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ABOUT THE USE OF R-66 REAGENT IN THE TECHNOLOGY OF FLOTATION ENRICHMENT OF MIXED COPPER

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Preliminary Note – Prethodno priopćenje

The paper presents laboratory and pilot flotation tests of the R-66 reagent on samples of mixed copper ore from the Konyrat deposit. The medium regulator reagent was supplied to the main flotation. Laboratory tests of the technology of flotation concentration on ore with a copper content of 0,31 % in a closed cycle in the optimal mode: R-66 - 100 g/t, sodium sulfide - 150 g/t, xanthate - 45 g/t, blowing agent - 60 g/t allows to extract copper into concentrate up to 85 %. At the same time, the copper content in the concentrate after two cleanings was reached at the level of 4,5 %, sulfur 42,3 %. At the same time, the R-66 reagent (100 g/t) makes it possible to completely eliminate the use of lime (1 000 g/t) in the ore dressing scheme.

Key words: mixed copper ore, flotation, flotation agent, enrichment, copper concentrate.

INTRODUCTION

The creation and expansion of the mineral resource base is one of the main prerequisites for the successful growth of the economy of any country. Mineral resources are the source of economic progress and prosperity. In terms of quantity and variety of mineral resources, the Republic of Kazakhstan occupies one of the leading places in the world [1]. The main amount of balance reserves and deposits of copper is concentrated in Eastern and Central Kazakhstan. The provision of mining enterprises with copper reserves prepared for exploitation is small and is approximately 15–20 years. At the same time, there are all potential opportunities for the development of the mineral resource base of the copper ore industry in the republic [2].

One of the promising deposits is Konyrat. It is assumed that the field will be developed for about 9 years. The volume of rock mass will exceed 99 million tons, with the extraction of ore about 57 million tons.

In this regard, the development of an efficient technology for processing this ore is promising.

Kazakhmys Corporation LLP plans to extract 3,5 million tons of ore for processing at the Balkhash enrichment plant.

The main method of processing copper ores is flotation. An increase in efficiency can be achieved by improving the reagent regime and using modified, combined reagents, and a combination of different collectors.

The use of new modified flotation reagents makes it possible to carry out more selective flotation, reduce the cost of reagents, and improve the quality and yield of collective and selective concentrates during the processing of low-grade and difficult-to-enrich polymetallic and copper-molybdenum raw materials [3–5].

In the beneficiation of copper ores, combined reagents are used, which are more efficient than those used in industry. These include the "PS" reagent, the Reaflot-2340 reagent, developed for refractory depleted copper-sandstone ores [6–8].

The use of combinations of various collectors in flotation is reflected in the works [9,10]. The use of modified semi-functional flotation reagents, which is a mixture of aeroflots and collectors, has been studied [11].

It have developed a method for enrichment of copper ores, the main task of which is to increase the extraction of copper into concentrate and exclude lime from the flotation scheme.

EXPERIMENTAL PART AND DISCUSSION OF THE RESULTS

The object of study is a sample of mixed copper ore from the Konyrat deposit with a total copper content of 0,31 % with a copper oxidation fraction of 10 %. After sample preparation, chemical, mineralogical and granulometric analyzes of the selected ore samples were carried out.

Chemical analysis of the technological sample is shown in Table 1.

Table 1 **Chemical composition of the studied samples**

Sample name	Content of components / %					
	Cu_{total}	$Cu_{oxidized.}$	Fe	S	SiO_2	Al_2O_3
OP-306	0,31	0,031	4,46	2,15	54,33	10,29

To determine the granulometric composition of the studied ore, a sieve analysis was carried out on an ana-

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lytical screening machine from Retch (Germany) with wet sieving.

The ore sample was sieved through five standard laboratory sieves with a metal shell with holes of different sizes / mm: 2,0; 1,0; 0,5; 0,25; 0,125; 0,071.

With a decrease in the size class, the proportion of small particles increases. To improve the accuracy of the analysis, the samples were dispersed in a wet way, washing the smallest particles with a weak jet of water until the washing water became clear. The distribution of components by size classes is presented in Table 2.

