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Technology for Processing Gold-Bearing Ores of the Angren Ore Field by Flotation Method Using New Local Reagents

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ABSTRACT: In the world, sulfide gold-bearing ores differ in their material composition, the nature of the association of gold and mineral components. Sulfide gold-bearing ores are classified as resistant and have low metal recovery rates. The proven reserves of gold-bearing ores confirmed their low content (3-7 g/t), thin inclusiveness, uneven distribution and high dispersion of gold. Gold inclusions in sulfide ores have a size from 0.002 to 4 mm.

KEYWORDS: enrichment, material composition, inclusiveness, resistant ores, flotation, technological process, product yield, extraction, flotation scheme.

I. INTRODUCTION

To date, all over the world, work is underway to improve technological schemes for the enrichment and hydrometallurgical processing of gold-containing ores, to maximize the opening of gold-containing sulfides by developing new technological and technical solutions and improving the efficiency of processing. The increase in gold prices creates favorable conditions for the involvement in the development of complex gold sulfide ores and the expansion of the mineral resource base. Despite significant progress in improving the efficiency of processing gold-bearing sulfide ores, the issues related to the development of technology for processing them by gravity and flotation enrichment using reagents from local industry waste remain not fully resolved [1-3].In connection with the depletion of easily cyanized oxidized gold-bearing deposits, the problem of involving sulfide gold-containing ores in the processing, which require preliminary flotation enrichment, becomes urgent. Due to the shortage and high cost of traditional flotation reagents, it is necessary to partially replace them with local reagents from products and waste from production enterprises, which will dramatically reduce the cost of reagents and reduce the cost of gold and silver production.
The improvement and intensification of the flotation process are mainly associated with the development of effective reagent regimes that make it possible to obtain a high recovery of useful components with an improvement in the quality of the concentrates produced. Conducting the process with effective reagents will reduce their costs, which will increase its selectivity and the residual concentration of reagents in the liquid phase. Therefore, the work aimed at studying and modifying reagents to give them more effective flotation properties is very relevant.

II. MATERIAL AND METHODS

Before the study of the richness of the samples, the material was isolated for chemical, sieve and mineralogical analyses, as well as for determining some physical properties (density, volume, relative hardness, etc.).Flotation tests were carried out in laboratory flotation machines with a chamber volume 3,0; 1,5; 1,0; 0,5; 0,25; 0,2 l. The volume of the chamber was selected depending on the weight of the floated product and the percentage of solid in this operation. In laboratory tests for the richness of flotation, 50 - 100 gr weights were taken. Ore grinding for flotation experiments was carried out in mills in an aqueous medium at a ratio of W:T: W=1:0.5:6. The fineness of grinding was measured by the duration of grinding in the mill with a constant load of crushing medium, ore, water and reagents.
The following reagents were used as flotation reagents: collector-potassium butyl xanthogenate (BCC), activator – copper sulfate ($CuSO_4$), medium regulator – soda, foaming agent – T-80. Reagents were fed into the process in the following sequence: reagents-regulators, activators, collectors, foaming agents. In the flotation experiments, the mass fraction of solid in the pulp ranged from 15 to 40%. The main and control flotation operations were carried out in dense pulp, and the re-flotation operations were carried out in more liquefied pulps [4-5].

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III. SIMULATION & RESULTS

As an object of research, we took samples of gold-bearing ore from the Kochbulak and Kyzylalma deposits, and the method of enrichment – flotation. Before starting the study, it was necessary to determine what type of ore this ore belongs to. Usually, the preliminary determination is performed on the basis of geological and mineralogical information obtained from the sample passport. More precisely, the type of ore is determined after studying the material composition of the sample.

The material composition of the samples has been studied by spectral, chemical, granulometric, mineralogical and other methods.

As a result of the conducted laboratory studies on the study of the material composition of gold-bearing ores, it was determined that the studied ores belong to the low-sulfide, mixed type. The ratio of sulfides to hypergenic minerals in it is-3.2:5.6; i.e., the sulfides in it are oxidized by about half. The ore minerals submitted for enrichment are arsenopyrite and pyrite, and chalcopyrite, chalcosine, covellin, and sphalerite are noted in the number of single signs. Of the non-metallic minerals, quartz, mica minerals, and feldspar are widely represented. The accessory minerals are mainly titanium minerals. The main useful component of the ore is gold, which is present in both native and subdisperse forms associated with sulfides and their oxidation products. The main distinguishing feature of the ore under study is the presence of elements of the platinum group, which is probably present in the composition of subdispersed gold found in sulfides and jarosite [6-8].

