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Application of Federated Learning to enhance model-based Decision Support for EAF online Monitoring and Control at multiple plants

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The Electric Arc Furnace (EAF) for scrap-based steelmaking plays an important role in realizing the transition towards Green Steel production, due to lower carbon dioxide emissions and inherent circularity compared to the iron-ore-based steelmaking.
This work presents an approach to enhance the performance and reliability of a model-based Decision Support System for EAF online monitoring and control by means of Federated Learning, which has been developed within the EU-funded project ALCHIMIA and applied at three EAF plants within the Celsa Group. The system consists of a web application for the characterisation of scrap type properties and a charge mix optimization, which considers multiple optimization criteria like purchase costs and environmental impact factors of the different scrap types. Furthermore, the system includes a dynamic EAF process model based on energy and mass balances and thermodynamic calculations for the online monitoring of the process behaviour and for decision support in real-time control.
The underlying process models and control functions were validated on the basis of historical production and measurement data from a large number of heats produced at the involved Celsa plants. The applied material and model parameters were fitted by means of parameter optimisation tools locally for each individual plant. A selected set of model parameters, which are generalisable for all involved EAF plants, was also optimized by a federated learning approach, to benefit from the information on process behaviour at varying operating points at the involved Celsa plants. This federated learning approach enables the creation of a more generalized global model while preserving data privacy and integrating a monitoring and data drift detection service to capture emerging trends and ensure continuous model adaptation.
The paper will present the model-based EAF decision support system, its performance at the Celsa plants and the benefits of the federated learning approach.

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