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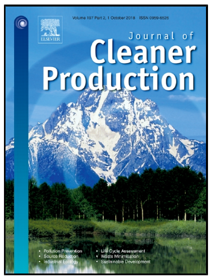

Enhancement of copper recovery by acid leaching of high-mud copper oxides: A case study at Yangla Copper Mine, China

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Enhancement of copper recovery by acid leaching of high-mud copper oxides: A case study at Yangla Copper Mine, China

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Abstract: Poor permeability, high mud and impurities contents, severe curing conditions and ore complexity are primary challenges faced by Yangla Copper Mine (YCM) during acid leaching, resulting in a poor 1 % copper extraction after 3 months of traditional leaching. A series of technological improvements, which included of antiscalant addition, ore washing, classified crushing and screening, thin-layer conveying and dumping, and mechanical/chemical activation, were applied in YCM to enhance heap permeability and copper extraction from low-grade copper oxides. These improvements increased copper extraction to over 60 and the production of cathode copper reached 2500 t/a. Related topics such as: ore surface erosion, particle size distribution, heap structure, irrigation rate, and passivation and its effects are also discussed in this study. Even though some of the relevant mechanisms for enhanced recovery are still being studied, this successful industrial case provides a good reference for copper oxide mines encountering similar problems.

Keywords: heap leaching; copper oxide ore; permeability; Yangla copper mine; case study; preferential flow

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1. Introduction

Hydrometallurgy has been widely applied in metal extraction from low-grade ores and wastes using heap leaching and other methods since the 1970s (Petersen, 2016, Yin et al., 2018) due to advantageous characteristics such as low cost, low environmental impact, and simplicity (Brierley, J. and Brierley, C., 2001). Hydrometallurgy plays a key role in recovering uranium (occupied 40 %), copper (occupied 25 %) and other critical metal resources around the world.

However, because ore characteristics such as mud and clay content, particle size distribution, bulk density, surface roughness and other characteristics can vary significantly. Differences in ore characteristics can lead to saturated and unsaturated regions co-existing inside ore heaps (Yin et al., 2013). Consequently, preferential flows in macro pores (Wu et al., 2009a; McBride et al., 2017) and slow-motion capillary driven flow as well as other types of flows (Yin et al., 2016) that are observed (Wu et al., 2009b) play a role that can lead to a poor and inhomogeneous extraction rate. Hence, to improve metal extraction rates, pursuing a better permeability and recovery during heap leaching have become among the most important parameters and ultimate targets. Thus, many relative investigations have been carried out to optimize process and leaching technology. Unlike alkaline leaching (Yin et al., 2018), it is easy to produce a large amount of insoluble substances and compaction during acid leaching. For instance, acid curing and agglomeration technology focused on copper oxide ores (Lu et al., 2017) and nickel laterites (Quast et al., 2013) were utilized to improve average heap permeability. Leaching of copper oxides under alkaline environment was also considered (Tanda et al., 2017). Design of gold extraction process has been enhanced based on a case-based reasoning system by some researchers (Rintala et al., 2017). To improve the permeability of oxide copper heap, the effect of sulfuric acid on hydro-mechanical properties is studied via friction angle, slake durability indices (Ghasemzadeh, et al., 2018). Optimization of flow rate and other characteristics have been performed by others (Mellado et al., 2011). Moreover, optimal design and planning of heap leaching was accomplished using mixed-integer nonlinear programming that was generated to control heap structure (Trujillo, et al., 2014). Also, enhance leaching of copper oxides is carried out using different acid solutions included of HCl, H_2SO_4 and $HNO_3$and its leaching mechanism is studied (Habbache, et al., 2009). Recently, potential effects of heap structure on metal extraction were common problems faced by researchers, and regulatory issues have attracted more and more attention (Hao et al., 2016). Curing and associated precipitation of compounds such as calcium sulfates can also be important in copper heap leaching (Dhawan et al., 2013). Mines around the world have evaluated and implemented strategies to mitigate the challenges associated with a variety of ore characteristics. For instance, to ease the compaction of ore heap, the technological methods are utilized in the Tuwu Copper Mine located in the Gobi Desert, in which the heap height is 2-4 m and percentage of fine ore is less than 8% (Liu et al., 2016, Ilankoon et al., 2018). Sarcheshmeh Copper Mine uses the sulfuric acid solution to extract copper from oxide ores in Iran (Shayestehfar et al., 2008), similarly, malachite-atacamite ore of Disele Copper Mine is rich in high-content of silca gangues and SiO_2, the sulphuric acid solution is used to extract valuable metal and main parameters such as particle size distribution, initial concentration of acid solution are studied (Lwambiyi et al., 2009). However, for the copper oxides heap with lower permeability, the systemic technological methods and innovations for industrial leaching chains are still insufficient.

Yangla Copper Mine is copper oxide mine located in the Yunnan Province, and it used to be faced with some challenges during the bioleaching operations and make it nearly closed. Based on the industrial leaching plant's technological experiments and records, the initial heap leaching was determined to be unsuccessful for the following reasons.