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PROCESSING OF MATURE COPPER TAILINGS FROM CONCENTRATION PLANT USING A COMPOSITE REAGENT

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The research presents the results of laboratory studies on the flotation processing of mature copper tailings using KF2 composite reagent. KF2 flotation agent is a mixture of sodium butyl xanthate, thionocarbamate, and composite aerofloat at a ratio of 1:1:3. In the base regime, a rough copper concentrate obtained had a copper content of 10,9 % with a recovery of 74,91 %. The use of KF2 composite flotation reagent increases the extraction of copper into rough copper concentrate by 5,31 %. This made it possible to obtain a rough copper concentrate with a copper content of 13,0 % and a recovery of 80,22 %. Consumption of KF2 flotation reagent is halved compared to the basic sodium butyl xanthate collector.

Keywords: industrial waste, flotation, composite reagent, copper concentrate, X-ray research

INTRODUCTION

The world practice of metal production has tendencies for the depletion of ores and the involvement of low-grade and industrial raw materials in processing. The growing scale of industrial production with the inclusion of raw materials poor in the content of valuable components in processing led to an increase in the volume of man-made waste that pollutes the environment [1-4]. Technogenic mineral formations are characterized by an industrially significant content of one or more elements. In terms of reserves, they are commensurate with small deposits. The flotation tailings differ significantly from the original ores not only in content but also in the degree of surface oxidation of minerals, the presence of a significant amount of intergrown pieces, and slime particles [5-6].

In this regard, the problem of choosing the most effective flotation reagents that increase the efficiency of flotation for additional recovery of valuable components from tailings is urgent [7-9].

Laboratory studies and industrial tests carried out were focused on the use of hexyl xanthate and its mixtures with butyl and isopropyl xanthates in the flotation of sulfide copper minerals. The technological and economic efficiency of a mixture of hexyl and butyl xanthates with a decrease in its consumption from 70 to 50 g/t is shown. The increase in copper extraction was about 0,4 % [10].

The current practice of using collectors in the flotation of sulfide minerals also provides for the joint use of xanthates and aerofloats. The use of aerofloats in addition to xanthates makes it possible not only to improve the quality of the obtained sulfide concentrates due to the more selective action of aerofloats, but also to increase the recovery of metals due to the ability of aerofloats to efficiently float fine particles.

Preparation of mature tailings before enrichment operations is an important point that determines the receipt of high technological results. Preparatory operations can include regrinding of tailings, fractionation, desliming, and washing.

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MATERIALS AND METHODS

The objects of research are the mature copper-bearing tailings from the Kazakh concentrating mill and KF2 composite flotation reagent. In the flotation of copper-bearing tailings, a mixture of sodium butyl xanthate, thionocarbamate, and composite aerofloat was used as KF2.

The original copper tailings were reground in a 40ML-000PS laboratory ball mill to 92 % content of 0 – 0,074 mm fraction. Closed-cycle flotation was carried out on FML laboratory flotation machines with a chamber volume of 3,0; 1,0; 0,75 liters.

The flotation scheme included regrinding of the base tailings, rougher flotation, scavenger flotation, and three cleanings of rough copper concentrate. Sodium sulphide was fed into the regrinding process to sulfidize oxidized minerals. In the process of flotation, sodium butyl xanthate and KF2 composite flotation reagent were used as a collector. T-92 was used as a foaming agent. In the first and second cleanings, liquid glass was fed to depress the mining waste. Rougher flotation lasted for 10 minutes; scavenger flotation lasted for 9 minutes, the first cleaning lasted for 7 minutes, the second and third cleanings lasted for 5 minutes each. KF2 flotation reagent was preliminarily dispersed on a UZDN-A1200T ultrasonic apparatus. The particle sizes of KF2 dispersed flotation reagent were measured on a PhotocorCompact particle size analyzer (Russia).

The S:L ratio in flotation was 1:3. The rotor speed of the flotation machine was 1 200 rpm.

Analytical equipment used in the research: Optima 2000 DV atomic emission spectrometer; D8 ADVANCE X-ray diffractometer; Thermo Nicolet Avatar 370 FTIR Spectrometer; Venus 200 X-ray fluorescence spectrometer (PANalyical B.V.); JXA-8230 electron probe microanalyzer (JEOL).

