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Processing of Malachite from the Shigar Region of Gilgit-Baltistan by Optimizing Some Operational Parameters of Floatation.

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Abstract: In this study, optimal operation parameters for the extraction of copper (Cu) from malachite ore of the Shigar region of Gilgit-Baltistan were identified. The effects of some operational parameters on Cu recovery has been identified. The pulp density (25%) and other parameters are kept constant throughout the process. Crushing and grinding were carried out and obtained the desired size range of flotation. The sample of malachite ore has been overwhelmed using roll and jaw crushers. The final product of roll crusher was finer than that of jaw crusher. It has been observed that more fines were obtained with increasing grinding time. After a certain time, there is little effect on grinding. With decreasing particle size, copper recovery increased. At 50 µm the recovery is almost 90% while at 325µm, recovery decreased to 46%. With increasing pH copper recovery is increased and at 12.5% pH, maximum recovery (up to 90%) has been achieved. The optimum parameters for the copper extraction from malachite ore of the Shigar valley are the pH 12.5%, 50-micron particle size and grinding time of 25 minutes.

Keywords: Flotation, optimum parameters, recovery, malachite ore, copper.

Introduction

The Gilgit-Baltistan is rich in metals, gemstones and dimension stones. The village Shigar is situated in the Baltistan region of Pakistan. This region hosts a variety of gemstones. Recently a copper (malachite) containing deposit was identified. Malachite is most important oxidized ore of copper. The main source of copper production is malachite (Ata et al., 2001). The hydrometallurgical process is commonly used for the extraction of copper from low-grade ore (Künkül et al, 2013). The fine particles and particulate matters are efficiently separated by flotation method (Zamboulis et al., 2011). The grade of flotation and recovery process is mostly affected by different parameters (Taşdemir et al., 2007). Such parameters include particle size, bubble volume, solution pH, pulp density, concentration of the collector and time of conditioning. Several industrial processes have produced fine particles ranging from 100µm to 1µm (Albijanic et al., 2010). The feed size range has an effect on floatation recovery. A sharp size dispersion curve facilitates a higher extent of fragments in the middle size range, thus enhancing flotation restoration/recovery (Vashisth et al., 2011). Mahajan et al., (2011), measured the effect of particle size and found that the peak recovery is achieved at 10-100µm particle sizes (Mahajan et al., 2007). In a single pH solution, the action of two different particle sizes is different (Gupta et al., 2007) i.e. In a single pH change in particle size can affect the recovery. The maximum recovery of flotation, is possible at 7.4pH(Muganda et al., 2011). A particular flotation technique being used for the exclusion of fine-grained particles is the common flotation method (Zouboulis et al., 1997). Floatation recovery also depends on the particle and bubble collision, the particle size and the bubble size impact this collision (Tao, 2005). The coarser scale is good for the economic reason and the fine particles are typically superfluous in processing (Matis et al., 1993). With increasing particle size, collision rate decreases at a constant bubble size (Hassanzadeh et al., 2016). If the element magnitude is decreased in fraction to the bubble size, the collision rate remains unchanged (Tao, 2005). The sharpness of curve for the rod mill is greater in the size-based output curves than the ball mill (Fuerstenau et al., 2004). The copper recovery improved as leaching time and pH increased (Li et al., 2010). Lime is used to increase pH as it is cheaper than collectors and frothers (Clark and Newell, 2000). Copper recovery has also been influenced by the grinding period; copper recovery has increased with increasing grinding time (Bruckard et al., 2011). Different concentration units have a feed size range at which they are working efficiently. Similarly, during the flotation of different minerals in flotation cell, there is a pH range for the extraction of minerals from their ores. Different operational parameters of flotation depend upon the type of ore of copper. However, the selection of parameters is a secondary issue as compared to the recovery of copper. The main aim of this study is to reach the highest extraction of copper while optimizing some of the operational parameters of flotation for a specific ore of copper. Similarly, different processing units have a range of suitable size. This study aims to highlight a particular size within the feed size range of the flotation machine for a particular ore of copper. The control of pH is one of the most suitable methods for the modulation of flotation. There is a range of pH for the flotation of different minerals. This study aims to determine the range of pH while extracting copper from malachite ore and to determine the optimum value of pH for this ore.