As a result of the study of the material composition, it was revealed that the ores of the Kochbulak and Kyzylalma deposits belong to the type of resistant ores.

Due to the impossibility of extracting gold from resistant ores directly by cyanidation, they are processed by flotation or gravity – flotation methods of enrichment with subsequent extraction of gold from the resulting concentrates by pyro-hydrometallurgical or other methods. The latter, as a rule, are characterized by great complexity and high operational and capital costs, which forces us to pay special attention to the possibility of reducing the yield of concentrates with a sufficiently high metal extraction. Another feature of most persistent gold-arsenic ores is the presence of carbonaceous shales, which are a fine-grained clay-shale aggregate impregnated with a carbonaceous substance. The technological persistence of these products is due to the fine inclusiveness of gold in sulfides (mainly in arsenopyrite) and the presence of a significant amount of active carbon with an increased sorption capacity in relation to the gold-cyanide complex [10, 12].

As you know, the size of gold is one of its most important technological properties. Large gold is released from the bond with minerals during ore grinding, and the free gold grains formed are easily captured during gravity enrichment, but are poorly floated and slowly dissolve during cyanidation. Therefore, at the beginning of the experiments, gravity enrichment was used to isolate relatively large particles of native gold from ore sulfides.

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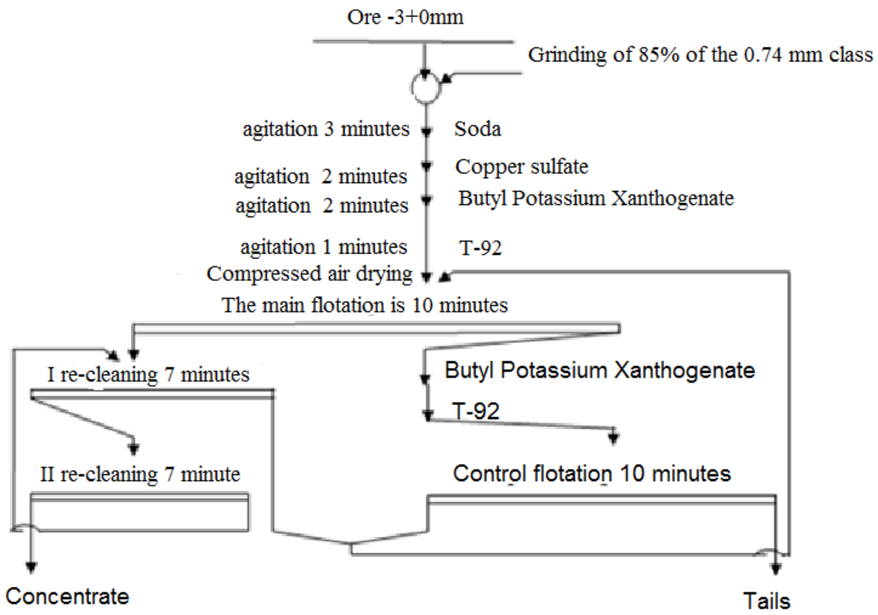

On all ore samples, the experiments were carried out according to the scheme shown in Fig. 1.
The jigging was carried out at the ore size of -1+0 mm. The heavy fraction of the jigging was reduced to the required size in the ball mill. In the experiments, the size of the material enriched on the table varied from 1 to 0.1 mm in order to obtain the maximum possible extraction of gold and its content in the concentrate. Ore weight-5-10 kg.
Mode of operation of the jigging machine: the thickness of the bed made of steel shot with a size of 3-4 mm was 30 mm; the vibration amplitude was 6 mm, the pulsation frequency was 452 min-1, the pressure water flow was 5 l / min, the water flow with power was 2.75 l/min, the size of the sieve holes was 2 mm.
Mode of operation of the concentration table: swing frequency-110 rpm, swing amplitude-8-11 mm, transverse slope of the deck-20 mm / m, flush water consumption-4.5 dm3 / min, ore size in the experiments varied from 1-0 to 0.1-0 mm.
The results of experiments with optimal ore size are shown in Table 1.

Name of products	Exit,	Content, g / t		Extract, %	
	%	gold	silver	gold	silver
Открытый цикл					
Concentrate	3,5	189,0	867,0	87,6	54,4
Promprodukt-1	4,4	2,75	119	1,6	9,45
Promprodukt-2	0,7	16,2	199	1,5	2,5
Promprodukt-3	5,0	7,1	72,0	4,7	6,5
Tails	86,4	0,4	17,57	4,6	27,2
Ore	100,0	7,55	55,8	100,0	100,0
According to the principle of a continuous process					
Concentrate	5,4	128,6	643,7	92,6	63,2
Tails	94,6	0,6	21,4	7,4	36,8
Ore	100,0	7,5	55,0	100,0	100,0

Flotation experiments were carried out according to the scheme (Fig. 2), which includes ore grinding, the main, control and two perechistnye flotation operations.

