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Modeling of sawability with diamond wire saw machine based on geomechanical parameters by using ICA: a new model for production rate estimation

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Abstract

Performance prediction of diamond wire saws and estimation of sawability are important in the cost estimation and the planning rock cutting projects. In this paper, the performance prediction of diamond wire saws in cutting carbonate rocks is considered on 14 different carbonate rocks in stone quarries. Uniaxial compressive strength (UCS), Brazilian tensile strength (BCS), Schmidt hammer value (SHv), Los Angeles (LA) abrasion and production rate (Ph) of diamond wire saws are determined in separated reference. The scope of this study is to evaluate the capability of two different methods in order to predict production rate of carbonate rock using diamond wire saw. A non-linear model presented by Ataei et al. and new proposed non-linear model are presented. An application of Imperialist Competitive Algorithm (ICA) is used to determine the non-linear production rate estimator coefficients. According to the calculated statistical error between the forecasted and real measured values of production rate, ICA-based model has the lower values of MAPE, MAE, VARE, MEDAE and RMSE than the previous model in the literature, while it has the higher value of VAF than the previous model in the literature. It is concluded that the production rate of carbonate rock using diamond wire saw can reliably be estimated using the developed model.

Keywords: *Sawability, Diamond wire saw, production rate, non-linear model and ICA*

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Extended Abstract:

1. Introduction

The diamond wire saw is one of the most important machines used in the dimensional stone extraction. A diamond wire is simply a steel cable on which small beads bonded with diamond abrasive are mounted at regular intervals with spacing material placed between the beads (Atici and Ersoy 2009). Nowadays, diamond wire saw is one of the most important tools used in the stone quarries. Predicting the sawability of dimension stone is very important in planning the dimension stone quarries. Up to the present time, diamond wire cutting has been well-reported in the literature.

2. Materials and methods

Performance prediction of diamond wire saw is important in the cost estimation and in the planning of the quarries. A correct estimation of sawability helps to make the stone sawing more efficient. In this work, a meta-heuristic algorithm is developed for evaluating the performance of a diamond wire saw using an evolutionary technique, Imperialist Competitive Algorithm (Biabangard-Oskouyi et al. 2009). During this research work, 14 different dimension stones belonging to the carbonate rocks were cut using a diamond wire cutting machine. The database including uniaxial compressive strength, Brazilian tensile strength, Schmidt hammer value, Los Angeles abrasion values and production rate of different rocks is collected from Ataei et al. experiments (Ataei et al. 2012).

3. Results and discussion

In this paper, relationship between production rate and some important rock properties is evaluated using ICA-based non-linear regression, and estimation model is developed. As a result of analysis, the best equation obtained is formulized in equation (1):

$$Ph = \begin{vmatrix} -29.815 - 38.518 \times UCS_i^{-3.839} + 62.295 \times BTS_i^{-1.349} - 45.479 \times LA_i^{-0.0686} \\ +570.811 \times SHv_i^{-0.526} - 1.929 \times UCS_i^{1.648} \times BTS_i^{-14.566} \times LA_i^{1.905} \times SHv_i^{2.309} \end{vmatrix} \quad (1)$$

The performance of different predictor models can be controlled by correlation coefficient (CC), Mean Absolute Percentage Error (MAPE), Route Mean Square Error (RMSE), Variance Absolute Relative Error (VARE), Median Absolute Error (MEDAE) and Mean Absolute Error (MAE) and Value Account for (VAF). According to the calculated statistical error between the estimated and real measured values of production rate, ICA-based model has the lowest values of MAPE, RMSE, MAE, VARAE and MEDAE, while it has the highest value of VAF, in comparison to the Ataei et al.'s model (Table 1).

Table 1. Results of regression goodness statistical criteria.

Model	CC	MAPE (%)	RMSE	MAE	MEDAE	VARE	VAF (%)
Ataei et al.'s model	0.878	17.209	1.560	1.203	0.2	1.378	73.955
ICA-based multivariate non-linear model	0.980	8.376	0.536	0.428	0.072	0.559	95.677

4. Conclusion

The correlation coefficient of the model was higher than 0.98. It is concluded that predicting the production rate of carbonate rocks using diamond wire saws can reliably be estimated using the ICA-based non-linear model.

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