Table 2 **Distribution of components by fractions**

Size class / mm	Output / %	Content / %			Distribution / %		
		Cu	Fe	S	Cu	Fe	S
+2,0	1,56	2,31	2,84	1,45	11,61	0,99	1,05
-2,0+1,0	24,66	0,34	3,72	1,67	27,42	20,58	19,14
-1,0+0,5	14,11	0,29	1,96	1,42	13,23	6,21	9,31
-0,5+0,25	11,11	0,37	1,98	1,65	13,23	4,94	8,52
-0,25+0,125	7,88	0,39	1,77	1,36	10,00	3,13	4,98
-0,125+0,071	4,51	0,62	2,99	3,21	9,03	3,03	6,73
-0,071	36,17	0,13	7,54	2,99	15,48	61,12	50,27
Ore	100,00	0,31	4,46	2,15	100,0	100,0	100,0

Sieve analysis showed that in the sample of the studied ore, the components are mainly distributed over two fractions: -2,0+1,0; -0,071 mm. In order to assess the grind ability of the ore, studies were carried out on the effect of grinding time on the yield of the -0,071 mm class.

Grinding was carried out by the wet method in a laboratory ball mill MSHL-1 with a grinding time of 1, 3 and 5 minutes. Graph of output class -0,071 mm versus grinding time is shown in Figure 1.

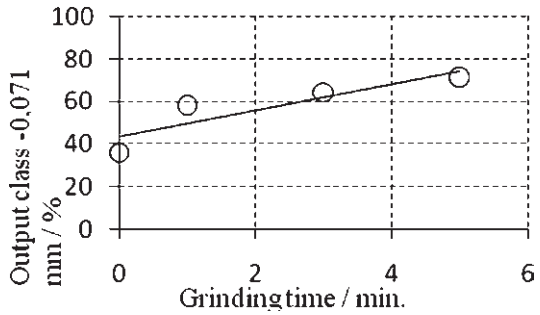

Figure 1 Kinetics of ore grinding from the Konyrat deposit

The optimal mode of grinding Konyrat ore is achieved when grinding for 3 minutes, the output of class -0,071 mm is 67,4 %. Further flotation studies were carried out on ore with the above fineness.

Flotation studies were carried out in order to determine the effectiveness of the use of R-66 as a medium regulator reagent, according to the open flotation scheme.

Flotation was carried out in a 237-FL-A flotation machine at a ratio of solid to liquid in the pulp 1:3. The time of the main and control flotation in all experiments was 6 and 10 minutes, respectively.

Reagent consumption: R-66 - 50-800 g/t, sodium sulfide - 150 g/t, xanthate - 75 g/t, blowing agent - 100 g/t. The flotation products were analyzed by the chemical method. The results of the experiments are shown in Table 3.

Table 3 **Indicators of flotation of Konyrat ore with R-66 reagent**

R-66 consumption, g/t	flotation product	output product / %	Cu		
			Content / %	Extraction / %	General* Extraction / %
50	concentrate	3,07	4,22	40,63	76,47
	intermediate product	9,22	1,59	46,88	
	tails	87,71	0,046	12,5	
	ore	100	0,32	100	
100	concentrate	8,81	2,95	83,87	92,5
	intermediate product	10,68	0,27	9,33	
	tails	80,51	0,026	6,8	
	ore	100	0,31	100	
200	concentrate	12,79	2,0	86,67	92,85
	intermediate product	9,55	0,24	6,67	
	tails	77,66	0,03	6,67	
	ore	100	0,30	100	
400	concentrate	8,56	3,02	83,87	92,83
	intermediate product	9,03	0,34	9,68	
	tails	82,41	0,025	6,45	
	ore	100	0,31	100	
800	concentrate	11,47	2,34	84,38	93,1
	intermediate product	8,81	0,32	9,38	
	tails	79,72	0,03	6,25	
	ore	100	0,32	100	

*Total recovery of copper in concentrate and intermediate product

The results of the experiments in the form of the dependence of the total copper recovery on the consumption of R-66 are shown in Figure 2.

