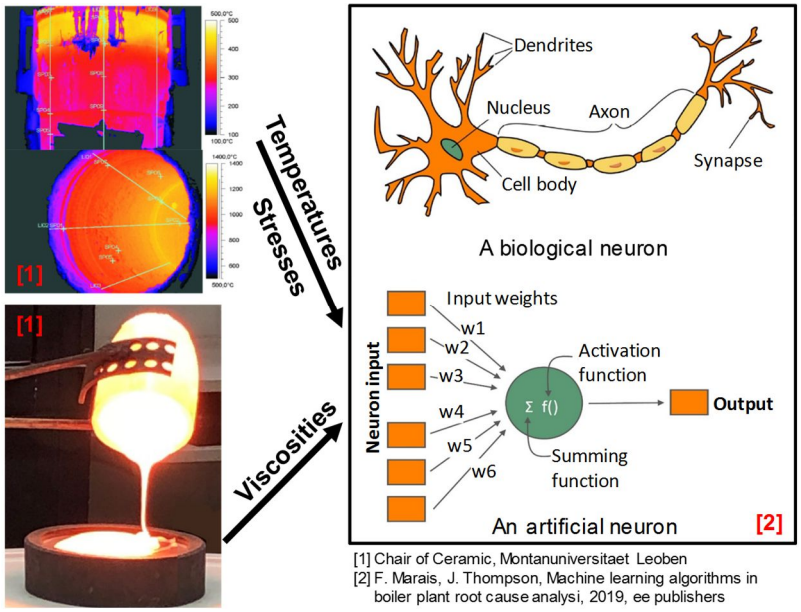
SUCCESS STORY

K1-MET
Competence center for Advanced Metallurgical and Environmental Process Development

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Centre (K1)

Type of project: P2.4 “A procedure for the design of refractory linings” and P2.5 “New mold slag types and viscosity of metallurgical slags”, 01.07.2019 - 30.06.2023, multi-firm



[1] Chair of Ceramic, Montanuniversitaet Leoben
[2] F. Marais, J. Thompson, Machine learning algorithms in boiler plant root cause analysi, 2019, ee publishers

APPLICATION OF ARTIFICIAL NEURAL NETWORK (ANN) FOR LINING OPTIMIZATION AND VISCOSITY MODELING

ANN WERE USED TO PREDICT STRESSES AND TEMPERATURES OF A STEEL LADLE AND TO CREATE A TOOL FOR SLAG VISCOSITY CALCULATIONS

An artificial neural network (ANN) is a computational model based on the structure of biological neurons of the human brain and a popular machine learning technique started in 1940s. They were widely applied as predictive models to solve real world nonlinear problems in steelmaking industry. In Area 2 project 2.4 and 2.5, ANN have been employed for two relevant applications. One is the prediction of the temperature and stresses in the refractory linings of a steel ladle, the other the calculation of slag viscosities.

The lifetime of a steel ladle is influenced significantly by the temperatures and stresses in the refractory linings. However, it is a tough task to directly measure these values especially during service. Therefore, it is necessary to predict the temperatures and stresses to monitor lining service conditions and to improve the lifetime of steel ladle linings. A steel ladle from the project partner voestalpine Stahl was selected for a case study. A representative factor-response dataset including 160 lining configurations for ANN training was obtained by the application of multiple orthogonal arrays and finite element (FE) simulations. With optimized ANN models, the temperatures, and stresses of two optimized lining concepts were predicted and favorable accuracy was achieved.

Slags are made of oxides present in various metallurgical processes. For its performance in liquid state during service one of the key properties is the viscosity, which depends on the slag’s chemical composition. As high-temperature viscosity measurement is practically difficult, time-and cost-

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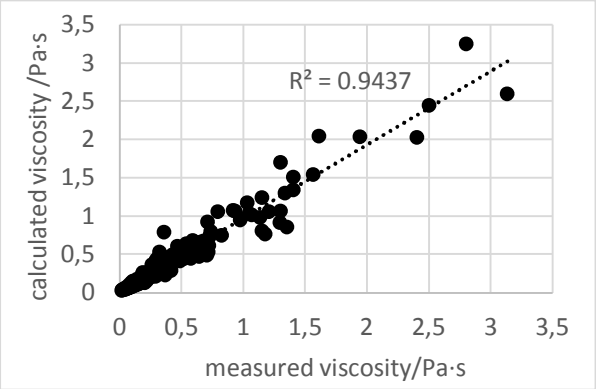
consuming, there is a necessity to develop a reliable mathematical model for the viscosity prediction. Therefore, the applicability of ANN for slag viscosity prediction was tested by using experimental slag viscosity data from literature and measured ones at the Chair of Ceramics at the Montanuniversitaet Leoben. The derived viscosity values by ANN modelling were compared to values calculated by already established viscosity models. The mean error was found to be smallest with the ANN modelling. Resulting from this study, a user-friendly viscosity prediction tool was generated, which will be extended during the remaining project period.

Impact and effects

In a steel ladle system, the ANN models were successfully applied to predict the temperatures and stresses with acceptable prediction accuracy. These models can be employed to predict the performance of new lining concepts prior to industrial application, which is beneficial in saving time, materials, and labor by reducing industrial trials. The studied case also forms one of the basic parts of a digital tool in steelmaking industry for refractory lining monitoring, maintenance, and optimization. The methodology is also promising for the prediction of lining behavior of other industrial vessels, optimization of steelmaking process parameters and material recipe developments.

With increasing computing capability, the potential of process simulation is increasing. The knowledge of the viscosity is therefore not only of importance for the daily business, but especially for process prospects. Therefore, required viscosity values can be easily derived by the created viscosity prediction tool.



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