Study Area

Shigar valley is located on the northern side of the Baltistan region and at the right side of Indus river. It is also known as the valley of K2. Geographically, it is situated between 25^{o}`25`32N and 75^{o}`42`58E and an altitude range of 2250 to 8611 meters above sea level. Geologically Shigar valley occupies partly southern margin of Karakoram plate and partly on the northern margin of Kohistan-Ladakh Island Arc (KLIA). Northern suture zone or main Karakoram thrust (MKT) is passing through the center of Shigar valley (Agheem et al., 2004). The rocks present are mainly metaigneous, metasediments and pegmatite dykes which belong to Karakoram Metamorphic Complex (Searle, 1991). According to Tahirkheli, (1982), meta-volcanic rocks of Rakaposhi complex are also occur in this area (Fig. 1). Various lithologic units have been recognized in this region such as Daltumbore, Bauma-Harel, Dassu gneiss and Katzarah formations (Hanson, 1989; Desio, 1963; Agheem et al., 2004).

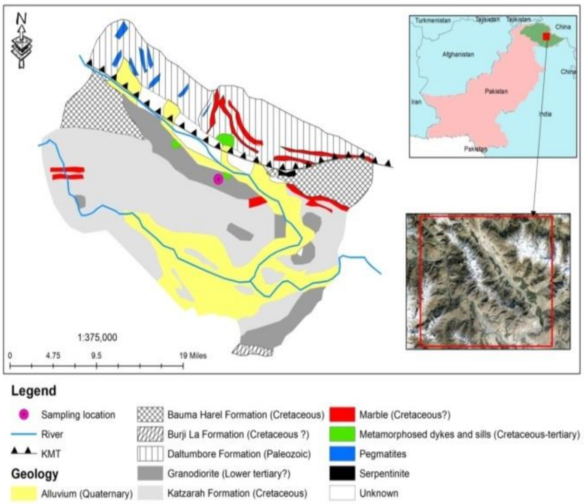

Fig. 1 Geological map of Shigar valley, Baltistan, Pakistan (after Hanson, 1988, 1989).

Materials and Methods

A malachite sample was selected from the Shigar district, Gilgit-Baltistan Pakistan. The specimen was crushed using a jaw and roll crusher and fine products were collected. The sieve analysis of crusher products has been done. Disparate dimension-based productivity curves were drawn and then the capability of the liberation process was calculated. The product of rod mill has been used in the Denver D12 flotation machine. The specimen was divided into two parts by the Rifle box. One is for a head sample's chemical analysis (500 g) and the other is for floatation (1500 g). Atomic absorption spectrometer (AAS) was used to determine the percentage of copper. The percentages of SiO_2 and Fe were assessed by using the gravimetric method and the titration process. For boost flotation, the influence of pH, particle size and grinding time on recovery of copper was examined. Through changing the grinding time, the specimen was ground in the rod mill. Such specimens were tested to assess the recovery of copper in a flotation device were plotted. Various curves against recovery for particle size, grinding time and pH and their effect on Cu recovery was also investigated. The malachite ore was crushed and ground for achieving the size range of flotation. Within the size range, there should be a size that gives maximum recovery of copper.

The ore sample of copper must be crushed to accomplish the required fraction for the flotation test. Two crushing measures (jaw and roll crushers) were considered (Figs. 2 and 3).

