Minerals Engineering 45 (2013) 142–145

Contents lists available at SciVerse ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Flotation of fluorite from ores by using acidized water glass as depressant

Wenbo Zhou [a], Josue Moreno [b], Roberto Torres [b], Hector Valle [b], Shaoxian Song [c,*]

[a] Hubei Key Laboratory for Efficient Utilization and Agglomeration of Metallurgic Mineral Resources, Wuhan University of Science and Technology, Wuhan, China
[b] Mexichem Fluor S.A. de C.V., San Luis Potosi, Mexico
[c] Instituto de Metalurgia, Universidad Autonoma de San Luis Potosi, San Luis Potosi, Mexico

ARTICLE INFO

Article history:
Received 24 October 2012
Accepted 19 February 2013
Available online 27 March 2013

Keywords:
Froth flotation
Nonmetallic ores
Flotation depressants

ABSTRACT

The flotation of fluorite from ores by using acidized water glass (AWG) as depressant has been studied for the substitution of the commonly used depressant (soda ash plus sodium lignosulfonate). The experimental results have shown that the flotation with AWG could considerably improve the sedimentation rate of fine particles in tailing slurry and thus produce cleaner recycled water, compared with the actual depressant. Also, it improved fluorite recovery and flotation rate. In addition, it has been found that AWG could achieve higher selectivity between fluorite and gangue minerals (carbonate and silicate minerals) in fluorite flotation.

1. Introduction

Fluorite flotation is usually realized with sodium lignosulfonate as depressant and fatty acid as collector at a high pH (Crozier, 1992; Ayhan et al., 2006). In the case where feed ores contain a significant amount of fine particles, the sedimentation rate of fine particles was found to be significantly slow due to the effective dispersion of the fine particles when lignosulfonate was used resulting in a high-turbidity of recycled water in the flotation circuit. It happened to the Las Cuervas fluorite concentration plant (which is attached to the Mexichem Fluor Corporation and located in the San Luis Potosi state of Mexico), leading to a poor separation efficiency. Therefore, there is a great significance to find out an alternative chemical scheme to solve this problem.

The mechanism for the poor sedimentation of particles in the tailing slurry might be due to the strong ability of sodium lignosulfonate to effectively disperse fine particles at high slurry pH. Conley (1996) and Lu et al. (2005) have shown that sodium lignosulfonate acts as an effective dispersant in aqueous suspensions through steric repulsion. The majority of the minerals in aqueous solutions at pH value over 9.5 are highly negatively charged (Kosmulski, 2011), resulting in a strong electric double layer between particles in aqueous mineral suspensions causing repulsion between particles (Lu et al., 2005). The use of an inorganic depressant at neutral or weak-acidic conditions may improve sedimentation of fine particles in fluorite flotation as the particles are not so negatively charged.

Numerous reports have concerned the development of alternative depressants for improving fluorite flotation (Marinakis and Shergold, 1985; Yuehua et al., 2003; Pearse, 2006; Kienko et al., 2010). For instance, water glass as depressant and fatty acid as collector was used for fluorite flotation (Sun et al., 2012). Salted copper sulfate was presented to be an effective depressant for phosphate minerals in fluorite flotation (Zhang and Song, 2003). Acidized sodium silicate showed to be an alternative depressant for carbonate minerals at a neutral pH (Zhou and Lu, 1992; Ding and Laskowski, 2006). As acidized sodium silicate (water glass) is an inorganic reagent and works in neutral or weak-acidic media, it might be a good alternative depressant for sodium lignosulfonate in fluorite flotation.

The objective of this work was to develop a better chemical scheme to improve the separation of gangue minerals in fluorite flotation and the clarity of the recycled water for the Las Cuervas concentration plant. The study included the comparisons of two different chemical schemes, the incumbent of sodium lignosulfonate and soda ash which is currently used and acidized water glass. The comparison examined the coagulation of tailing slurry, flotation rate and separation efficiency.

2. Experimental

2.1. Materials

The ore sample used in this work was collected from the feed ore of the fluorite flotation circuit in the Las Cuervas concentration plant. The ore sample consisted of fluorite, quartz, calcite and clay minerals. The head grade for the sample was determined to be 75.08% CaF_2, 5.01% $CaCO_3$ and 9.69% SiO_2. The particle size distribution of the sample was determined by using standard

* Corresponding author. Address: Instituto de Metalurgia, Universidad Autonoma de San Luis Potosi, Av. Sierra Leona 550, San Luis Potosi, CP 78210, Mexico.
E-mail address: shaoxian@uaslp.mx (S. Song).

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http://dx.doi.org/10.1016/j.mineng.2013.02.017

Table 1
Process conditions for the actual scheme and new scheme.

