

FLOTATION PROCESSING OF COPPER-MOLYBDENUM ORE USING A COMBINED FLOTATION REAGENT

Received – Primljeno: 2021-07-01

Accepted – Prihvaćeno: 2021-09-20

Preliminary Note – Prethodno priopćenje

The paper presents the results of laboratory studies on the flotation of copper-molybdenum ore from the Kazakhstani deposit using a combined reagent. A combination of butyl xanthate, a nonionogenic collecting agent with a thioamide group – TC-100 thionocarbamate and higher aerofloat (Reafloat series) was used as a combined flotation reagent. The ratio of the components of the combined reagent was, in %: 85:15:5. The combined flotation reagent was preliminarily passed through a T18 digital ULTRA-TURRAX disperser before flotation to obtain a reagent microemulsion. The use of a microemulsion of a combined reagent increases the extraction of copper into the copper-molybdenum concentrate by 3,69 %, the extraction of molybdenum by 6,05 %.

Keywords: copper-molybdenum ore, flotation, dispergation, concentration, extraction

INTRODUCTION

As the deposits are depleted and the need arises to involve poor, finely disseminated ores in processing, it becomes necessary to improve the reagent modes of enrichment of copper ores, the use of additives and reagent compositions, the use of modernized equipment [1, 2]. Increasing the extraction of useful components in the concentration can be achieved with flotation enrichment methods, using different reagent modes. Different combinations of collecting agents can be used to obtain higher process values. The efficiency of flotation enrichment is determined by improvements in the reagent mode and the use of flotation reagents, given that flotation is the main method of extraction of non-ferrous metals [3]. Studies were conducted on the effectiveness of the anabasinium, a new “PS” flotation reagent, in the flotation of sulfide copper ores in open and closed cycles. The obtained results confirm that the use of the new “PS” flotation reagent increases copper extraction into the concentrate by 0,87 % compared to the figure obtained when using the traditional flotation reagent - butyl xanthate [4].

New complexing reagents for the flotation of sulfide ores of non-ferrous metals - monohydroxyamide and monohydrazide of alkenyl succinic acid obtained by the reaction of alkenyl succinic anhydride with the corresponding nucleophilic agent are proposed. Complexes of 2-ethyl-hexenylsuccinic acid mono-hydroxyamide

and monohydrazide with nickel and copper have been synthesized.

Comparison of the results obtained using the proposed reagents and aerofloat suggests the promising use of such bifunctional compounds as collecting agents in sulfide ores flotation [5].

Improved flotation efficiency can be achieved by using a combination of different collecting agents. The effect of the proportion of sulphhydryl ionogenic collecting agent butyl xanthogenate or isobutyl dithiophosphate in combination with thionocarbamates; the proportion of butyl xanthogen in combination with sulphhydryl M-TF collecting agent (combination of thionocarbamate and dithiophosphate) on flotation rate of base metal minerals was studied.

The effect of phosphorus-containing sulphhydryl collecting agents on the flotation of refractory, difficult-to-enrich sulfide copper ores was studied. Tests were conducted with collecting agents: Berafloat 3026, Berafloat 40, Berafloat 3035, Aerofloat 308, Aerofloat 238, BTF 1552, BTF 1517, BTF 163. Butyl xanthate was used as a reference. The selectivity of copper recovery and loss of copper to tailings were compared. The best results were obtained when using collecting agents based on dialkyldithiophosphate BTF 1517 [6, 7]. The authors of the article have experience in the development and testing of enrichment schemes using various modified reagents (foaming agents, collecting agents, depressants) and additional equipment to intensify flotation processes. Technologies to process technogenic raw materials have also been developed, which make it possible to reduce the loss of useful components in tailings, reduce the cost of reagents, and reduce the flotation time [8, 9].