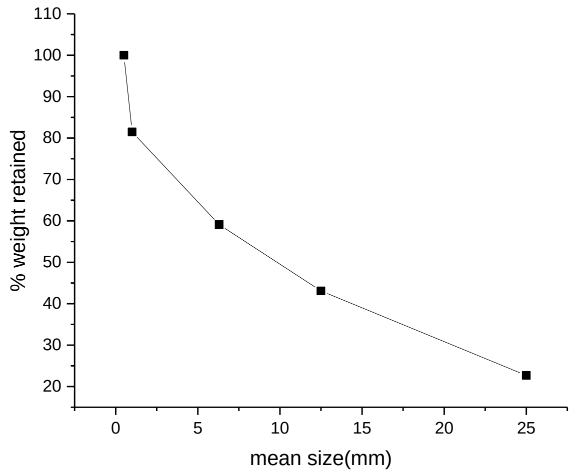

Fig. 2. Particle size curve for jaw crusher

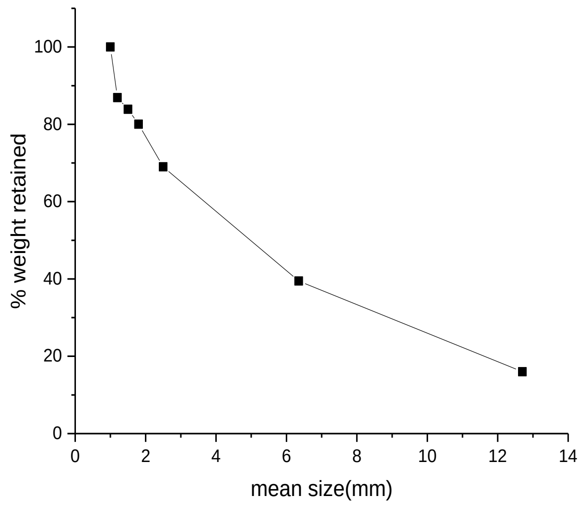

Fig. 3 Particle size curve for roll crusher.

It is observed that, the d_{50} of roll crusher is less than that of jaw crusher. It means that the roll crusher's size-based performance exceeds the jaw crusher. Figure 2 reveals that 80% of the sample which is crushed using a jaw crusher is less than 5 mm while in roll crusher it is less than 3 mm. To achieve the required size of floatation grinding is performed using a rod mill.

The sample has been grounded to achieve the appropriate size and acceptable degree of freedom for floatation tests. The influence of grinding time on fines is shown in Figure 4. The number of fines passing through 70 µm is increased with increasing grinding time. The particles were getting fines with increasing grinding time. The 20 minutes gave the finest grinding 61.1 %, followed by 15 minutes (43.9%), 10 minutes (37%) and 5 minutes (21.1%), respectively passing through 70 microns.

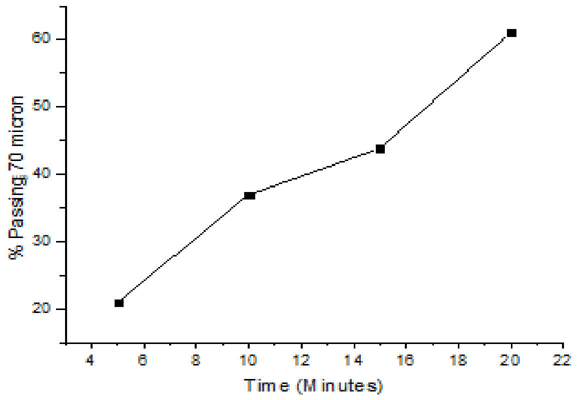

Fig. 4 Effect of grinding time on particle size.

Results and Discussion

Based on maximum recovery of copper some of the parameters like particle size, pH and grinding time were optimized using malachite ore of the Shigar region of Gilgit-Baltistan.

Optimization of Particle Size

The size-based partition curve gives information about the size value which maximizes the copper recovery. The particle size of 50 µm yields the maximum recovery of copper (Fig. 5). In this study, 50 µm is the feed size of flotation which maximizes the recovery of copper. This indicates that the decreasing particle size enhances the probability of attachment of particles with air bubbles.

