Journal of Mineral Resources Engineering, 7(2): 123-138, (2022)

Imam Khomeini International University
Vol. 7, No. 2, Summer 2022

نشریه مهندسی منابع معدنی
Journal of Mineral Resources Engineering
(JMRE)

Research Paper

Effect of Galvanic Interaction Between Grinding Media and Sulfide Minerals on Grinding and Flotation Efficiency

Massinaei M.[1*], Namvar F.[2]

1- Associate Professor, Dept. of Mining Engineering, University of Birjand, Birjand, Iran
2- M.Sc, Dept. of Mining Engineering, University of Birjand, Birjand, Iran

Received: 06 Oct. 2020 **Accepted: 21 Nov. 2020**

Abstract: Galvanic interaction between sulphide minerals and grinding media has a pronounced impact on grinding (in terms of wear rate of balls and liners, energy consumption, product size and throughput) and flotation (in terms of surface products formed which affect mineral hydrophobicity) performance. The main objective of the current research study is to investigate the influence of electrochemical control on grinding and flotation performance. Laboratory tests were carried out on a representative sample taken from the Miduk copper concentrator plant feed under controlled electrochemical conditions. Laboratory grinding tests with different grinding media indicated that chromium balls not only resulted in the reduced grinding media wear in the mill, but also led to the improved flotation performance.The mass wear rate of steel balls was found to be 1.68 times of high-chromium balls. This is related to more oxidizing and alkaline conditions with higher oxygen concentrations in the presence of high-chromium balls. Addition of lime in the mill caused more oxidizing conditions (increasing the pulp Eh from 55.91 mV to 189.79 mV) with higher oxygen content (increasing the pulp DO from 2.44 ppm to 6.39 ppm) of the pulp which eventually resulted in higher flotation grade and recovery. Maximum copper recovery was observed when xanthate (Z11) and thionocarbamate (X231) collectors were added to the flotation cell, while the highest selectivity was achieved when the both collectors were fed directly into the mill. The more reducing grinding conditions and lower oxygen content of the pulp was related to oxidation of xanthate to dixanthogen when it was added into the mill.

Keywords: Galvanic interactions, Grinding media, Sulfide minerals, Flotation.

How to cite this article
Massinaei, M., and Namvar, F. (2022). *"Effect of galvanic interaction between grinding media and sulfide minerals on grinding and flotation efficiency"*. Journal of Mineral Resources Engineering, 7(2): 123-138.
DOI: 10.30479/JMRE.2021.14294.1452

*Corresponding Author Email: *mmassinaei@birjand.ac.ir*

INTRODUCTION

Grinding is the most energy-intensive operation in mineral processing plants. It has been estimated that about 50% of the energy consumed in the mineral processing plants is used in comminution [1]. Grinding media is one of the major operating costs in mineral processing plants, which can be up to 50% of the overall grinding costs [2].

Galvanic interactions between the grinding media and mineral particles has a significant influence on the gridning media consumption in the grinding mills. When the galvanic interaction occurs in the grinding mill, electrons are transfered from the anode (i.e. grinding media) to the cathode (i.e. cathodic mineral), resulting in the oxidation (corrosion) of grinding media and the reduction of oxygen according to the following reactions [3]:

Anodic oxidation of grinding media:

$$Fe + 2OH^- \rightarrow Fe\,(OH\,)_2 + 2e^- \quad (1)$$

$$Fe\,(OH\,)_2 + OH^- \rightarrow Fe\,(OH\,)_3 + e^- \quad (2)$$

Cathodic reduction of oxygen:

$$0.5O_2 + H_2O + 2e^- \rightarrow 2OH^- \quad (3)$$

Thus, the galvanic interactions in the grinding environment change the pulp potential (Eh), disolved oxygen content (DO) and pH of pulp which may affect the floatability of sulphide ores and the flotation performance. The corrosion of grinding media can reduce the dissolved oxygen content of pulp. The decrese of dissolved oxygen content can also hinder the successful adsorption of xanthate on the surface of sulfide minerals [4-9]. In this study, the effect of gavanic interactions between grinding media and sulfide minerals on the performance of grinding and flotation processes are investigated.

METHODS

The grinding and flotation teste were conducted on SAG mill feed sample of Miduk copper concentrator.

