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Original Article

Recovery of kaolinite from tailings of Zonouz kaolin-washing plant by flotation-flocculation method

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A B S T R A C T

The traditional processing of kaolin is achieved by dispersion of the mined ore and classification by multistage hydrocyclone plants. The inefficiencies inherent to cyclones produce a middling product that is commonly disposed back into the quarry. In this research, recovery of kaolinite from tailings of Zonouz kaolin washing plant, which is located in Iran was investigated by flotation and flotation- flocculation. Flotation experiments show that the flotation of kaolinite from the tailings is better in an acidic than in an alkaline medium containing cationic collectors. Flotation under acidic condition causes problems such as equipment corrosion at industrial scale. As a result, the cationic flotation of kaolinite is enhanced by addition of polyacrylamide as a flocculant. The results showed flocculation by polyacrylamide improved flotation of kaolinite within a range of pH. With 300 g/t dodecylamine, 500 g/t aluminum chloride, 50 g/t pine oil (frother), 15 g/t polyacrylamide, at pH = 7 and without de-slimming a product has 37.19% Al_2O_3, 54.19% SiO_2 and 34.43% mass recovery was archived.

1. Introduction

In general, kaolin is upgraded by physical methods such as water-washing or froth flotation. Kaolin particles are predominantly below 25 μm and are flat shaped particles. The industrial separation is commonly achieved by the dispersion of the mined ore and classification using multistage hydrocyclones. The kaolin reports to the overflow which is then reprocessed in other smaller cyclones. Due to inefficiencies associated with hydrocycloning, most plants are not able to produce clean kaolinite products and after the 4th or 5th hydrocyclone stage, the underflow cannot be separated further. The underflow is disposed as waste or sold cheaply to the cement industry and brick-manufacturing or used as back fill in the quarry [1–5].

Zonouz mine, which is located in eastern Azerbaijan Province, has the only kaolin-washing plant in Iran. The plant has a considerable amount of tailings containing about 15% Al_2O_3. The tailings mineralogical constituents are quartz,

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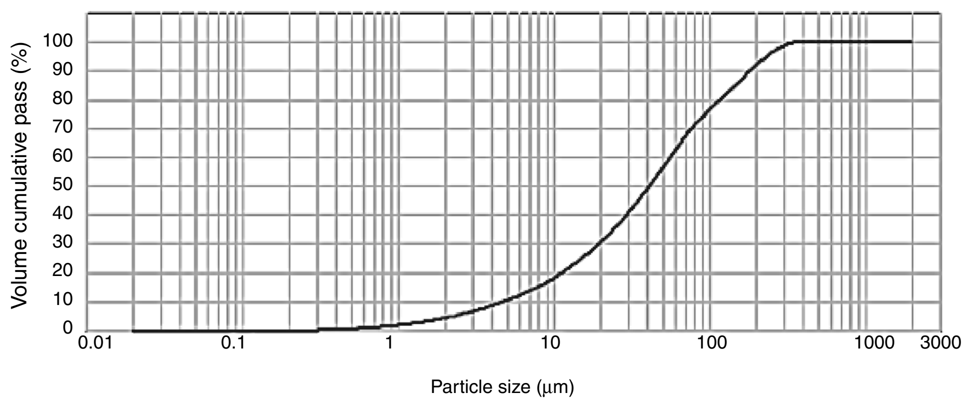

Fig. 1 – Particle size distribution of the tailing sample by laser diffraction.

kaolin and iron oxide. The tailing has fine particles (100% finer than 100 μm and about 30% finer than 20 μm); the fine particles can be easily dispersed by wind and settle down by rain and snow. Without treatment or recycling, the tailing would cause environmental pollution. It is important to re-evaluate the tailings because of economic and environmental causes. The evaluation will be economically feasible since it will not require additional mining cost. Kaolinite can be retrieved from the tailings by using flotation. However, flotation of kaolinite from the tailing is difficult because kaolinite and quartz, the two main minerals in the tailings, have the same flotation behavior.

Point of zero charge of quartz is at pH = 1.8 and zeta-potential of kaolinite is negative in a wide range of pH values, then both minerals can be floated by amine collectors in acidic and alkaline medium [6–8].

Many studies have been carried out on kaolinite flotation (pure samples) by cationic collectors such as ether diamine, hydroxyl-alkyl-diethanolamine, Cetylpyridinium chloride, cetyltrimethylammonium bromide, and dodecylamine. The results of these studies showed that kaolinite flotation by cationic collectors is better in acidic an environment than in a alkaline environment [7–13]. Yuehua et al. [11] tried to increase kaolinite recovery in alkaline medium by using a macromolecule as a flocculant. Without polyacrylamide, the kaolinite recovery decreased from 70 to 15%, with increasing the pH from 2 to 10. But, with polyacrylamide as a flocculant, kaolinite recovery increased under both acidic and alkaline environments [11].

Comparison of flotation of kaolinite and quartz show that two collectors (dodecylamine and EDA Flotigam) and two quaternary ammonium salts (Cetylpyridinium chloride and cetyltrimethylammonium bromide) are among the most effective collectors for floating both kaolinite and quartz. But, the time required for kaolinite flotation is 5–10 times that for the quartz flotation, depending on the type of the collector [10].

The purpose of the present study is to investigate the recovery of kaolinite from tailings of kaolin washing plants using flotation and flotation-flocculation.

2. Experimental

2.1. Material

Samples used in this study were taken from the tailing dam of Zonouz kaolin washing plant in East Azerbaijan Province, Iran. The particle size distribution of the representative sample was carried out by laser diffraction (Fig. 1). It is observed that the percent passing 100 μm and 50 μm is respectively 100% and 50% and more than 30% of the particles were smaller than 20 μm (slime particles).

According to the mineralogical analyses by X-ray diffraction, it was found that the sample contains quartz, kaolinite and calcite as the main minerals, and muscovite, biotite, montmorillonite and iron-rich epidote as the minor minerals. Chemical composition of the sample is given in Table 1.

2.2. Flotation experiments

Flotation experiments were carried out in a 1000 cm^3 conventional laboratory cell (Denver model), at 25% solids ratio and agitation rate was 850 rpm. The suspension was added to the flotation cell and conditioned for 5 min. The pH was adjusted to a desired value by adding NaOH or H_2SO_4. Cetylpyridinium

Table 1 – Chemical composition of the sample.

Composition	%	Composition	%
SiO_2	74.67	CaO	1.74
Al_2O_3	15.35	SrO	>0.01
K_2O	0.25	P_2O_5	>0.01
SO_3	0.11	MgO	>0.01
Fe_2O_3	0.33	loss on ignition	7.54

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