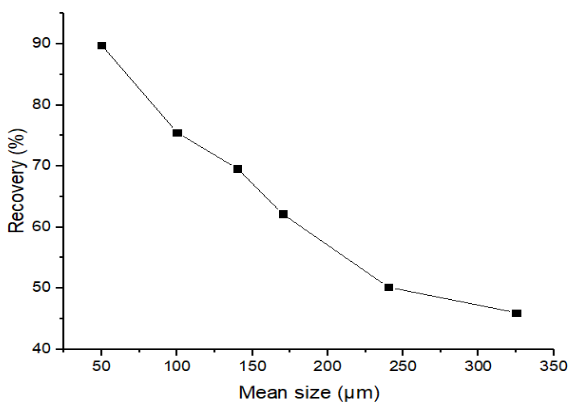

Fig. 5 Recovery of copper as a function of particle size.

Optimization of pH

The results reveal that 49% of copper is achieved at pH value of 8 (Fig. 6), suggesting a large loss of copper in tailing. Copper recovery increased significantly at pH 12.5 up to 90 percent. This suggests that with the increasing value of pH, the recovery of copper from malachite ore is improved. The optimal flotation for malachite ore has been achieved with a pH range of 10-12.5. The increasing pH (using lime) has no such effect on copper as a depressant. However, for sulfide minerals, the increasing pH value decreased the concentration of copper.

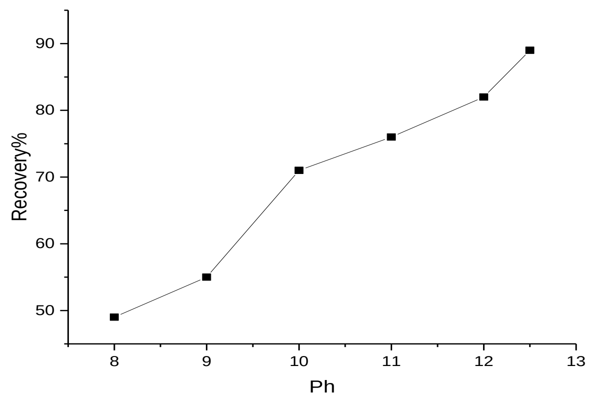

Fig. 6 Recovery of copper as a function pH.

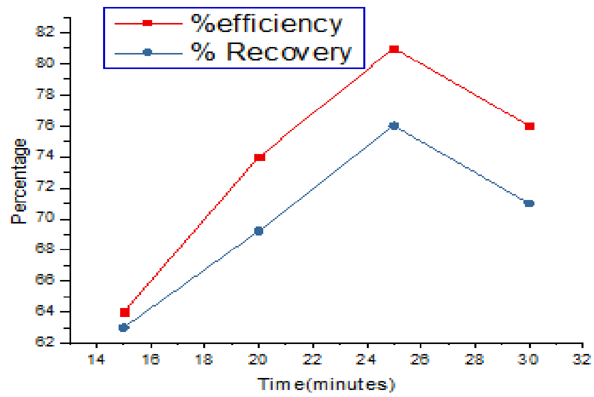

Fig. 7 Recovery of copper as a function of grinding time

Optimization of Grinding Time

Figure 7 shows how much copper recovery is influenced by grinding time. With 25 minutes increase in grinding time, about 80% of copper recovery is increased. This is due to excessive concentrations of fine particles. Such fine particles can be regarded as a flotation negative factor. This means that it is possible to spend too much energy to improve the grinding time. The sample of malachite ore can be ground up to 25 minutes to touch the anticipated degree of liberty. Hard material like copper slags needs a lot of grinding time in order to achieve optimum particle fraction for the process of flotation. At grinding time of 25 minutes, 80% of copper-bearing minerals are released. The optimal grinding time for malachite ore is 25 minutes. As the grinding time increases, the size is decreased and it remains unchanged at a certain size range. The size range achieved with grinding time is 50 µm – 250µm.

