult operating conditions.

The Institute has over 75 years' experience as a leading UK technology provider. Extensive materials processing knowledge is supported by state-of-the-art facilities with a broad range of equipment, from laboratories through to demonstration, scale-up and production plant.

Scientists and engineers work with industry and apply their expertise to develop and implement robust solutions to research and development and improvements for products and processes.

Expertise is spread across a wide range of disciplines, including:

- Materials Characterisation, Research and Development
- Simulation and Design
- Monitoring, Measurement and Control in Hostile Environments
- Process Development and Upscaling
- Specialist Melting and Steel / Alloy Production
- Engineering / Asset Management
- Materials Handling
- Minerals and Ores

Research and project management teams deliver support across a wide range of industrial and manufacturing sectors including:

- Metals and Metals Manufacture
- Chemicals and Process
- Nuclear
- Oil & Gas
- Energy
- Aerospace and Defence
- Mining and Quarrying

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