Contribution ID: **57** Type: **Oral presentation (paper for Ironmaking & Steelmaking special issue)**

Impact of New Iron Sources on Basic Oxygen Furnace Operations

Monday 11 May 2026 12:30 (20 minutes)

The global shift toward decarbonised steel production with the increasing use of low-grade iron sources has driven interest in introducing electric smelting furnace (ESF) to process low-grade direct reduced iron (DRI) and generate ESF hot metal as a replacement of the blast furnace (BF). At the same time, the gradual scarcity of high-quality scrap has increased interest in using hydrogen based DRI as a coolant in the BOF. While attractive from both sustainability and resource-flexibility perspectives, the thermochemical implications of incorporating ESF hot metal and hydrogen based DRI as alternate feeds with variation in composition, temperature, and gangue content into the BOF are still not well quantified. A better understanding of these effects is critical for ensuring stable operation and preserving steel quality while executing decarbonisation strategies.

Building upon previous research at Swinburne, this study evaluates how alternate feed characteristics influence BOF performance through mass and energy balance (MEB) analysis and kinetic modelling with focus on droplet bloating and decarburisation. A detailed MEB model of the overall process was developed and validated against industrial data. Parametric simulations were performed across representative ranges of carbon and silicon levels in ESF hot metal and across different types of DRI, such as natural gas DRI and hydrogen DRI, allowing assessment of BOF process sensitivity to alternate feed chemistry.

The results demonstrate that reduced carbon and silicon contents significantly lower the thermal reserve of the BOF, decreasing the available chemical heat. Consequently, scenarios with low C and Si exhibit reduced scrap melting capacity and steel yield. Increasing the temperature of ESF hot metal can partially compensate for the loss of thermal input. Slag generation shows a stronger dependence on silicon, since a higher Si level produces more SiO2 in the slag and increases flux demand to maintain the basicity. Preliminary results show that DRI can be used as an effective cooling agent to reduce the bath temperature mainly due to higher gangue levels or lower metalisation rate. Overall, these trends highlight the importance of selecting appropriate amount and temperature when operating with alternate iron sources in order to maintain a stable heat balance and achieve the required process performance.

Future work will extend the current model through dynamic modelling that includes time dependent droplet behaviour and decarburisation kinetics. These developments aim to support optimisation of BOF operations when using alternate iron feeds and contribute to the broader goal of achieving green steel production.

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Session Classification: Use of alternative iron sources

Track Classification: EMECR: EMECR 5. Cleaner Production and Technologies in Steel Industry