Contribution ID: **42** Type: **Oral Presentation**

Valorization of EAF Slag & Dust for High-Value Applications: Challenges and Technological Solutions

Wednesday 13 May 2026 08:50 (20 minutes)

The steel industry's transition towards lower CO2 emission is accelerating the shift from BF/BOF routes to direct reduction and electric arc furnace (EAF) operations. This green steel transformation will significantly increase EAF-related byproducts such as slags and dusts. Unlike BF slag, widely used as a secondary cementitious material (SCM), EAF slag faces limited utilization due to compositional challenges—particularly high FeO, MgO as well as Cr and V-Oxides—resulting in frequent landfilling or low value applications. EAF dusts, typically rich in Zn, are mainly recycled via the Waelz process to recover crude zinc oxide. While energy-efficient, this process emits high CO_2, produces iron-rich slag requiring disposal, and yields zinc oxide that demands further treatment and remains only partly usable in primary zinc applications—highlighting the need for cleaner, circular technologies.

This paper examines advanced valorization strategies for EAF by products, focusing on thermal reduction processes in electric smelting furnaces which could be a promising solution for both slags and dusts. Smelter-based treatment of EAF slags enables recovery of valuable metals and allows to modify slag mineralogy, making it suitable for usage as SCM or as a decarbonized raw material for cement production depending on the legislative limits. The recovered metal fraction can substitute scrap or be reused as hot metal, supporting circular economy principles by reducing CO_2 emissions and eliminating landfilling. Comparison with other slag treatment solutions like conventional cold processing shows the smelter based thermal reduction is the only option for full metal recovery and highest value output material streams.

For EAF dust, several technologies—including hydrometallurgy and pyrometallurgy—are under development. Primetals Technologies'Zinc Extraction Process (ZEP), combining pre-calcination and thermal reduction, addresses Waelz process drawbacks by fully valorizing iron- and zinc-containing dust with minimal CO_2 emissions. The Smelter step recovers iron and zinc while converting the mineral fraction into a product suitable for construction industry. The pre-calcination step for high-zinc containing EAF dust is designed to remove contamination of halogens and heavy metals enabling higher purity crude zinc quality. Utilizing renewable energy and secondary carbon carriers, ZEP offers a sustainable, circular solution for dust recycling.
Technical, economic, and regulatory challenges for implementing these processes will be discussed, alongside their role in enabling high-value outputs for steel and cement industries, contributing to a low-carbon future.

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Session Classification: Integration of Renewable Energy & Biochar Applications

Track Classification: EEC 4 - Environmental and Sustainability Issues: EEC 4.C Waste management and by-product utilization