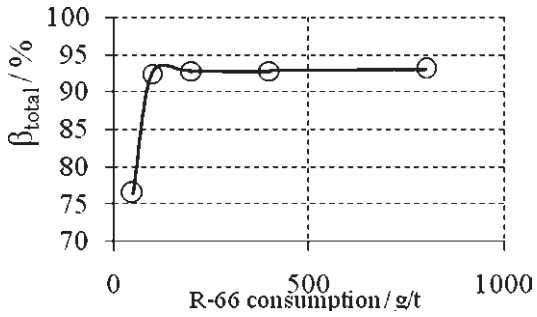

Figure 2 Dependence of the total copper recovery on the consumption of R-66

The analysis of the dependence obtained shows that the optimal consumption of the R-66 reagent is 100 g/t.

The tests were carried out according to two flotation schemes in a closed cycle: 1. with lime (flotation scheme of the Balkhash processing plant); 2. using reagent R-66.

The scheme of enlarged laboratory experiments according to scheme 1 in a closed cycle is shown in Figure 3.

Calcium oxide was used as flotation reagents (with feed to the mill at a flow rate of 1 000 g/t), sodium sulfide, butyl potassium xanthate collector, and T-92 oxal blowing agent.

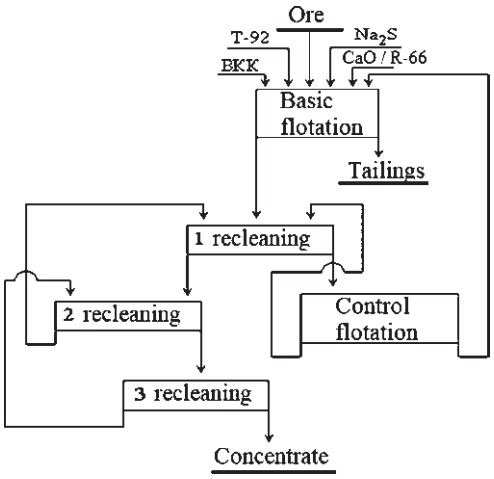

Figure 3 Scheme of flotation of ore with lime

The direct flotation scheme included three cycles. The flotation products were analyzed chemically for copper content. The flotation results are shown in Table 4.

Table 4 **Results of flotation with lime**

Product	output product / %	Cu	
		Content / %	Extraction / %
1 concentrate III recleaning	0,1	5,49	1,82
2 concentrate III recleaning	0,23	5,49	4,24
3 concentrate III recleaning	1,63	5,49	29,71
tailings III recleaning	1,2	4,25	16,90
tailings II recleaning	1,0	3,24	10,74
control flotation concentrate	0,63	2,31	4,85
control flotation tails	2,47	0,99	8,09
1 tailings of the main flotation	29,9	0,08	8,03
2 tailings of the main flotation	30,7	0,07	7,21
3 tailings of the main flotation	32,1	0,08	8,40
Ore	100	0,3	100,0

In the general concentrate, the copper content is 5,49 %, the extraction of copper is 60,21 %.

The experimental conditions are the same as for flotation with lime, but with the difference that R-66 was used instead of lime (with supply to the flotation chamber at a flow rate of 100 g/t and agitation for 1 min.) and sodium sulfide consumption of 50 g/t.

According to the flotation scheme with R-66 reagent, 3 kg of ore from the Konyrat deposit was processed in three cycles. The flotation products were analyzed chemically for the content of copper, iron and sulfur. Based on the data of chemical analysis, the extraction of ore components into flotation products was determined. The flotation results are shown in Table 5.

Table 5 **Results of flotation with R-66**

Product	output product / %	Cu	
		Content / %	Extraction / %
1 concentrate III recleaning	0,1	5,03	1,7
2 concentrate III recleaning	0,7	5,03	12,45
3 concentrate III recleaning	1,9	5,03	31,68
tailings III recleaning	1,2	2,95	12,28
tailings II recleaning	1,0	2,49	8,4
control flotation concentrate	0,5	3,36	6,05
control flotation tails	1,7	0,92	5,38
1 tailings of the main flotation	29,7	0,07	7,3
2 tailings of the main flotation	30,7	0,07	7,56
3 tailings of the main flotation	32,4	0,07	7,21
Ore	100	0,3	100,0

In the general concentrate, the copper content is 5,03 %, copper extraction is 67,5 %.

