Application of Response Surface Method to the Estimation of Bond Work Index

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Extended Abstract

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Introduction

The main objective of this contribution is to focus on the portion of the comminution process which deals with the prediction of the energy consumption due to the comminution portion of the milling processes.

The comminution energy in mineral processing and cement industry is usually determined by empirical Bond Work Index (BWI), regardless of the mechanical properties of a rock. The BWI is a measure of ore resistance against grinding and is determined by using the Bond grindability test. Determining the BWI value is quite complicated and time consuming. Its value constitutes ore characteristic and is used for industrial commination plants designing and optimization. The BWI is defined as the calculated specific energy (kW h/t) applied in reducing material of infinite particle size to 80% passing 100 µm. The higher the value for BWI, the more energy is required to grind a material in a ball mill. The energy consumed in the process of comminution depends on both the mechanism of comminution and the mechanical properties of the materials being ground. It is interesting to study the effect of the essential ones of these properties on the energy efficiency of grinding process.

Material and methods

Several attempts have been made to obtain and optimize the comminution energy. An efficient Response Surface Method, (RSM)-based method for the BWI approximate value determination, which is based on physico-mechanical tests, is presented in this paper.

BWI and some physico-mechanical tests on 8 typical rock samples and its correlation are studied; it would be beneficial to examine this relation based on physical concept. The database including Uniaxial Compressive Strength (UCS), Abrasion (AT), Hardness (HT) and Modulus of Elasticity (ME) are assembled by collecting data from Haffez experiments.

Results and discussion

The determination of the BWI from RSM- based multivariate model is almost matched with measured Bond's work index. As a result of analysis the best equation obtained from RSM-based model is formulized in Equation 1:

$$\begin{aligned}(BWI)^{-3} &= +6.4466\times10^{-4}\\ &-1.7720\times10^{-7}UCS\\ &+1.5910\times10^{-4}AT\\ &+1.1101\times10^{-6}HT\\ &-5.9770\times10^{-6}ME\\ &+1.2317\times10^{-6}UCS\times AT\end{aligned} \quad (1)$$

Standard statistical evaluation criteria are used to evaluate the performances of predictive models.

Conclusion

The performance of the estimator models can be controlled by R^2, VAF, RMSE, MAPE, VARE and MEDAE. The RSM- based model with higher VAF as well as lower RMSE, MAPE, VARE, MEDAE shows better performance in comparison to the Haffez single-variable models. AT and ME have the greatest effect on the value of BWI; and also HT has the least impact.

Keywords: Bond work index, milling energy, RSM

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