The SAG mill feed sample was first crushed to -2 mm in a jaw crusher and then further ground in a ball mill to d_{80}=100µm. Flotation experiments were conducted with Z11 (sodium isopropyl xanthate) and X231 (trithiocarbamate) as collector and A65 (polyglycol ether) and A70 (polyglycol ether) as frother. The froth samples were collected at 0.5, 2, 5 and 10 min time intervals. The feed, concentrate and tailing samples were filtered and dried and their copper content was determined. The pulp potential, dissolved oxygen level and pH were continuously measured during the griding and flotation tests. The pulp potential was measured using a Ag/AgCl electrode and reported versus the standard hydrogen electrode (SHE). The effect of griding media type (chromium and steel balls), lime addition strategy (in the mill and in the flotation cell) and distribution of Z11 and X231 collectors in the mill and in the flotation cell on the galvanic interactions between the grinding media and mineral particles as well as the flotation performance was studied.

FINDING AND ARGUMENT

Effect of grinding media type

The effect of grinding media type on ball wear rate during the grinding process is shown in Figure 1. The wear rate of chomium balls is much lower than steel balls especially in longer times. The results presented in Figure 2 indicate that the flotation performance is highly affected by the grinding media type. Higher copper recovery and concentrate grades were obtained after grinding the sample by the chromium balls. This can be related to more oxidizing conditions and higher oxygen level of pulp during the grinding of copper ore with the chromium balls (Figure 3).

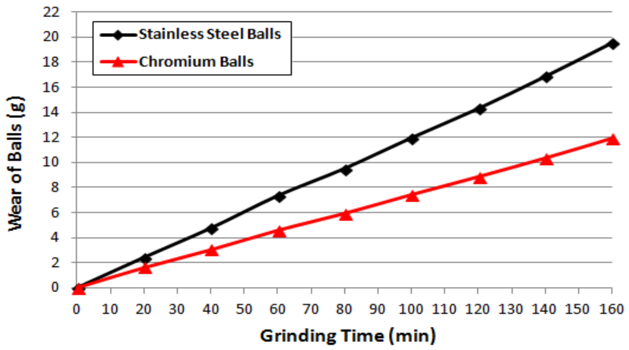

Figure 1. Effect of grinding media type on ball wear rate during grinding process

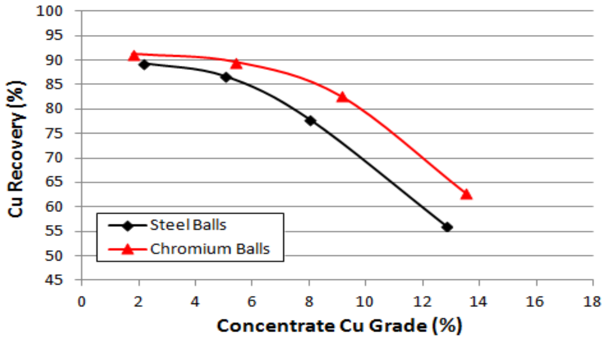

Figure 2. Effect of grinding media type on flotation performance

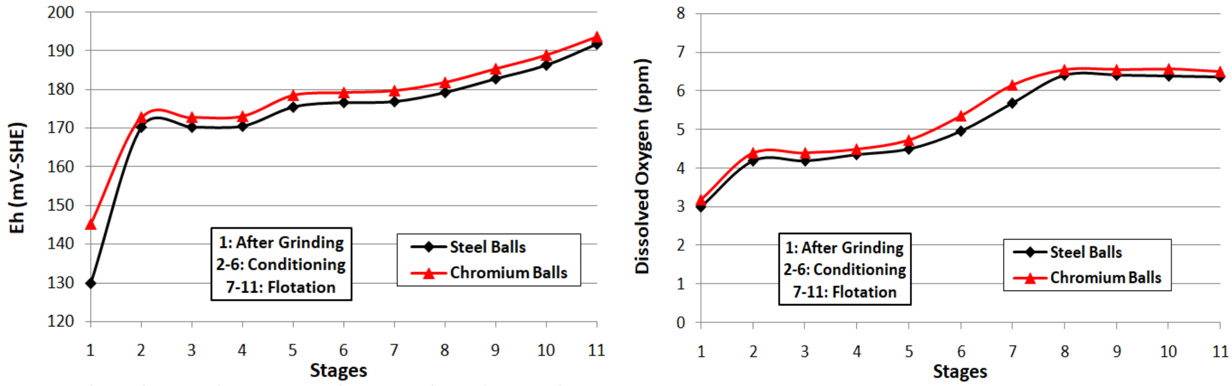

Figure 3. Effect of grinding media type on Eh and DO during grinding and flotation