Thus, the results of large-scale laboratory experiments on the flotation of copper mixed ore from the Konyrat deposit indicate the effectiveness of the use of the R-66 reagent as a medium regulator. Replacing lime with R-66 reagent allows to increase copper extraction by 7,29 %, without significant change in the quality of the concentrate.

Further, under contract No. D1925-190982-005160, industrial tests of the R-66 reagent were carried out on mixed copper ore from the Konyrat deposit at the Balkhash concentrating plant, which operates in accordance with the technological instructions of the factory. The ore was floated on sections 4 and 5.

Table 6 **General actual indicators of Konyrat ore processing according to the approved commodity balance fi. 2021 y**

Period	SMT processing / tons	Initial ore Cu / %	Recovery / %	Cu concentrate quality / %
December (received)	114 256,480	0,39	72,70	12,04
December (shipped)	114 256,480	0,39	76,68	11,88

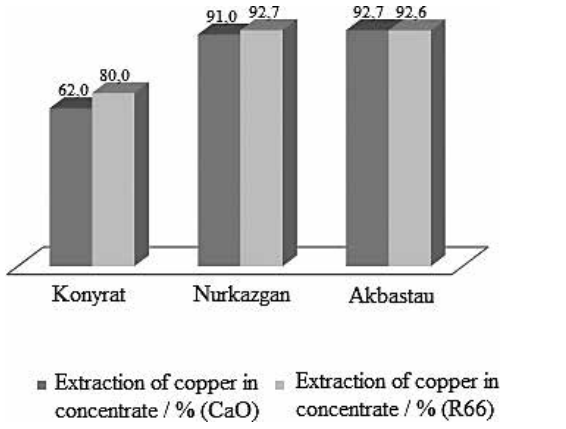

Figure 4 Indicators of copper extraction into concentrate (comparison of R-66 and CaO)

The performance indicators of the R-66 reagent as a substitute for lime for September 2019 during the processing of ore from the Konyrat deposit mixed with ores from the Sayak, Nurkazgan, waste slag, Ashaly, Akzhal deposits in the main building of the BOF are shown in Table 6. The indicators of the Konyrat ore are determined by the balance.

Similar tests were carried out at the Nurkazgan and Karagayli concentrating plants. The results are presented in Figure 4.

CONCLUSIONS

The kinetics of grinding was studied on ore samples. The optimal conditions for grinding with respect to the yield of particles of the flotation class are determined.

The results of laboratory studies on ore samples from the Konyrat deposit showed the effectiveness of using R-66 as an environmental regulator reagent capable of replacing lime. The optimal reagent mode of ore flotation with R-66 was determined: R-66 consumption 100 g/t; sodium sulfide 50 g/t; potassium butyl xanthate 50 g/t; foaming agent oksal T-92 50 g/t, and optimal conditions: basal flotation time 3 minutes; control - 5 min.

Large-scale laboratory flotation tests were carried out for flotation of ore with a copper content of 0,31 % according to the factory scheme with lime and with R-66 reagent. During flotation with lime, a concentrate was obtained with a copper content of 5,49 %, sulfur 55,83 % with a total copper recovery of 60,21 %. During flotation with reagent R-66 (without lime), a concentrate was obtained with a copper content of 5,03 %, sulfur 55,05 % with a total recovery of 67,5 %. It was found that the performance of flotation with reagent R-66 for the extraction of copper is higher by 7,29 without changing the quality of the concentrate.

Industrial tests of the reagent R-66 at the Balkhash enrichment plant made it possible to calculate the economic effect from the use of this reagent:

- Effect of replacing lime (1 000 g/t) with R-66 (100 g/t), $ per year: 220 360.
- Additional income from increased extraction, $ per year: 417 010. Total: $ 637 370 per year.

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Note: the responsible translator for English language is Nataliya Drag, Karaganda, Kazakhstan.