The separation efficiency and recovery both are increased with increasing grinding time. This may be due to the higher liberation. However, at a particular grinding time, the recovery is decreased.

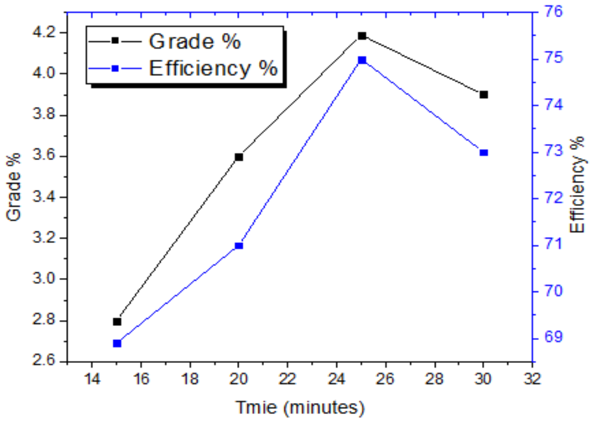

Fig. 8 Effect of grinding time on grade.

Figure 8 shows the effect of grinding time on the grade of Cu and the efficiency of separation. As grinding time increases, grade and separation efficiency are increased. At 25 minutes, maximum grade and separation efficiency were achieved. After this time grade and separation efficiency, is decreased. This may be the increase of fines which can create problems in the separation of ore and gangue. The optimal grinding time for this study was considered as 25 minutes.

Conclusion

Based on maximum recovery and separation efficiency following separation parameters of flotation may be recommended for this deposit. Copper recovery is 80 percent at a grinding time of 25 minutes. The recovery is reduced after 25 minutes. It indicates that a large number of fine particles to be recorded for tailing. With increasing grinding time, the particle size decreased. The particle size remains unchanged at a particular size and the increasing value of grinding time does not affect after this size. The grinding time of 25 minutes may be considered as optimum for this deposit. Secondly, an increase in particle size results in the reduction of recovery. Copper recovery is 56% at 385 µm. The recovery improved at 50 µm particle size to a maximum value of 90%. From this behaviour, it can be concluded that for fine particles the probability of attachment of particles with air bubbles is higher than coarser particles. This is the reason why 50-micron size particles result in more recovery than coarser sizes. Based on this study the pH range for malachite ore of the same composition is 6-13. Similarly, the feed size range of the same composition malachite ore range is 80-250µm. It can be concluded that the optimum pH for copper flotation is considered as 12.5%.

References

Albijanic, B., Ozdemir, O., Nguyen, A. V., Bradshaw, D. (2010). A review of induction and attachment times of wetting thin films between air bubbles and particles and its relevance in the separation of particles by flotation. *Advances in Colloid and Interface Science*, **159** (1), 1-21.

Ata, O. N., Çolak, S., Ekinci, Z., Çopur, M. (2001). Determination of the optimum conditions for leaching of malachite ore in H_2SO_4 solutions. *Chemical Engineering & Technology: Industrial Chemistry Plant Equipment Process Engineering Biotechnology*, **24**(4), 409-413.

Bruckard, W., Sparrow, G., Woodcock, J. (2011). A review of the effects of the grinding environment on the flotation of copper sulphides. *International Journal of Mineral Processing*, **100**(1-2), 1-13.

Clark, D. W., Newell, A. J. H. (2000). Reduction of pH modifying agent in the flotation of copper minerals: Google patents.

Desio, A. (1963). Review of the geological formations of the western Karakoram (Central Asia). *Rivista Italiana de Paleontologia e Stratigraphia.*, **69**, 475-501.

Fuerstenau, D., De, A., Kapur, P. (2004). Linear and nonlinear particle breakage processes in comminution systems. *International Journal of Mineral Processing*, **74**, S317-S327.