	Reagent and dosage (g/ton)				pH
	Soda ash	Sodium lignosulfonate	AWG	PQM-1907	
Actual scheme	2000	800		800	9.5
New scheme			500	800	6.2

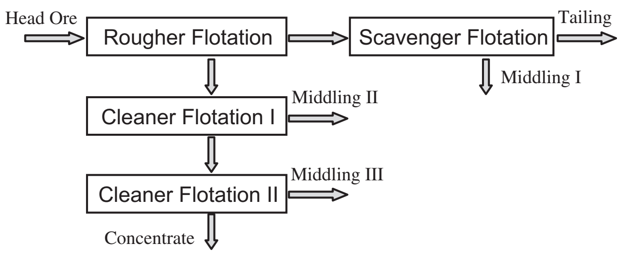

Fig. 1. Flowsheet of the fluorite flotation tests.

sieves, showing that the d_{30}, d_{50} and d_{80} (diameter at the cumulative undersize of 30%, 50%, and 80%) was 18, 39 and 150 μm, respectively.

Water glass from Silicatos y Derivados (Mexico) was used, which has the SiO_2:Na_2O ratio of 2.8 and a purity of 99%. Sodium lignosulfonate from the BARMEX (Mexico) with purity of 55% was also used. Commercial product PQM-1907 (a fatty acid mixture) from the Productos Químicos Monterrey (Mexico) was used as collector. Soda ash from the Productos Alcali (Mexico) and sulfuric acid from the Agricel (Mexico) were used as modifiers, which had the purities of 99% and 98%, respectively.

The water used was the potable water in the San Luis Potosi city, Mexico.

2.2. Preparation of acidized water glass

The AWG solution was prepared by mixing two solutions of 9% w/w of sulfuric acid and 10% w/w of water glass in a volume ratio of 1:1. After mixing the solution was conditioned for 1 h on a magnetic stirrer.

2.3. Flotation tests

Flotation tests were carried out using a Denver laboratory flotation cell. Tests were conducted at a solid content of 25%. The chemical reagents were added to the cell and condition for 10 min before flotation. The chemical scheme where AWG was used as depressant was termed as the new scheme and that where soda ash and sodium lignosulfonate was used was termed as the actual scheme. Process conditions for each reagent suite are given in Table 1.

The flowsheet of the flotation test is illustrated in Fig. 1. First, rougher flotation with the reagents and the dosages was performed in 5 min. Then, the rougher concentrate was upgraded by cleaner flotation I and II in sequence without any reagent addition in the flotation time of 3 and 2 min, respectively, producing one final concentrate and two middlings (middling II and III). The rougher tailing was treated by scavenger flotation without any reagent addition in 5 min, producing middling I (froth product) and final tailing. All of the five products were thermally dried, weighed and analyzed chemically. Each test was repeated two times. The arithmetic averages of the grade and recovery of the products from the two tests were reported in this paper. The errors for the grade and recovery were controlled in the range of ±0.3% and ±3%, respectively.

3. Results and discussions

Fluorite flotation tests were carried out with the actual and new schemes. Fig. 2 showed the photographs of the tailing slurries after being settled for 96 h from the flotation test with the actual scheme and being settled for 2 h from the test with the new scheme. With the actual scheme (Fig. 2a), 96 h of sedimentation did not produce clarified water in the tailing slurry, indicating a very high dispersive stability. However, sedimentation was different with the new scheme. It set down completely during 2 h, produced a large amount of quite clarified water on the upper part

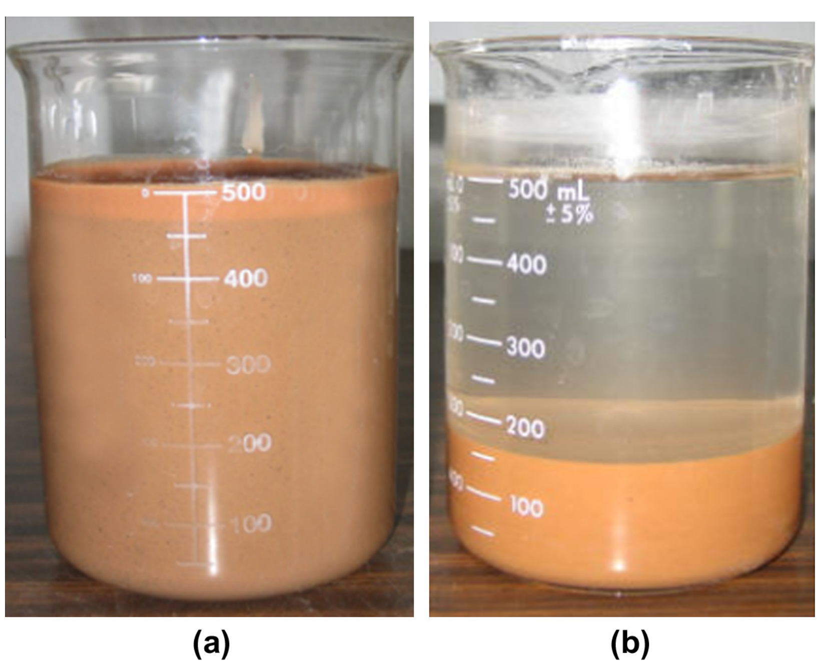

Fig. 2. The photographs of the sedimentation of tailing slurries. (a) Slurry after being settled for 96 h from the test with the actual scheme and (b) slurry after being settled for 2 h from the test with the new scheme.