Contribution ID: **59** Type: **Oral Presentation - Full Paper will be submitted**

Innovations and Optimizations in Tracing Non-Metallic Inclusions in Steel

Wednesday, 21 May 2025 12:00 (20 minutes)

The steel industry is at a critical turning point, driven by the urgent need to lower CO_2 emissions. The transformation includes the development and implementation of novel processes as well as a higher recycling rate to produce iron and steel efficiently and sustainably. However, the high demand for steel quality cannot be disregarded. One major point within this topic is steel cleanness, which relates to the significance of non-metallic inclusions (NMIs). These mainly microscopic particles appear during steel making and cannot be completely avoided. Hence, it is necessary to identify the sources of NMIs and track their modification over the process, especially for novel production procedures and higher scrap recycling rates.
A common technique to trace NMIs during steelmaking is active tracing by directly adding specific metals, primarily rare earth elements (REEs), to the melt or oxides, such as BaO or SrO, to the slag. Active tracing has the advantage of marking and tracking deoxidation products over different production steps. However, the determination of REE-traced NMIs requires an optimization of the state-of-the-art- characterization method, the automated scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS), as these NMIs appear brighter than conventional deoxidation products. Since this method influences the behavior of NMIs, and it is therefore necessary to search for novel tracing techniques.
One promising approach is the use of REE fingerprinting, a passive method already applied in food chemistry to identify the origin of raw products. This technique is based on the natural concentration of REEs in potential sources and NMIs. By analyzing similarities in the REE concentration patterns, connections between sources and NMIs can be identified. These patterns make it possible to determine which auxiliary materials contributed to the formation of specific NMIs.

Speaker Country

Austria

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Session Classification: Impact of changed raw material mix on BOF process and secondary metallurgy

Track Classification: Impact of changed raw material mix on BOF process and secondary metallurgy