Effect of lime addition strategy

The effect of lime addition strategy (in the mill and in the flotation cell) on the flotation performance is shown in Figure 4. Lime is a strong depressant for pyrite in flotation of sulfide minerals using xanthate collectors. Interestingly, the copper recovery and concentrate grade were improved substantially when the lime was added directly in the grinding mill to achieve alkaline conditions for the copper flotation. This can be ascribed to the reduced galvanic interactions between sulphide minerals and grinding media in the grinding mill owing to more oxidizing and oxygen-rich environment produced during grinding with lime which promotes the flotation performance (Figure 5).

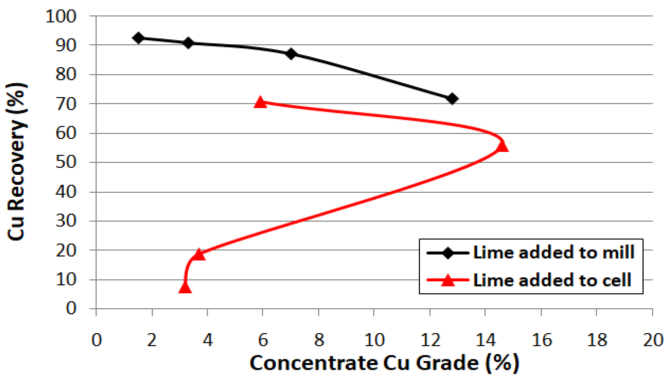

Figure 4. Effect of lime addition strategy on flotation performance

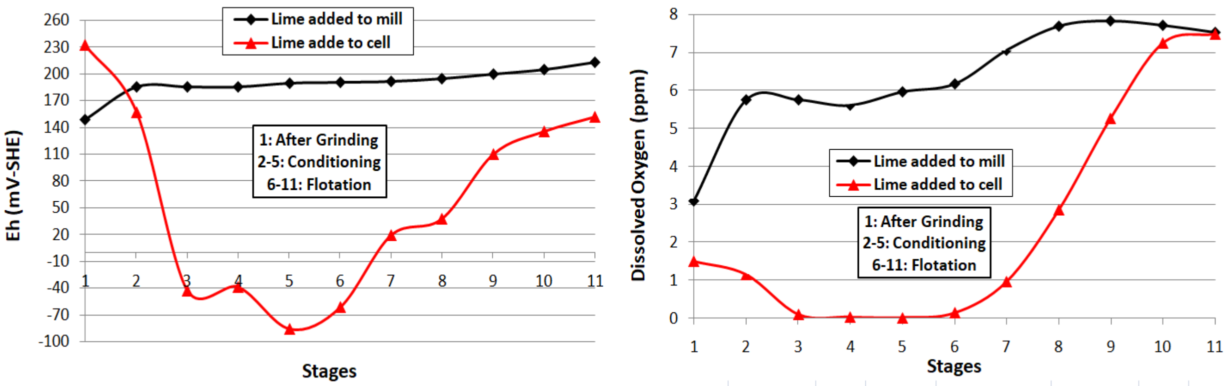

Figure 5. Effect of lime addition strategy on Eh and DO during grinding and flotation

Effect of collector distribution between grinding and flotation

The influence of collector distribution on the flotation performance in terms of the copper recovery and concentrate grade is presented in Figure 6. The variations in the pulp potential and dissolved oxygen content during the grinding and flotation tests are shown in Figure 7. It was found that the higher copper recovery was achieved when Z11 and X231 collectors were added into the flotation cell, while the highest selectivity (now shown) was yielded when the both collectors were fed directly into the mill. The more reducing grinding conditions and lower oxygen content of the pulp was related to oxidation of xanthate to dixanthogen when it was added into the mill.