RESULTS AND DISCUSSION

Studies were carried out to study the possibility of processing copper-bearing tailings of a Kazakh concentrating mill using KF2 composite flotation reagent.

To obtain a KF2 composite flotation reagent, a mixture of reagents was selected, and the collection capacity of this mixture will vary depending on the pH of the medium. This makes it possible to selectively separate sulfide minerals with similar physical and chemical properties. Therefore, butyl xanthate (BX), TC-1000 thionocarbamate, and composite aerofloat were taken as the base reagents. Composite aerofloat is synthesized from purified fusel oil and phosphorus (V) sulfide. According to the fractional distillation of fusel oil, isoamyl alcohol is the main component of refined fusel oil (more than 80 %).

The advantage of the proposed composite flotation reagent over other known reagents is that it contains two polar groups and a long hydrocarbon radical. Such a structure in water in the flotation process does double service: firstly, as a collector, being adsorbed on the surface of the mineral, it forms metal complexes with polar groups in the form of bridges, and, secondly, apolar radicals flocculate useful slimed components, thereby intensifying the flotation process.

It was found that the optimal ratio of reagents in the composition of the composite reagent is as follows: composite aerofloat: thionocarbamate TS-1000: sodium butyl xanthate = 1 : 1 : 3.

According to the results of chemical analysis, copper tailings contain 0,13 % copper; 0,01 % lead; 0,01 % zinc; 66,31 % SiO_2; 2,3 % iron total; 11,8 % Al_2O_3; 5,96 % CaO; < 0,0003 % Cd; 0,16 % sulfur.

The mineralogical composition of the base tailings (main content) is represented by quartz, calcite, albite-type plagioclase, orthoclase, and muscovite. Copper is present mainly in the form of chalcopyrite and a small number of oxidized copper minerals.

Electron probe microanalysis of the base tailings sample (Figure 1) confirms that the bulk of the tailings consists of quartz and aluminosilicates.

The analysis of variance of the tailings was carried out and the distribution of copper by sizes was studied. Analysis of variance results is shown in Table 1. According to the results of Table 1, the main part of copper (72,43 %) is contained in the size class - 74 + 50 μm, as well as in the size class finer than 10 μm (17,2 %).

Before flotation, the KF2 flotation reagent was dispersed on a UZDN-A1200T ultrasonic apparatus. The optimal degree of dispersion of the reagent was selected. The optimum dispersion time was 20 sec. Then, the reagent solution was analyzed on a PhotocorCompact particle size analyzer. Figure 2 shows the results of the particle size of the KF2 flotation reagent after treatment with an ultrasonic apparatus.

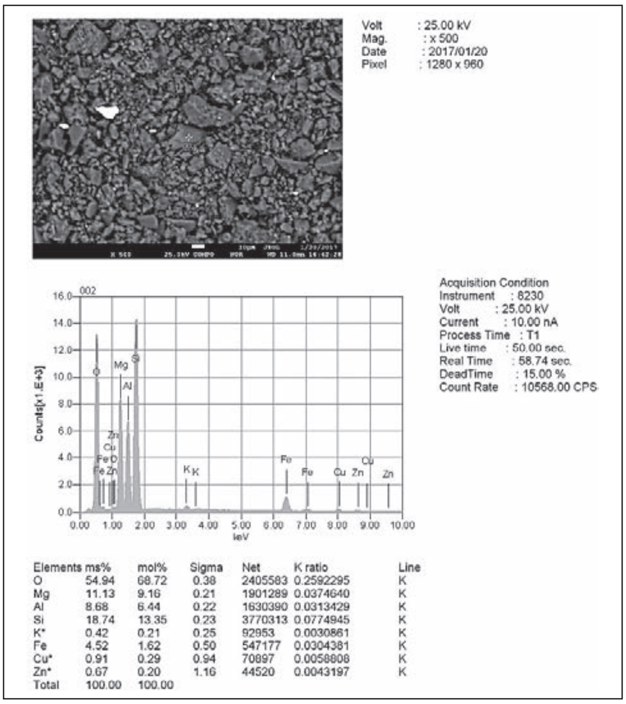

Figure 1 Electron probe microanalysis of the initial sample of copper tailings

Table 1 **Results of analysis of variance for the original copper tailings**

Size class, μm	Yield, %	Content Cu / g/t	Extraction Cu / %
-74 +60	41,15	0,11	42,26
-60+50	5,05	0,64	30,17
-50+40	5,25	0,05	2,45
-40+30	7,25	0,04	2,71
-30+20	4,2	0,046	1,80
-20+10	6,9	0,053	3,41
-10+0	30,2	0,061	17,2
Original tailings	100,0	0,1071	100,0

With an optimal ultrasonic treatment time of 20 sec., the amount of 130 μm particles of KF2 composite flotation agent was 98,7 %.

