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An application of learning machine methods in prediction of wear rate of wear resistant casting parts ☆

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ABSTRACT

In this paper, a method of floating ball wear rate identification, using two machine-learning techniques Support Vector Machine (SVM) and Improved Support Vector Machine (ISVM) are proposed. Both models are used to relate the wear rate and technological parameters of the wear resistant drip moulding using different kernel functions. The models for determining the wear rate of white iron casting with low chromium content (flotation balls), was trained and tested by using the existing exploitation data from the Bor Flotation Plant, Serbia. In order to select the best model parameters the statistical indicators for both models are presented. Results show that the ERBF (SVM) and ERBF+POLY (ISVM) achieved the best classification accuracy compare to other kernels used: the absolute mean error of ERB (SVM) is 5.85%, while the error of ERBF+POLY (ISVM) is 6.67%. The tuned ISVM model with mixture of kernels is able to accurately predict the wear rate and can be used to define the optimum chromium content in liquid metal alloys for the casting of flotation balls.

1. Introduction

The wear rate of flotation balls depends upon their material, mechanical–chemical characteristics obtained from the casting process and ore composition. The technology of developing flotation balls through hardness (HRC) and chemical composition has an influence on the balls' wear rate. In order to achieve the optimum process of ore milling, it is necessary to establish a relationship between the wear rate and the technological process parameters. For that purpose a machine learning methods have been used i.e. a Support Vector Machine (Gunn, 1998) and improved support vector machine (Jaya, Vinodhini, & Karthik, 2012; Smits & Jordaan, 2002) and then the one that gives the best results was used to manage the casting process of floating balls.

SVM is based on statistical learning theory and is a new achievement in the field of data-driven modelling and has been successfully implemented in classification, regression and function estimation (Shi & Gindy, 2007). The concept underlying this algorithm is that of observing the relationships that are valid for a finite set of data. By identifying and learning these relationships, SVM acquires the characteristic of generalisation, which means that the algorithm will be able to perform predictions for a new data set generated by the same source. Recently, SVM has been widely used to solve various problems in almost all scientific disciplines. Huang, Li, and Gan (2010) analysed SVM as a supervised method for problem classification taking advantage of prior knowledge of tool wear. Cho, Asfour, Onar, and Kaundinya (2005) applied Support Vector Machines for Regression (SVR) to model the power and maximum cutting force in an end milling application. In their investigation, the SVR approach was better than a Multiple Variable Regression (MVR) approach. Yang and Shieh (2010) used machine learning approach i.e. SVR for model development that predicts consumers' affective responses for product form design, through *a* comparison of two standard kernel functions (polynomial and RBF). Li (2009) presents a machine vision and image processing techniques combining a novel classifier, support vector machine, to detect and classify copper clad laminate surface defects, while Shin, Eom, and Kim (2005) used one-class support vector machines in machine fault detection and classification. Based on ground roughness variation during the grind able period, Chiu and Guao (2008) used SVM for classifying the intercepted grinding acoustic emission data. Their SVM model was constructed from the result of a grinding experiment and was found to predict with 85% accuracy. Wang, Jing, and Ren (2007) introduced the application of wavelet packet and SVM method for the classification recognition of the rift wear mark. Malyscheff, Trafalis, and Raman (2002) describe how the support vector algorithm can be modified in order to identify the minimum enclosing zone for straightness and flatness tolerances. To improve the precision of coal reserve

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