L. Semushkina (syomushkina.lara@mail.ru), G. Abdykirova, D. Turysbekov, S. Narbekova, Zh. Kaldybaeva, A. Mukhamedilova, Satbayev University, Institute of Metallurgy and Ore Benefication, Almaty, Kazakhstan

MATERIALS AND METHODS

The initial ore was crushed in a laboratory jaw crusher to $-2,5 + 0$ mm and ground in a laboratory ball mill to a 94 % class of $-0,074$ mm for the purpose of the study. Sieve analysis was performed to determine the particle size distribution of the crushed and milled ore on a set of wire sieves with square holes corresponding to a standard scale. The ore charge was 500 grams. Copper and molybdenum content and distribution were determined in each size class. Dispersive analysis was performed on the milled ore on a photometric sedimentometer FSKh-6K.

Flotation studies were performed on laboratory flotation machines with chamber volumes of 3; 1,0; 0,5 liters. The mass of the ore charge was 1 kg. Experiments were performed in open and closed cycles. The flotation scheme included grinding, main flotation, control, and three cleaning operations of the collective copper-molybdenum concentration. Seven 1 kg ore samples were used in the experiment to achieve a stable disintegration of the returned products. Lime was supplied into the grinding process to create a pH of the medium equal to 8,0 - 9,0; sodium sulfide for the minerals sulphidization.

The main collective copper-molybdenum flotation was performed for 17 minutes, the control one for 8 minutes, and in the basic mode the following reagents were used as a collecting agent - sodium butyl xanthate; foaming agent - T-92. The liquid glass was added to all of the re-washings to depress the minerals in the waste rock. Total consumption of the base chemicals used: lime (medium regulator) - up to pH 8,0 - 9,0; sodium sulfide (sulphidizer) - 200 g/t; sodium butyl xanthate (collecting agent) - 180 g/t; liquid glass (depressor) - 150 g/t; T-92 (foaming agent) - 120 g/t. Lime and sulphuric soda were supplied into the ore grinding process in a ball mill. Sodium butyl xanthogenate and T-92 were supplied to the main and control copper-molybdenum flotation. Liquid glass was supplied to the collective copper and molybdenum concentrate refinery.

It was supplied into the main and control flotation instead of the basic collecting agent of sodium butyl xanthate during flotation processing of ore using a combined flotation reagent. The combined flotation reagent was a mixture of sodium butyl xanthate, thionocarbamate TS-100, and reafloc in the ratio, in %: 80:15:5. The combined flotation reagent for the microemulsion was pre-flocculated with a T18 digital ULTRA-TURRAX dispersant before flotation. The optimum particle size of the microemulsion for the best ore flotation was determined on a Winner2000E laser particle analyzer.

The mineral suspension was placed in a flotation chamber after grinding in a ball mill in the presence of sodium sulfide and adjusting the pH (by adding lime) at 8,0 - 9,0. Then sodium butyl xanthate (or combined flotation reagent) and T-92 foaming agent were added to it. The mineral suspension was stirred for 1 minute without air supply at a rotor speed of 1 500 rpm. Flotation

treatment of the pulp was performed according to the applied enrichment scheme after the supply of atmospheric air (3,3 l/min). The liquid glass was added to the first rewashing of the collective copper-molybdenum concentrate to depress the waste rock.

RESULTS AND DISCUSSION

The copper minerals in the ore are mainly chalcopyrite, while chalcocyanite and covellite are present in lesser quantities, according to mineralogical analysis. The main molybdenum mineral is molybdenite. The ore contains pyrite, magnetite, to lesser extent hematite, and ilmenite. In addition, the ore contains a small amount of rutile, galena, sphalerite.

Chalcopyrite exists mainly independently in the form of xenomorphic grains or is associated with pyrite and is unevenly disseminated in vein minerals, sometimes located in the form of veins. The grain size of dispersed chalcopyrite varies from 0,001 to 1 mm. Chalcopyrite grain size in veins and nests is generally more than 0,01 mm. Figure 1 shows grains of chalcopyrite of various types: independent in the form of xenomorphic grains (1); in association with pyrite (2); interspersed in vein minerals (3).

