iSteel-Expert Newsletter No 5

The iSteel-Expert project, which is now coming to an end, proved how Artificial Intelligence can play a key role in the realization of a **remote expert virtual system** for EAF continuous monitoring. In particular, it can support the identification of anomalous situations, thus contributing to improving situation awareness for the operators, with relevant benefits in terms of process reliability and health and safety conditions at the workplace.

Artificial Intelligence-based anomaly detection

Anomalies in EAF operations, such as intense in-furnace reactions, slag reactions, or a decline in chemical and electrical equipment performance, can lead to significant productivity losses, safety hazards and product quality degradation. Early and accurate detection of the onset and evolution of such events enables timely corrective actions and reduces reliance on operator experience alone, which is increasingly at risk due to workforce aging and knowledge attrition.

In iSteel-Expert a comprehensive dataset was gathered during normal and anomalous production operations at an industrial facility. The dataset integrates heterogeneous data sources encompassing chemical composition measurements, process operational parameters, and electrical signals recorded throughout each heat. The anomaly classification in the dataset was provided by skilled operators, and 2 tasks were established: (i) detecting whether an anomaly occurred; (ii) distinguishing between the different anomaly types in a multi-label setting.

One of the most relevant challenges in application of Artificial Intelligence for detection and identification of anomalous conditions is represented by the fact that **anomalies are** (luckily!) **rare events**, as plant managers are skilled and trained to avoid such situations. Therefore, any experimental dataset gathered from real operating practices is obviously “imbalanced,” namely it contains a markedly higher number of data representing “normal” operating conditions.



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In iSteel-Expert the problem of imbalance is currently faced by under-sampling of the training data (i.e. eliminating some data belonging to the most numerous classes), but other approaches are currently being evaluated, including the generation of synthetic data to increase the number of the “rare” patterns.

Two supervised machine learning algorithms were evaluated: **Histogram Gradient Boosting** and **AdaBoost**.

In the binary (anomalous vs. standard heat) classification task, the first one provides better performance (90% balanced accuracy) when under-sampling is applied. The multi-label classification task is even more challenging, due to the extreme rarity of some individual anomaly categories. Without under-sampling, all algorithms fail to detect several rare anomaly types, defaulting to the majority class. However, when down-sampling is applied on the training dataset, detection rates improved substantially across most categories exceeding 80% of balanced accuracy on most of them.

The target is to embed this solution into a **Decision Support System** combining predictive models with a Genetic Algorithm optimization framework to provides actionable recommendations for corrective actions that minimize the probability of anomalies

Dissemination



The AI-based solution for anomaly detection has been presented by SSSA in a Special Session of the **European Electric Steelmaking Conference EEC2026**, which was held in Milan on May 11-13, 2026.

The related paper is published in the Conference Proceedings.

A further paper concerning investigations on AI use in the project has been recently published on the May 2026 issue of the journal **La Metallurgia Italiana**.

https://www.aimnet.it/la_metallurgia_italiana/2026/maggio/Aim_maggio2026_2.pdf

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