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 (Na₂S, FeSO₄, ZnSO₄). 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.
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.

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 (Na2S - sodium sulfate, FeSO4 - iron sulfate, ZnSO4 - zinc sulfate) at pH 7-8. Agitation time

![Figure 1 SEM of initial zinc concentrate (350 x magnification)](image-url)

<table>
<thead>
<tr>
<th>Product name</th>
<th>% of free mineral grains</th>
<th>Predominant size of minerals in the clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhezkent concentrate</td>
<td>91.3</td>
<td>77.7</td>
</tr>
</tbody>
</table>

**Table 2** Rational analysis of zinc concentrate

<table>
<thead>
<tr>
<th>Mineral Forms</th>
<th>Zinc concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Content / %</td>
</tr>
<tr>
<td>CuS</td>
<td>0,01</td>
</tr>
<tr>
<td>CuSs</td>
<td>0,17</td>
</tr>
<tr>
<td>CuSs</td>
<td>3,25</td>
</tr>
<tr>
<td>CuSs</td>
<td>3,43</td>
</tr>
<tr>
<td>ZnCO3</td>
<td>1,06</td>
</tr>
<tr>
<td>ZnSiO2</td>
<td>0,34</td>
</tr>
<tr>
<td>ZnS</td>
<td>41,82</td>
</tr>
<tr>
<td>ZnSs</td>
<td>43,22</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Spectra</th>
<th>O</th>
<th>S</th>
<th>Fe</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum 1</td>
<td>17,25</td>
<td>16,74</td>
<td>3,00</td>
<td>0,82</td>
<td>18,85</td>
<td>43,34</td>
<td>100,00</td>
</tr>
<tr>
<td>Spectrum 2</td>
<td>7,88</td>
<td>44,42</td>
<td>30,64</td>
<td>-</td>
<td>17,06</td>
<td>-</td>
<td>100,00</td>
</tr>
<tr>
<td>Spectrum 3</td>
<td>15,98</td>
<td>21,79</td>
<td>3,46</td>
<td>-</td>
<td>30,27</td>
<td>28,50</td>
<td>100,00</td>
</tr>
<tr>
<td>Spectrum 4</td>
<td>4,71</td>
<td>31,24</td>
<td>3,31</td>
<td>0,93</td>
<td>59,81</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Spectrum 5</td>
<td>10,74</td>
<td>17,45</td>
<td>3,47</td>
<td>1,47</td>
<td>20,34</td>
<td>46,53</td>
<td>100,00</td>
</tr>
<tr>
<td>Average</td>
<td>10,98</td>
<td>30,58</td>
<td>16,82</td>
<td>1,15</td>
<td>38,44</td>
<td>37,52</td>
<td>100,00</td>
</tr>
<tr>
<td>Maximum</td>
<td>17,25</td>
<td>44,42</td>
<td>30,64</td>
<td>1,47</td>
<td>59,81</td>
<td>46,53</td>
<td>100,00</td>
</tr>
<tr>
<td>Minimum</td>
<td>4,71</td>
<td>16,74</td>
<td>3,00</td>
<td>0,82</td>
<td>17,06</td>
<td>28,50</td>
<td>100,00</td>
</tr>
</tbody>
</table>
with butyl xanthogenate and foaming agent con-
sisted 3 minutes, with depressors 10 minutes fol-
lowed by main flotation of 3 minutes. All open ex-
periments 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 flota-
tion was carried out through Mekhanobr laboratory flo-
tation machine, with a chamber volume of 1 dm³.

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 pur-
pose, it is recommended to make hydraulic classifica-
tion (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 consump-
tion, 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 op-
timum sludge yield.

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

On the basis of the research data, taking into account
factory productivity and the chosen thickener, the opti-
mum degree of washing is considered to be a sludge yield
of 3.5 %. The water consumption is 12 dm³ per 200 g,
accordingly 60 m³ per 1 ton of concentrate product.

Open experiments carried out in laboratory condi-
tions according to the scheme in Figure 2, using a facto-
rial experiment, tested the effect of grinding time and
depressants consumption (Na₂S - sulfuric sodium,
FeSO₄ - iron sulfate, ZnSO₄ - 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 2 Scheme of open laboratory experiments

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 opera-
tion 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 out-
put when washing the initial zinc concentrate during
this experiment consisted 3.5 % according to the closed-
loop scheme.
gated zinc concentrate sample have are as follows: standard zinc concentrate dressing has been proposed. The optimal technological scheme of sub- theogenate and depressors on the dressing process has been studied. The sludge output was determined. The sludge output was

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 Kazzintech 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 m³ 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 sub-standard 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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REFERENCES


Note: The responsible translator for English language is E.V. Popkova, Ust’-Kamenogorsk, Kazakhstan

Table 5 Results of scheme experiments on zinc concentrate dressing

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