Contribution ID: **80**

Type: **Oral Presentation**

# Development of Intelligent Monitoring Systems for Anomaly Detection in Electric Arc Furnace Steelmaking

*Tuesday 12 May 2026 08:50 (20 minutes)*

The steel industry's transition toward intelligent manufacturing requires sophisticated monitoring systems capable of detecting operational anomalies in real-time. This study presents the development and implementation of Artificial Intelligence-based predictive models for automated anomaly detection in Electric Arc Furnace operations, conducted within the project entitled "Remote expert virtual system enhancing human management capabilities that favors preservation, transfer, and continuous evolution of knowledge for steelmaking operations"(Ref. iSteelExpert, Grant Agreement No. 101112102) , which is co-funded by the Research Fund for Coal and Steel of the European Union.

A comprehensive dataset was collected during normal production operations at an industrial facility. The dataset integrated heterogeneous data sources including chemical composition measurements, operational parameters, and electrical signals. Operator-reported anomalies were systematically annotated, with some heats exhibiting abnormal events across eight distinct categories, including electrodes breakage, roof closing troubles, high-carbon melts, and strong furnace reactions. Several machine learning algorithms were evaluated including Random Forest, XGBoost, Histogram Gradient Boosting, Support Vector Machine, and AdaBoost. The experimental framework encompassed two complementary objectives: generic anomaly detection (identifying any abnormal heat) and specific anomaly classification (distinguishing between different anomaly types). Extensive hyperparameter optimization was performed to maximize detection capability while maintaining acceptable precision. For generic anomaly detection, the models demonstrated robust performance with balanced accuracy exceeding 80% and high detection rates. Specific anomaly classification proved more challenging due to severe class imbalance. Strategic undersampling approaches dramatically improved detection rates for most anomaly types, though requiring careful consideration of the precision-recall trade-off based on anomaly severity.

A proof-of-concept decision support system was developed, integrating genetic algorithms with trained predictive models to suggest corrective process adjustments when anomalies are predicted. The optimization framework balances avoiding alarms with minimizing deviation from current operating conditions while respecting physical and safety constraints. This represents a novel approach combining near real-time ML predictions with actionable operational recommendations in Electric Arc Furnace steelmaking. The findings demonstrate that AI-driven monitoring systems can effectively detect process deviations, particularly for subtle anomalies difficult for operators to consistently identify. Future development will focus on advanced techniques for imbalanced classification to further optimize detection capability across all anomaly categories, ultimately delivering a practical and reliable monitoring solution for Electric Arc Furnace operations.

## Speaker Country

Italy

## Speaker Company/University

Scuola Superiore Sant'Anna

**Primary authors:** Dr SIDDIQUE, Arslan (Scuola Superiore Sant'Anna, TeCIP Institute); Dr BAVESTRELLI, Giovanni (Tenova); Dr VANNUCCI, Marco (Scuola Superiore Sant'Anna, TeCIP Institute); Mr AKRAM, Muhammad Waseem (Scuola Superiore Sant'Anna, TeCIP Institute); Mr GIRELLI, Renato (Tenova S.p.A.); Mr PEDE, Stefano (Scuola Superiore Sant'Anna, TeCIP Institute); Prof. COLLA, Valentina (Scuola Superiore Sant'Anna)

**Presenter:** Prof. COLLA, Valentina (Scuola Superiore Sant'Anna)

**Session Classification:** Safety and Training I

**Track Classification:** EEC 1 - Technological Advancements: EEC 1.F Use of artificial intelligence (AI) and machine learning in process optimization