Molybdenite is mainly disseminated in quartz in the form of lamellar single crystals or their aggregates. It is found in calcite, quartz-calcite, and quartz veins. This mineral also forms nests and placers in alteration zones with potassium feldspar.

Rock-forming minerals are sodium feldspar, quartz, calcium-sodium feldspar, chlorite, and to lesser extent potassium feldspar, sericite, potassium microplagioclase. In addition, there are small quantities of biotite, epidote, calcite, wollastonite, titanite, and apatite.

According to the results of chemical analysis, the investigated sample of copper-molybdenum ore contains 0,42 % copper; 0,009 % molybdenum. The phase analysis of the original ore for copper and molybdenum was performed. The results of the analysis showed that the content of primary copper sulfides (chalcopyrite CuFeS_2) in the ore is 95,5 %; secondary copper sulfides (chalcocite Cu_2S , covellite CuS) – 2,1 %; in the form of

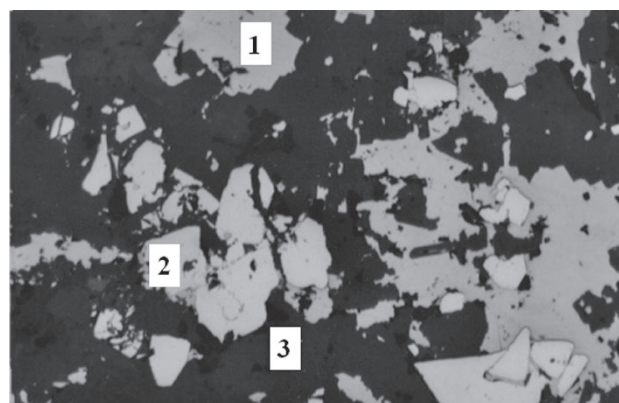


Figure 1 Chalcopyrite

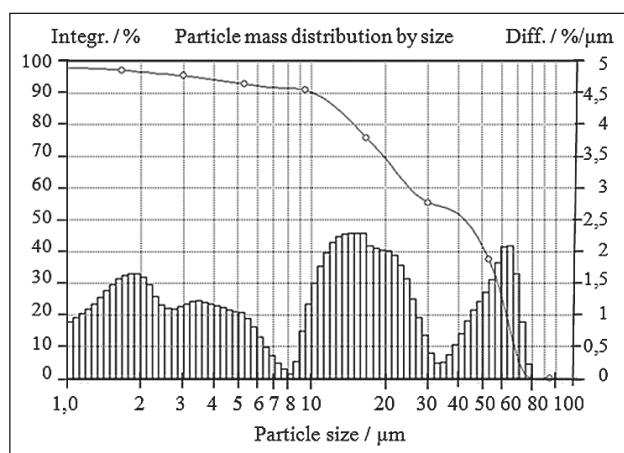


Figure 2 Dispersion analysis of a sample of crushed copper-molybdenum ore at FSKh-6K

copper oxides – 2,4 %. The content of molybdenum in the original ore in the sulfide form (molybdenite MoS_2) is 96 %; in oxidized form – 4,0 %.

Dispersive analysis of crushed ore was performed on the FSKh-6K photometric sedimentometer (Figure 2).

Ore for variance analysis was ground to a flotation fineness of 92 % class - 0,074 mm. The results of the analysis of variance show that in the initial sample of crushed ore the biggest share of the size classes 15-20 μm and 60-70 μm .

The reagent mode of flotation of copper-molybdenum ore has been worked out using a combined reagent, which is a mixture of sodium butyl xanthate, thionocarbamate, and reafloat in the ratio, in %: 80:15:5. The combined flotation reagent was pretreated before flotation on a T18 digital ULTRA-TURRAX disperser. The microemulsion of the combined flotation reagent obtained in the disperser allows to improve the hydrophobization of the slime particles of copper and molybdenum minerals. In this case, the bubbles of the foaming agent are better fixed on the surface of the floating minerals, which leads to an increase in the technological parameters of flotation.