During the flotation of the ore charge from the Kyzylalma and Kochbulak deposits, the following optimal flotation regime was determined using traditional reagents:fineness of grinding % cl. -0.074 mm -85.0; reagent

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consumption, g / t: in grinding: soda ash 500; in the main flotation: BPX-120; T-92 -80; in control flotation: BPX -60; T-92-20. Time of the main flotation, min: - 10, control flotation-10; 1 perechistki-7; 2 perechistki-5.

The experiments varied: the size of the grinding from 75 to 100 % cl. - 0.074 mm, the consumption of sodium sulfide, soda ash, copper sulfate, butyl potassium xanthogenate (BPX), foaming agent T-92. As a result, the optimal flotation mode was set for each ore sample. The gravity tails were flown according to the same schemes in the optimal mode for ore.

In the developed mode, an experiment was conducted in open and closed cycles, the results of which are shown in Table 2.

Name of products	Exit,		Content, g / t		Extract, %			
	from the operation	from ore	gold	silver	from the operation		from ore	
					Au	Ag	Au	Ag
a) in an open loop								
Concentrate	3,4	3,3	33,67	500,33	77,5	50,4	14,7	33,0
Promprodukt-1	4,1	3,9	0,88	68,22	2,5	7,4	0,5	4,8
Promprodukt-2	1,0	1,0	1,73	75,60	1,2	2,0	0,2	1,3
Promprodukt-3	4,8	4,6	1,62	43,31	5,4	5,5	1,0	3,6
Tails	86,7	83,4	0,19	15,13	11,4	34,7	2,1	22,7
Initial gravity tails	100	96,2	1,44	37,8	100,0	100,0	18,5	65,4
b) according to the principle of a continuous process								
Concentrate	6,0	5,8	20,9	379,0	87,1	60,2	16,1	39,4
Tails	94,0	90,4	0,20	16,0	12,9	39,8	2,4	26,0
Initial gravity tails	100,0	96,2	1,44	37,8	100,0	100,0	18,5	65,4

As can be seen from Table 2, when flotation with the traditional reagents BPX and T-92, a concentrate with a yield of 5.4% can be obtained from the ore in question, containing 128.6 g / t of gold and 643.7 g / t of silver, while extracting metals of 92.6 and 63.2%, respectively.

Table 3 shows the results with traditional reagents of gravity tails isolated from the charge.

Name of products	Exit,	Content, g / t		Extract, %		Reagent consumption, g / t
		gold	silver	gold	silver	
a) in an open loop						
Concentrate	3,5	187,35	850,1	87,2	54,1	BPX-180
Promprodukt-1	4,1	3,85	127,4	2,1	9,5	
Promprodukt-2	1,0	11,29	148,5	1,5	2,7	
Promprodukt-3	5,0	6,92	71,5	4,6	6,5	
Tails	86,4	0,40	17,2	4,6	27,2	
Ore	100,0	7,50	55,0	100	100	
Concentrate	3,0	214,0	920,64	85,6	50,4	SD-1-150
Promprodukt-1	5,1	4,7	107,45	3,2	10,0	
Promprodukt-2	1,0	14,25	120,6	1,9	2,2	
Promprodukt-3	4,2	7,32	88,7	4,1	6,8	
Tails	86,7	0,45	19,34	5,2	30,6	
Ore	100,0	7,50	55,0	100,0	100,0	

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b) closed loop						
Concentrate	5,01	131,34	615	89,6	62,7	BPX-180
Tails	94,99	0,35	15,5	7,2	34,7	
Ore	100,0	7,50	55,0	100,0	100,0	
Concentrate	4,9	140,9	721	92,8	65,3	SD-1-150
Tails	95,1	0,55	17,48	10,4	37,3	
Ore	100,0	7,50	55,0	100,0	100,0	

IV. CONCLUSION

As can be seen from Table 3, during the flotation of gravity tails, the extraction of gold into concentrate decreases to 87.1 %, silver to 60.2 % of the operation. At the same time, the quality of the concentrate deteriorates: the content of gold in it is 20.9 g / t (against 128.6 g/t when flotation from ore), silver is 379 g/t (against 643.7 g/t) . The total recovery of gold in the gravio-and flotation concentrate will be 97.6 %, silver 74.0%.

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