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RESEARCH ON ZINC CONCENTRATE DRESSING AT THE ZHEZKENT PROCESSING PLANT TO OBTAIN CONDITIONED CONCENTRATE

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The article investigates dressing of zinc concentrate of Zhezkent processing plant with the purpose of receiving conditioned zinc concentrate and copper product output. The scheme of the zinc concentrate ressing is suggested which includes the following operations: desorption of the initial concentrate by sodium sulfide and activated carbon; preliminary hydraulic classification (washing of thin sludge) complicating the flotation process; comminution of the concentrate in a ball mill up to the size of 96 %, class - 0,044 mm; flotation of copper minerals by reagents: xanthate, Methyl isobutyl ketone blowing agent, and depressors (Na_2S, $FeSO_4$, $ZnSO_4$). The proposed dressing scheme provides obtaining conditioned zinc concentrate of grade KC-3 with Zn 47,0 %, and Cu 1,9 %.

Key words: zinc concentrate, hydraulic classification, sludge, flotation, copper product.

INTRODUCTION

Due to the increasing requirement in high-quality zinc concentrate production the problem of upgrading ordinary and substandard concentrates is of great urgency.

The major problem of the technology improvements of lead and zinc complex processing, copper and zinc, and polymetallic ores in Kazakhstan is the increase of concentrate quality at rather high extraction of metals in the same-name concentrates [1].

Decrease of metal content in the processed ores, increase of the number of thinly disseminated hard-to-enrich ores in the total volume of extracted ore raw materials, transfer of the majority of plants to recycled water supply make it difficult to obtain relatively pure and rich concentrates. Under the existing conditions, the majority of factories in the lead and zinc sub-industry allow for significant mutual losses of metals in concentrates.

Thus, zinc losses in lead and copper concentrate products comprise from 10 to 17 %, lead losses in zinc concentrates are from 7 to 13 %, and copper losses in zinc concentrates are from 5 to 9 %.

To date, a number of scientists have been engaged in improving the quality of zinc and copper concentrates. For example, in [2] effective chemical and mechanical methods of zinc flotation process intensification were developed, providing the improvement of zinc concentrate quality. The authors [3] effectively separated zinc from zinc-containing sulfide-copper concentrate by chemical leaching to improve the quality of copper concentrate product, etc.

It is necessary to note, that previously we studied regularities of oxidized zinc minerals leaching. Additionally, it investigated kinetics of zinc leaching from calamine and smithsonite minerals by sulfuric acid [4,5].

It became necessary for our research to study dressing of low-quality zinc concentrate of Zhezkent processing plant to determine the possibility of improving the concentrate quality.

EXPERIMENTAL PART

It used in our researche the representative laboratory-technological sample of zinc concentrate of Zhezkent processing plant. The chemical composition of the investigated sample is given in Table 1.

Table 1 **Original Sample Chemical Composition**

Componentry	Content / %
Zink	44,77
Lead	2,30
Copper	3,20
Iron	15,96
Sulfur pyrite	14,82

Chemical analysis given in Table 1 shows that zinc concentrate contains 44,77 %, iron 15,96 %, copper 3,20 % and lead 2,30 %. The outcome of the rational analysis of zinc concentrate is given in Table 2.

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Table 2 **Rational analysis of zinc concentrate**

Mineral Forms	Zinc concentrate	
	Content / %	Distribution / %
$Cu_{fr.}$	0,01	0,29
$Cu_{secon.}$	0,17	4,96
$Cu_{prim.}$	3,25	94,75
$Cu_{com.}$	3,43	100,00
$ZnCO_3$	1,06	2,45
$ZnSiO_2$	0,34	0,79
ZnS	41,82	96,76
$Zn_{com.}$	43,22	100,00

Rational analysis given in Table 2 shows, that sphalerite in zinc concentrate for 96,76 % and chalcopyrite for 99,71 % are represented by sulfide forms.

According to the mineralogical analysis, zinc concentrates are represented by sulfides, in the form of thin clusters. Size of minerals in these clusters varies from 3 to 200 microns, with prevailing grains from 3 to 50 microns. The composition and characteristics of the clusters are heterogeneous. There are thin increments of sphalerite to pyrite, and to galenite, and of sphalerite and galenite to chalcopyrite. Zinc concentrate contain aggregate compounds of pyrite-chalcopyrite-sphalerite; sphalerite-pyrite-halenite. There are additions of galenite to sphalerite and chalcopyrite. Galenite in concentrates is completely in the mineral cluster, with prevailing size of 15-20 microns. The degree of the main mineral disclosure in zinc concentrates is given in Table 3.