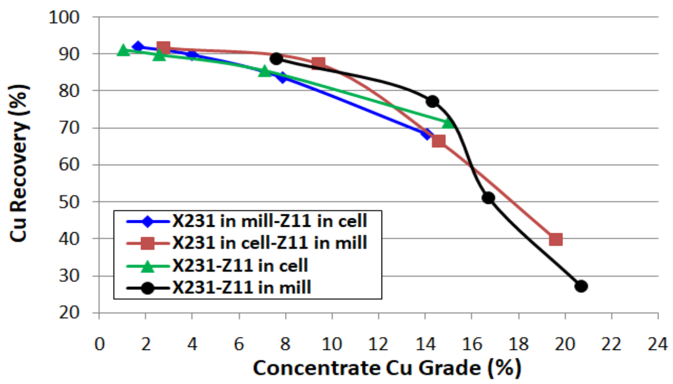

Figure 6. Effect of collector distribution on flotation performance

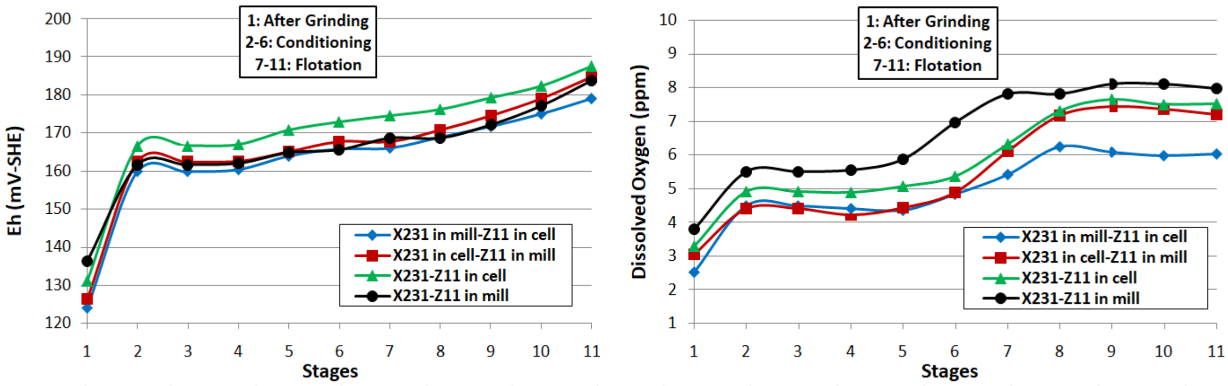

Figure 7. Effect of collector distribution on Eh and DO during grinding and flotation

CONCLUSIONS

The type of grinding media had a strong influence on the ball wea rate and and the flotation performance. The wear rate of chromium balls was much lower than steel balls. The flotation performance increased substantially as the chromium balls were added in the grinding mill. Lime added into the mill largely eliminated the galvanic interactions and improved the flotation performance. The optimum copper recovery was obtained when Z11 and X231 collectors were added into the flotation cell, while the highest selectivity was observed when the collectors were fed directly into the mill.

REFERENCES

[1] Wills, B. A., and Napier-Munn, T. J. (2006). *"Mineral processing technology"*. Elsevier Science & Technology Books.

[2] Rabieh, A., Albijanic, B., and Eksteen, J. J. (2016). *"A review of the effects of grinding media and chemical conditions on the flotation of pyrite in refractory gold operations"*. Minerals Engineering, 94: 21-28.

[3] Bruckard, W. J., Sparrow, G. J., and Woodcock, J. T. (2011). *"A review of the effects of thegrinding environment on the flotation of copper sulfides"*. International Journal of Mineral Processing, 100(1-2): 1-13.

[4] Greet, C. J., Small, G. L., Steinier, P., and Grano, S. R. (2004). *"The Magotteaux Mill investigating the effect of grinding media on pulp chemistry and flotation performance"*. Minerals Engineering, 17: 891-896.

[5] Leppinen, J. O., Kalapudas, R., and Heiskanen, K. (2000). *"Influence of grinding media on the electrochemistry of sulphide ore flotation"*. In: Electrochemistry in Mineral and Metal Processing,Woods, R., and Doyle, F. M. (Eds.), Electrochem. Soc, Pennington, USA, 1-12.

[6] Peng, Y., and Grano, S. (2010). *"Effect of grinding media on the activation of pyrite flotation"*. Minerals Engineering, 23: 600-605.

[7] Zanina, M., Lambert, H., and du Plessis, C. A. (2019). *"Lime use and functionality in sulphide mineral flotation: A review"*. Minerals Engineering, 143: 105922.

[8] Multani, R. S., Williams, H., Johnson, B., Li, R., and Waters, K. E. (2018). *"The effect of superstructure on the zeta potential, xanthate adsorption, and flotation response of pyrrhotite"*. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 551: 108-116.

[9] Yelloji Rao, M. K., and Natarajan, K. A. (1991). *"Factors influencing ball wear and flotation with respect to ore grinding"*. Mineral Processing and Extractive Metallurgy Review, 7: 137-173.