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Summary: Centerline segregation in steel cast products is an internal defect that can be very harmful when slabs are rolled in heavy plate mills. Consequently, anticipate its presence is a matter of importance to prevent future risks. The aim of this study was to obtain a predictive model able to perform an early detection of central segregation severity in continuous cast steel slabs. This study presents a novel hybrid algorithm, based on support vector machines (SVMs) in combination with the particle swarm optimization (PSO) technique, for predicting the centerline segregation from operation input parameters determined experimentally in continuous cast steel slabs. This optimization technique involves kernel parameter setting in the SVM training procedure, which significantly influences the regression accuracy. Additionally, a multilayer perceptron network (MLP) and a multivariate adaptive regression splines (MARS) approach, this last method also in combination with the particle swarm optimization (PSO) technique, were fitted to the experimental data with comparison purposes. To this end, the most important physical-chemical parameters of this industrial process are monitored and analyzed. The results of the present study are twofold. In the first place, the significance of each physical-chemical variables on the segregation is presented through the model. Secondly, some models for predicting segregation are obtained with success. Indeed, regression with optimal hyperparameters was performed and coefficients of determination equal to 0.98 for continuity factor estimation and 0.97 for average width were obtained when this hybrid PSO-SVM-based model with RBF kernel function was applied to the experimental dataset, respectively. Furthermore, the results obtained with the MLP and PSO-MARS-based models are clearly worse than those obtained with the PSO-RBF-SVM-based model. The agreement between experimental data and the model confirmed the good performance of the latter. Finally, conclusions of this innovative research work are exposed.

MSC:
74N05 Crystals in solids
62G08 Nonparametric regression and quantile regression
62H30 Classification and discrimination; cluster analysis (statistical aspects)
68T05 Learning and adaptive systems in artificial intelligence
68T20 Problem solving in the context of artificial intelligence (heuristics, search strategies, etc.)

Keywords:
support vector machines (SVMs); multivariate adaptive regression splines (MARS); particle swarm optimization (PSO); artificial neural networks (ANNs); continuous cast steel slabs; centerline segregation prediction

Software:
LIBSVM; ABC; earth; hydroPSO

Full Text: DOI

References:
Karaboga, D.; Basturk, B., A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC)


Eberhart, R. C.; Shi, Y.; Kennedy, J., Swarm intelligence, (2001), Morgan Kaufmann San Francisco

Clerc, M., Particle swarm optimization, (2006), Wiley-ISTE London, United Kingdom · Zbl 1139.90059

Dorigo, M.; Stützle, T., Ant colony optimization, (2004), Bradford Publisher, The MIT Press Cambridge, Massachusetts, USA · Zbl 1092.90066


Hastie, T.; Tibshirani, R.; Friedman, J., The elements of statistical learning, (2003), Springer-Verlag New York


Steinwart, I.; Christmann, A., Support vector machines, (2008), Springer New York · Zbl 1203.68171


Fister, I.; Strnad, D.; Yang, X.-S.; Fister, I., Adaptation and hybridization in nature-inspired algorithms, (Fister, I.; Fister, I., Adaptation and Hybridization in Computational Intelligence, Vol. 18, (2015), Springer New York), 3-50


UNE-AEN CTN 36432, Macrographic examination by sulfur print (Bauman method) of steel products and foundry products, Spanish Institute of the Streamlining and Standardization, IRANOR, Madrid (AEN/CTN 36; ICN 77.080.01), 1981.