Table 3 **Degree of disclosure of minerals in zinc concentrates**

Product name	Product size, mcm		% of free mineral grains			Predominant size of minerals in the clusters		
	-74	- 44	chalcopyrite	sphalerite	pyrite	chalcopyrite	sphalerite	pyrite
Zhezkent concentrate	91,3	72,7	52	90	95	20-40	20-40	15-30

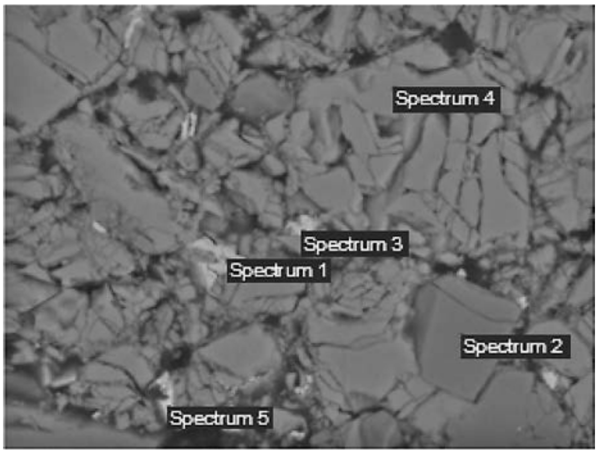

Figure 1 SEM of initial zinc concentrate (350 x magnification)

While analyzing this table, it can be noted mutual association of zinc, copper, iron and lead that zinc concentrates are characterized by a close sulfide with each other, which must be considered when choosing the parameters of the reagent mode and the scheme of zinc concentrate quality improvement [6,7].

The character of valuable components distribution in minerals in zinc concentrate was studied by means of Scanning Electron microscopy (SEM) with the INCA Energy microanalysis system. The SEM of the initial zinc concentrate is shown in Figure 1. Chemical analysis of spectra is given in Table 4.

As it can see from Table 4, the content of copper, zinc, sulfur and iron in separate spectra varies within a wide range, which testifies to their uneven distribution in the initial zinc concentrate.

According to the previous data, the zinc concentrate sample submitted for the research has black color visually. The dark color of sphalerite, according to mineralogical analysis of zinc concentrate, is caused practically in all clusters by the significant content of chalcopyrite emulsion inclusions in sphalerite, most often associated with fine and less often with relatively fine subgraphic chalcopyrite inclusions [6].

It recommends the dressing scheme according to the scheme of direct selective flotation including the following operations:

- Desorption of initial zinc concentrate with sodium sulfide and activated carbon followed by laundering of xanthogenate from sphalerite surface;
- Pre-washing of thin sludge (without zinc loss) complicating the flotation process;
- Zinc concentrate regrinding in a ball mill to 96 % fine, grade – 0,044 mm;
- Flotation of copper minerals with reagents: xanthogenate, Methyl isobutyl ketone blowing agent, and depressors (Na_2S - sodium sulfate, $FeSO_4$ - iron sulfate, $ZnSO_4$ - zinc sulfate) at pH 7-8. Agitation time

Table 4 **Distribution of valuable components in initial zinc concentrate**

Spectra	O	S	Fe	Cu	Zn	Pb	Outcome
Spectrum 1	17,25	16,74	3,00	0,82	18,85	43,34	100,00
Spectrum 2	7,88	44,42	30,64	-	17,06	-	100,00
Spectrum 3	15,98	21,79	3,46	-	30,27	28,50	100,00
Spectrum 4	4,71	31,24	3,31	0,93	59,81	-	100,00
Spectrum 5	10,74	17,45	3,47	1,47	20,34	46,53	100,00
Average	10,98	30,58	16,82	1,15	38,44	37,52	
Maximum	17,25	44,42	30,64	1,47	59,81	46,53	
Minimum	4,71	16,74	3,00	0,82	17,06	28,50	

with butyl xanthogenate and foaming agent consisted 3 minutes, with depressors 10 minutes followed by main flotation of 3 minutes. All open experiments were conducted at the temperature of 30-32 Celsius, with pulp density of 25-30 %.