The optimum dispersion time and particle size of the combined reagent microemulsion were selected using the Winner 2000E laser particle analyzer. Figure 3

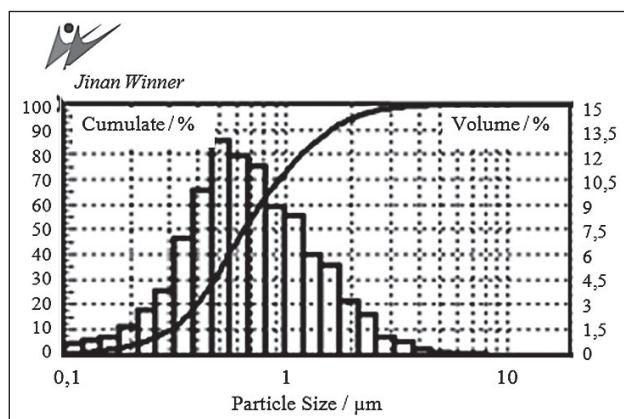


Figure 3 Particle distribution of the combined reagent obtained on the Winner 2000E

shows the results of the emulsion measurement of the combined reagent after treatment on the T18 digital ULTRA-TURRAX dispersant.

The optimum dispersion time is 2 min for a combined reagent solution with a concentration corresponding to the flow rate in flotation. Particles of less than 3,7 μm in size make up 99,4 %.

Laboratory studies were performed on the flotation concentration of copper-molybdenum ore of the Kazakhstan deposit using a combined flotation reagent in comparison with the basic mode in a closed cycle. The results of the flotation of the collective copper-molybdenum cycle are presented in Table 1.

Table 1 Results of collective flotation of copper-molybdenum ore in a closed cycle

Name of the sample	Yield / %	Content / %		Extraction / %	
		Cu	Mo	Cu	Mo
Basic mode (butyl xanthate)					
Cu- Mo concentration	1,76	16,8	0,40	80,98	82,69
Tailings	98,24	0,07	0,0015	19,02	17,31
Source ore	100,0	0,37	0,009	100,0	100,0
Using a combined reagent					
Cu- Mo concentration	1,8	18,06	0,43	84,67	88,74
Tailings	98,2	0,056	0,001	15,33	11,26
Source ore	100,0	0,36	0,009	100,0	100,0

As can be seen from the data presented, the use of a dispersed microemulsion of the combined reagent increases, in comparison with the baseline mode, the extraction of copper into the collective copper-molybdenum concentrate by 3,69 %, the extraction of molybdenum by 6,05 %. In this case, the consumption of the combined reagent is less than sodium butyl xanthate by 15 %.

Thus, the research results show that the use of the combined reagent is promising to process the copper-molybdenum ores.

CONCLUSION

The effect of the combined flotation reagent on the flotation of copper-molybdenum ore of the Kazakhstan deposit has been studied. The investigated ore sample contains 0,42 % copper; 0,009 % molybdenum. The reagent mode of flotation of copper-molybdenum ore has been worked out using a combined reagent, which is a mixture of sodium butyl xanthate, thionocarbamate, and reafloat in the ratio, in %: 80:15:5.

The combined reagent was supplied to flotation in the form of a microemulsion obtained on a T18 digital ULTRA-TURRAX disperser. The optimum dispersion time for the combined flotation reagent is 2 minutes. At the same time, 99,4 % are microemulsion particles with a particle size of less than 3,7 μm . The use of a microemulsion of combined reagent increases copper extraction into copper-molybdenum concentrate by 3,69 %, molybdenum extraction by 6,05 %. The copper content

in copper-molybdenum concentrate increases by 1,26 %. The copper content in flotation tailings decreases from 0.07 to 0,056 %. The consumption of the combined reagent, compared to the basic butyl xanthate, is reduced by 15 %.

Acknowledgments

The work is performed with financial support from Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (grant AP08855565).

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Note: The person responsible for the translation into the English language is Kurash A.A., Almaty, Kazakhstan