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# Machine Learning-based Scrap Characterization for Process Optimization in Electric Arc Furnaces

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Scrap characteristics significantly influence the performance of the melting process in the Electric Arc Furnace (EAF). Along with other charged materials, scrap accounts for significant production costs. Hence, marginal process improvements can yield significant economic gains. However, the inherent heterogeneity of charged materials and the lack of elemental composition data on scrap properties currently act as primary constraints on scrap-mix optimization. To address this, the **MultiSensEAF** project was initiated with model-based scrap characterization as a core objective, leveraging both existing operational data and modern off-the-shelf sensors.

This study develops a comprehensive scrap characterization model using a multi-modal data approach. The primary data sources include high-fidelity operational and scrap-mix records provided by **Georgsmarienhütte (GMH) GmbH**. These datasets are integrated with Optical Emission Spectroscopy (OES) sensor data delivered by the **LUXMET** system installed at the GMH facility. To process this high-dimensional dataset, rigorous data exploration and feature engineering were conducted to identify the most influential scrap properties and their relationship to key operational parameters. Subsequently, various machine learning architectures, including multivariate regression, artificial neural networks, and random forests, were implemented to realize a robust statistical characterization model. A significant innovation in this research is the exploration of auto-adaptation for model parameters. By utilizing historical process data in conjunction with OES-based sensor data, the model can dynamically adjust its own parameters.

In conclusion, this study demonstrates the enhanced capabilities of integrated multi-sensor systems in developing predictive models for scrap characterization. The findings provide furnace operators with critical real-time insights into expected meltdown behavior, reducing uncertainty during the meltdown phase. Furthermore, the results indicate how estimated scrap properties can be utilized for advanced process control and the continuous monitoring of scrap quality, marking a significant step in the digitalization of EAF steelmaking.

## Speaker Country

India

## Speaker Company/University

IOB RWTH Aachen

**Primary author:** NACHANKAR, Siddharth (IOB RWTH Aachen)

**Co-authors:** Prof. WUPPERMANN, Christian (IOB RWTH Aachen); Mr JOKINEN, Mikko (LUXMET); Dr ELSABAGH, Sami (Georgsmarienhütte GmbH); Dr ECHTERHOF, Thomas (IOB RWTH Aachen)

**Presenter:** NACHANKAR, Siddharth (IOB RWTH Aachen)

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