Gupta, A. K., Banerjee, P., Mishra, A., Satish, P. (2007). Effect of alcohol and polyglycol ether frothers on foam stability, bubble size and coal flotation. *International Journal of Mineral Processing*, **82**(3), 126-137.

Hanson, C. R. (1986). Bedrock geology of the Shigar valley area Skardu, northern Pakistan. Dartmouth College, New Hampshire.

Hanson, C. R. (1989). The northern suture in the Shigar valley, Baltistan, northern Pakistan. In: Tectonics of the Western Himalaya. *Geol. Soc. Am. Spec. Paper*, **232**, 202-216:

Hassanzadeh, A., Hassas, B. V., Kouachi, S., Brabcova, Z., Celik, M. S. (2016). Effect of bubble size and velocity on collision efficiency in chalcopyrite flotation. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, **498**, 258-267.

Künkül, A., Gülezgin, A., Demirkiran, N. (2013). Investigation of the use of ammonium acetate as an alternative lixiviant in the leaching of malachite ore. *Chemical Industry and Chemical Engineering Quarterly/CICEQ*, **19** (1), 25-35.

Li, C., Xie, F., Ma, Y., Cai, T., Li, H., Huang, Z., Yuan, G. (2010). Multiple heavy metals extraction and recovery from hazardous electroplating sludge waste via ultrasonically enhanced two-stage acid leaching. *Journal of Hazardous materials*, **178** (1-3), 823-833.

Agheem, M. H., M. T. S. T. (2004). Gem bearngpegmatites of Shigar valley, Skardu northern Pakistan. *Geol. Bull. Univ. Peshawar*, **37**, 167–178.

Mahajan, V., Misra, M., Zhong, K., Fuerstenau, M. (2007). Enhanced leaching of copper from chalcopyrite in hydrogen peroxide–glycol system. *Minerals Engineering*, **20** (7), 670-674.

Matis, K., Gallios, G., Kydros, K. (1993). Separation of fines by flotation techniques. *Separations Technology*, **3** (2), 76-90.

Muganda, S., Zanin, M., Grano, S. (2011). Influence of particle size and contact angle on the flotation of chalcopyrite in a laboratory batch flotation cell. *International Journal of Mineral Processing*, **98** (3-4), 150-162.

Searle, M. P., Tirrul, R. (1991). Structural and thermal evolution of the Karakorarn crust,. *Jour. Geol. Soc. London*,**148**, 65–82. https://doi.org/10.18306/dlkxjz.2018.11.010

Tahirkheli, R. A. K. (1982). Geology of the Himalaya, Karakorum and Hindukush in Pakistan,. *Geol. Bull. Univ. Peshawar*,**15**, 51p.

Tao, D. (2005). Role of bubble size in flotation of coarse and fine particles—A review. *Separation Science and Technology*, **39** (4), 741-760.

Taşdemir, A., Taşdemir, T., Öteyaka, B. (2007). The effect of particle size and some operating parameters in the separation tank and the downcomer on the Jameson cell recovery. *Minerals Engineering*, **20** (15), 1331-1336.

Vashisth, S., Bennington, C. P., Grace, J. R., Kerekes, R. J. (2011). Column Flotation deinking: State-of-the-art and opportunities. *Resources, Conservation and Recycling*, **55** (12), 1154-1177.

Zamboulis, D., Peleka, E. N., Lazaridis, N. K., Matis, K. A. (2011). Metal ion separation and recovery from environmental sources using various flotation and sorption techniques. *Journal of Chemical Technology & Biotechnology*, **86**(3), 335-344.

Zouboulis, A., Matis, K., Lanara, B., Loos-Neskovic, C. (1997). Removal of cadmium from dilute solutions by hydroxyapatite. II. Flotation studies. *Separation Science and Technology*, **32**(10), 1755-1767.