The research was carried out by open experiments according to the scheme shown in Figure 2. The flotation was carried out through Mekhanobr laboratory flotation machine, with a chamber volume of 1 dm^3.

To obtain high-quality zinc concentrate, preliminary hydraulic classification is required, i.e. it is required to exclude harmful influence of fine sludge. For this purpose, it is recommended to make hydraulic classification (washing) of fine grades of zinc concentrate before regrinding and feeding of pulp for flotation [8,9].

In order to optimize the hydraulic classification process carried out in the thickener, and to reduce water consumption, it is necessary to determine the optimum sludge yield in this operation.

In this connection, open experiments were carried out on different sludge yields during washing.

The experiments were conducted at different washing rates and water flow rates to determine the optimum sludge yield.

The sludge yield was calculated based on the water consumption for washing and the performance of the thickener by draining.

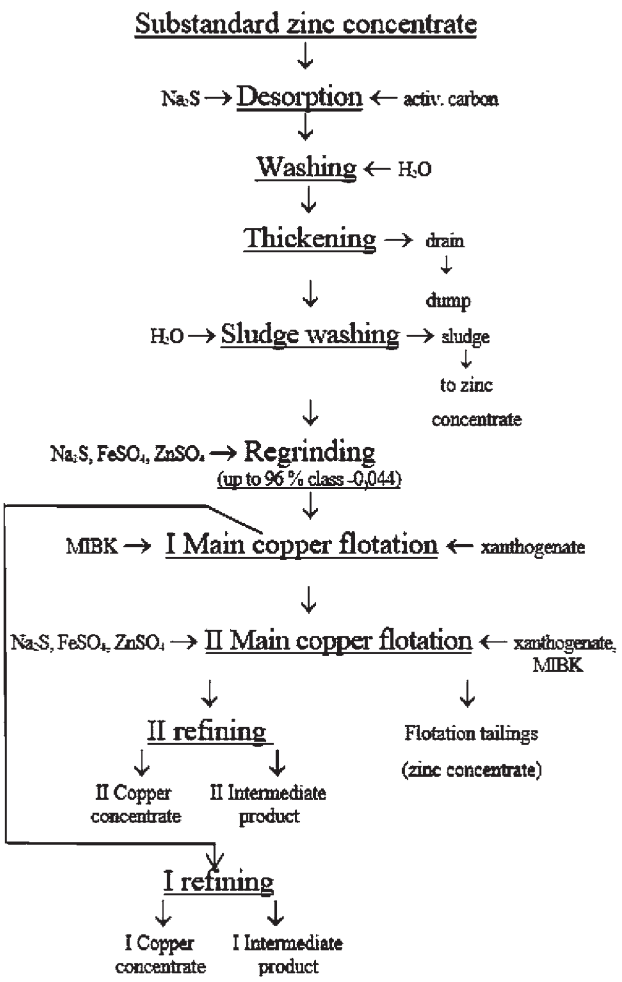

Figure 2 Scheme of open laboratory experiments

On the basis of the research data, taking into account factory productivity and the chosen thickener, the optimum degree of washing is considered to be a sludge yield of 3,5 %. The water consumption is 12 dm^3 per 200 g, accordingly 60 m^3 per 1 ton of concentrate product.

Open experiments carried out in laboratory conditions according to the scheme in Figure 2, using a factorial experiment, tested the effect of grinding time and depressants consumption (Na_2S - sulfuric sodium, $FeSO_4$ - iron sulfate, $ZnSO_4$ - zinc sulfate) for copper mass fraction in zinc concentrate product.

The research resulted in the confirmed following regularities of dependence of copper mass fraction in zinc concentrate on separate parameters under other equal conditions (Figures 3,4).

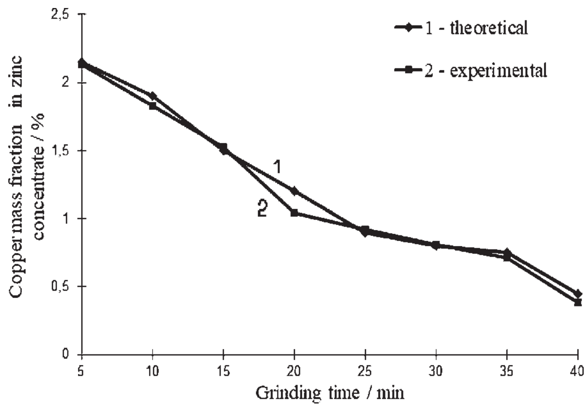

Figure 3 Dependence of copper mass fraction in zinc concentrate on the grinding time of the initial zinc concentrate

