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Study of Parameters Affecting on Copper Recovery from Oxide Ores by Column Leaching Using Artificial Neural Network

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ABSTRACT

Artificial Neural Network was used for predicting optimized conditions of column leaching on copper oxide ore. Optimization, control and analysis of heap leaching implicate an accurate, proper and comprehensive modeling. Providing such models need to identify all the effective parameters and their impact simultaneously on the output of the process. Important parameters such as height of column, particles size, acid flow rate and leaching time were studied and it was investigated their impacts on recovery of copper. Experiments were performed in three columns with the heights of 2, 4 and 6 meters and in the particle size distributions of 25.4 and 50.8 mm. The results showed that the copper recovery has an inverse relation with the column height and particle sizes. This relation is direct with leaching time and acid flow rate. The copper recovery obtained in the columns with heights of 2, 4 and 6 m were 78.63%, 66.27%, and 52.89% respectively. According to the results, the Trained ANN modeling predicts the copper recovery based on operation conditions.

KEYWORDS:

Heap leaching, Copper Oxide Ore, Recovery, Artificial Neural Network

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1- Introduction

Column leaching is a hydrometallurgical method in which the ore is crushed and agglomerated. It is an operation of solid–liquid mass transfer that can occur in ambient conditions. Column leaching is dependent on the grade of valuable metals contained in the ore and also the solubility of minerals in the solution. It is extensively used on low grade oxidized and sulfide ores. Many parameters that affect the process must be determined according to the type of minerals and impurities associated with them. Effective metallurgical parameters that must be optimized are: particle size, temperature, porosity and permeability of the ore, column height, time, acid concentration, the acid flow rate and mineralogy and chemistry of the ore.

Many studies have been carried out for leaching and the optimal condition of the operation. However, little research has been done on the process optimization. Recently, analytical models have been used for leaching processes in order to carry out the planning, optimization, design and control process. A study has been carried out by analytical–numerical method for solving a heap leaching problem of one or more solid reactants from porous pellets. In this regard, an analytical model has been used to optimize flow rates on copper heap leaching [1-2].

Artificial neural networks have been applied lately in mineral processing. It is capable of modeling and controlling complicated systems and identifying very difficult relations between input and output data. Neural networks are utilized to establish a relationship between a set of inputs and outputs. They are used successfully in many researches and industrial works. Artificial neural networks use a set of nonlinear basis functions between input and output data to be communicated acting as black box. In general, a neural network consists of one input layer, one or more hidden layers and one output layer. Each layer consists of one or more neurons. The neurons are inter-related by a weight parameter. Neural networks typically are learning its performance. One of the most useful types of neural networks is the back-propagation algorithm. BPA is used to converge to the minimum error. In this network, the error is calculated from comparing the networks output and true output. Then, according to the error rate, the weights communication and bias are updated [3-4].

The aim of present study is to obtain optimum conditions for column leaching by testing of various parameters such as column height, particle size, leaching time and acid flow rate on copper recovery. The process is modeled by the Artificial Neural Network (ANN).

2- Methodology

The tests were performed on copper oxide ore obtained from Tarom deposit, Zanjan, Iran. Sulfuric acid with a concentration of 20 g/l and LIX98N solvent were used for ore leaching and solvent extraction of copper, respectively. ICP-emission spectrophotometry was used to determine chemical composition and X-ray diffraction to determine species of the ore mineralogy. The initial sample was split into two fractions. One of the samples was crushed to less than 50.8 mm by a jaw crusher and another one to less than 25.4 mm. Representative samples were used for particle size distribution analysis, chemical analysis, and mineralogical characterization. The screen analysis was performed by mechanically shaken Tyler sieves.

To train the ANN, 120 sets of data recorded in column leaching of Tarom copper ore were used, in which 102 sets to train the network and 18 sets to test its correctness. The size of particles, height of column, leaching time and acid flow rates were selected as the network input parameters. The designed network output was copper recovery. The back propagation algorithm was used for training the network, which does not always converge to the absolute minimum. It might stop at a local minimum. The network is designed for column leaching process with 4 hidden layers and one output layer. The layers array of this network is in the form [25 _ 25 _ 17 _ 15 _ 1].

