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Hybrid solution for local heat transfer coefficients in a transient solidification model for continuous casting

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Abstract

The heat transfer coefficient (HTC) is an essential parameter in the numerical simulation of solidification during the secondary cooling zone in continuous casting. Accurate prediction of the HTC is essential for controlled slab cooling and ensuring product quality by preventing crack formation. The HTC is commonly estimated using empirical equations from literature. However, an alternative approach is statistical regression modeling based on experimental data. This study presents the development and evaluation of regression models trained on measured data from the Nozzle Measuring Stand (NMS) at Montanuniversität Leoben. Multiple regression techniques were implemented using Python, and their performance was evaluated using the error values RMSE (root mean square error) and MAE (mean absolute error).

At the Chair of Ferrous Metallurgy, an offline numerical simulation software, m²CAST, has been developed to integrate experimental HTC and water distribution (WD) data into predictive modeling. The software enables solidification simulations by incorporating regression-based HTC predictions as boundary conditions. Various regression models were implemented using Python and compared to optimize HTC predictions. The impact of higher HTC values on the precision of the model was investigated. Additionally, feature importance analysis, using the Pearson Correlation Matrix and feature selection methods, identified the most influential parameters for HTC prediction.

Simulation outcomes from the offline simulation software m²CAST were used to validate the impact of operating parameters and variations on solidification profiles. The dependency of HTC on nozzle type, spray water distribution, and initial slab temperature was analyzed, revealing critical secondary cooling optimization. This study demonstrates the potential of machine learning-driven HTC modeling to enhance solidification simulations for industrial applications, improving process control and product quality in continuous casting.

Keywords

Continuous Casting, Secondary Cooling, Heat Transfer Coefficient, Simulation, Regression Model

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