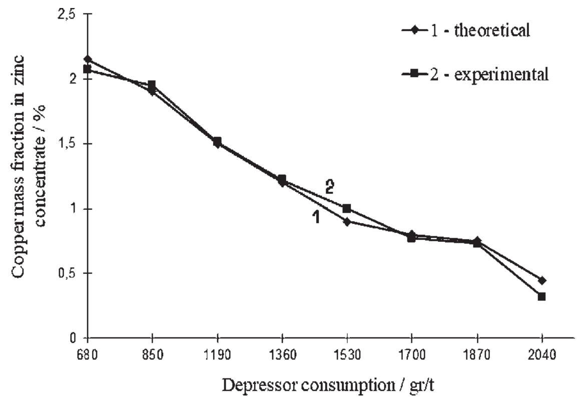

Figure 4 Dependence of copper mass fraction in zinc concentrate on depressor consumption

The results of preliminary hydraulic classification of the material before flotation showed that this operation has a significant impact on crude zinc concentrate quality. According to previous studies [6,10] and the practice of zinc concentrate enrichment at Zhezkent processing plant, the preliminary washing of the initial concentrate before milling ensures the production of high-quality zinc concentrate products. The sludge output when washing the initial zinc concentrate during this experiment consisted 3,5 % according to the closed-loop scheme.

Table 5 **Results of scheme experiments on zinc concentrate dressing**

Product Name	Output / %	Content / %			Extraction / %		
		Cu	Zn	Fe	Cu	Zn	Fe
Total copper concentrate	20,04	8,92	29,88	21,57	54,90	13,35	27,09
Flotation tailings	79,55	1,83	48,51	14,55	44,77	86,20	72,53
Sludge	0,41	2,60	49,00	15,00	0,33	0,45	0,39
Total tailings	79,96	1,90	47,00	15,00	45,10	86,65	72,91
Initial zinc concentrate	100,00	3,25	44,77	15,96	100,00	100,00	100,00

Increasing the grinding time has a significant impact on the crude zinc concentrate output, on the zinc content and its extraction. The increase of depressors consumption has a depressing effect on copper flotation and improvement of the crude zinc concentrate quality with a natural decrease in copper extraction.

RESULTS AND DISCUSSIONS

The results of scheme experiments are given in Table 5.

The results of the scheme experiment on the investigated sample of zinc concentrate showed:

- the possibility of obtaining conditioned zinc concentrate of KC-3 grade with zinc content of 47,0 % and copper content of 1,9 %, with their extraction of 86,65 % and 45,10 % respectively;
- copper product output with mass fraction of 8,92 % with its extraction of 54,9 %.

The results of closed-loop scheme experiment on dressing based on the investigated sample of zinc concentrate have demonstrated obtaining conditioned zinc concentrate of KC-3 grade with Zn 47,0 % and Cu 1,9 %, corresponding to the technical requirements for chemical composition of this product. At that, zinc extraction in flotation tailings is 86,65 %, compared to 72,77 % in earlier research on zinc concentrates conducted by Kazzinctech Ltd [10].

The commercial zinc concentrate is further processed to produce zinc in metallurgical production. It is recommended to process copper product by autoclave leaching.

CONCLUSION

The possibility of a regulated hydraulic classification of zinc concentrate in the thickener before dressing process has been determined. The sludge output was 3,5 %, at water consumption of 60 m^3 per 1 ton of concentrate.

The influence of grinding time, consumption of xanthogenate and depressors on the dressing process has been studied. The optimal technological scheme of substandard zinc concentrate dressing has been proposed.

The results of scheme experiment with the investigated zinc concentrate sample have are as follows:

- obtaining conditioned zinc concentrate of KC-3 grade with Zn content of 47,0 % and Cu 1,9 %, with their extraction of 86,65 % and 45,10 % respectively;
- copper output with a copper mass fraction of 8,92 % and its extraction of 54,9 %;
- an increase in the zinc mass fraction in zinc concentrate by 2,5-3 % due to a decrease in the mass fraction of copper and iron;
- additional copper product output with a mass fraction of 9 % and more, used in metallurgical production.

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