Laboratory studies were carried out to develop technological regimes of flotation of copper-bearing tailings using KF2 composite agent. The regime of regrinding of the tailings from the concentrating mill was selected; the optimal consumption of reagents was determined. The flotation results are shown in Table 2. According to the table, the use of KF2 composite agent in the flotation cycle of copper concentration tailings can significantly improve the performance of the tailings processing.

According to the basic technology, using only butyl xanthate (250 g/t), the rough copper concentrate was obtained, where a copper content was 10.9% with a recovery of 74,91 %.

The use of KF2 composite flotation reagent (125 g/t) pretreated with an ultrasonic apparatus increases the ex-

Table 2 **Results of flotation of copper-bearing tailings**

Sample name	Yield / %	Content Cu / g/t	Extraction Cu / %
Base regime			
Cu concentrate	0,68	10,9	74,91
Tailings	99,32	0,025	25,09
Original tailings	100,0	0,099	100,0
With KF2 reagent			
Cu concentrate	0,62	13,0	80,22
Tailings	99,38	0,02	19,78
Original tailings	100,0	0,100	100,0

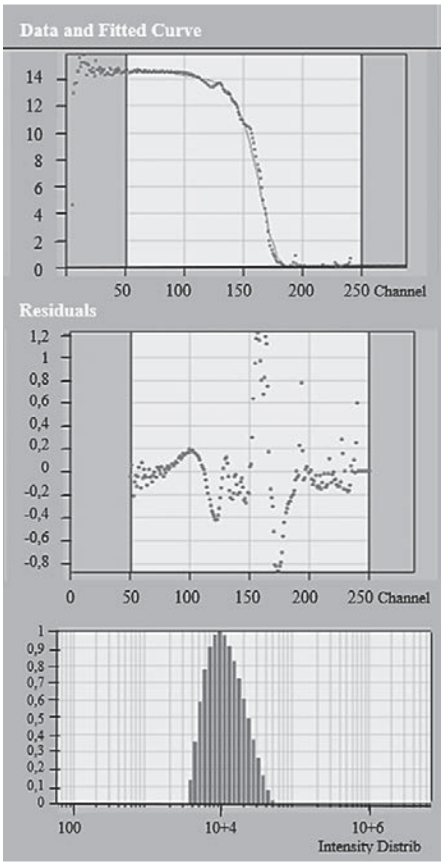

Figure 2 Particle size distribution of KF2 composite reagent

traction of copper into rough copper concentrate by 5,31 %. This made it possible to obtain a rough copper concentrate with a copper content of 13,0 % and a recovery of 80,22 %. Consumption of KF2 flotation reagent is halved compared to the basic sodium butyl xanthate collector.

Thus, the research results show that the use of KF2 composite flotation reagent is promising in the processing of mature copper tailings from concentration plants.

CONCLUSION

Based on comprehensive studies, a selective KF2 composite flotation reagent consisting of a mixture of composite aerofloat, TS-1000, and butyl xanthate was selected. The reagent ratio was 1 : 1 : 3.

The advantage of the proposed flotation reagent is that it contains two polar groups and a long hydrocarbon radical. Such a structure in water in the flotation process does double service: firstly, as a collector, being adsorbed on the surface of the mineral, it forms metal complexes with polar groups in the form of bridges, and, secondly, apolar radicals flocculate useful slimed components, thereby intensifying the flotation process.

It studied the effect of the reagent on the copper-bearing tailings from the Kazakh concentrating mill. It has been shown that, during the flotation of tailings with lower consumption of the composite reagent compared to butyl xanthate, we obtained rough copper concentrate with a copper content of 13,0 % and a recovery of 80,22 %. Compared to the base technology, copper recovery into rough copper concentrate is increased by 5,31 %.

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