3- Results And Discution

There is an inverse relationship between column height and recovery. Copper recovery decreases in both size fractions with an increasing column height of 2 m to 6 m. The amount of acid consumption and leaching recovery increase with increasing time. More fresh solution is entered to the column with increasing the leaching time which causes the dissolution of more minerals and increasing the recovery. The effect of particles size and height of the column on the copper recovery are presented in Fig. 2. A more recovery is obtained on finer particles.

After training and testing the neural network, the complete and trained network was tested on the testing set of estimated values for each data.

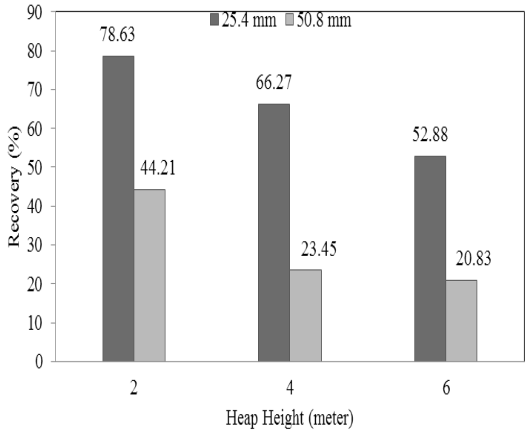

Figure 1. Comparison between copper recovery in 25.4 mm and 50.8 mm crushed ore

They were compared with the actual values and parameters of gradient regression line, correlation coefficient (R^2) and the root mean square error (RMSE). As shown in Fig. 2, the measured recovery values in the laboratory and predicted by the neural network are well correlated (R^2=0.99). The gradient of the regression line between them is equal to 0.997, which is close to its optimal value. The RMSE value calculated by the model is equal to 0.48. Based on these three parameters (gradient of the regression line, R^2 and RMSE), it can be concluded that the trained neural network is able to predict recovery rate.

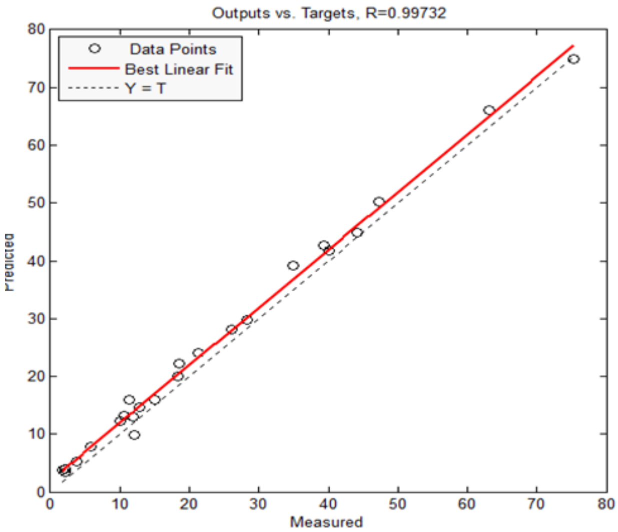

Figure 2. Recovery scatter diagram values measured in the laboratory and predicted by the neural network model in the control data sets

4- Conclusions

In this study, the artificial neural network was trained for the recovery of column leaching with the input parameters such as: particle size, column height, leaching time and flow rate of acid. The characteristic of this network is providing an appropriate model according to parameters affecting the recovery of copper during leaching. The results showed that the particle size, column height and flow rate of acids have a significant effect on copper recovery. The recovery of copper ore for particles finer than 25.4 mm in column heights of 2, 4 and 6 m are 78.63%, 66.27%, 52.88%, respectively. For particles finer than 50.8 mm, it is obtained 44.21%, 23.45% and 20.83%, respectively. Consequently, the copper recovery is considerably decreased when the column height increases from 2 m to 6 m.

5- Refrerences

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