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EFFECT OF THE WATER-AIR EMULSION SIZE OF THE FOAMING AGENT SOLUTION ON THE NON-FERROUS METAL MINERALS FLOTATION ABILITY

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Preliminary Note – Prethodno priopćenje

The research objective is to study the effect of the water-air emulsion size of the foaming agent solution on the flotation ability of non-ferrous metal minerals. An air-water emulsion of a foaming agent solution was obtained in a water-air microemulsion generator. It has been established that the supply of microbubbles to the monomineral flotation process makes it possible to increase the yield of minerals with different dispersion ability and accelerate the flotation process by 10 - 15 %.

Keywords: non-ferrous metal, monomineral flotation, foaming agent, water-air microemulsion, size of minerals

INTRODUCTION

The overwhelming majority of ores processed at present in Kazakhstan are distinguished by the close intergrowth of very thin, up to colloidal, mineral inclusions. All the ore has to be finely ground since the mineral grains containing useful components are so small to open and release them into free particles applicable to be separated from the host rock. A significant part of the currently mined ores requires much deeper grinding up to 30 - 40 µm to open monomineral grains, while the optimal grain size for flotation beneficiation is ~ 70 µm. Itresults in the loss with microdispersions (superslimes) of a significant part of the opened monomineral grains containing enriched metals.

The low efficiency of micron-sized particles flotation extraction from ores is one of the important reasons for the large losses of valuable components in concentration plants. The use of combined microflotation with the water-air microdispersion production that will enable additional extraction of microdispersed valuable ore minerals, optimize the flotation process and obtain higher technological parameters, is one of the solutions to this problem.

In some works [1–4], options for increasing the efficiency of processing fine-dispersed ores using concentration methods and different reagent modes are considered.

In the middle of the last century, researchers [5-11] have shown that the most effective method to beneficatemicroparticles is flotation by aeration with gases released from their aqueous solution. The use of combined microflotation, where both micro- and macrobubbles are involved in the flotation process, can be one of these problem solutions.

It is theoretically shown [12-13] that the solution to the flotation problem for particles with a size less than 25 µm can be achieved only by using air bubbles that size does not exceed 50 µm, in the flotation process. The air bubbles used in the process are formed outside the treated pulp in the form of a concentrated water-air microemulsion performing the fundamental difference between this method and conventional flotation.

The research aimed to use combined microflotation [14-18] thatenables to additional extract the finely-dispersed minerals lost with flotation tailings and obtain concentrates with a high extraction of the useful component, are relevant and economically feasible.

This work purpose is to study the effect of the water-air microdispersionnature on the flotation ability of non-ferrous metals sulfide minerals. The water-air microdispersion of the foaming agent solution is obtained in the generator and the obtained microdispersion contains 66 - 70 % of gas in the form of microbubbles.

MATERIALS AND METHODS

Objects of the research are the foaming agents: oxal T-92, dialkyldithiophosphate BTF-163. The analysis of the foaming agent solutions surface tension with various concentrations (solution pH is 8,5 - 9) was performed with a KRUSS tensiometer, K20 Easy Dyne series (Table 1).

The results show that the smallest surface tension has solutions at a concentration of 2,5 mg/cm^3 for T-92, 5,0 mg/cm^3 for BTF-163.

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Table 1 **Surface tension of the starting reagents**

Name	Concentration/ mg/cm^3	t/ °C	σ/ mN/m
Water	-	22,0	72,6
T-92	0,25	22,3	60,2
T-92	0,5	21,7	55,1
T-92	2,5	21,6	48,4
BTF-163	0,5	22,1	46,1
BTF-163	2,5	22,2	45,2
BTF-163	5,0	21,9	42,4

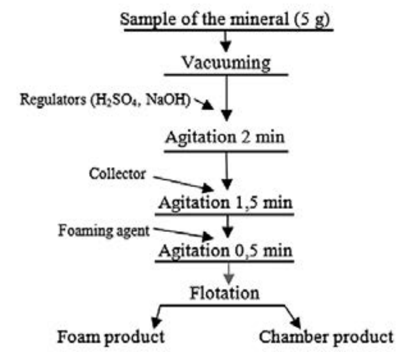


Figure 1 Monomineral flotation flow diagram

Then these solutions are passed through a water-air microemulsion generator. It forms a water-air microemulsion. The microbubbles' size and the amount depend on the foaming agent concentration. The obtained water-air microemulsions were investigated on a Photocor Compact particle size analyzer.

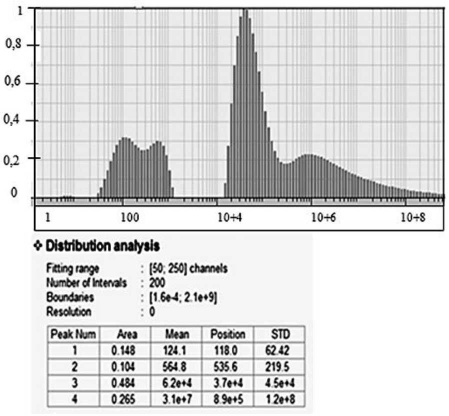
The water-air microemulsion effect on the monominerals (chalcopyrite, galena, sphalerite, pyrite) flotation ability has been studied. The minerals were ground in a porcelain mortar; the weight was 5 grams. Flotation was performed in a laboratory FL type (Russia) flotation machine with a volume of 50 cm^3. The impeller rotation speed was 1100 revolutions per minute. The minerals were mixed with water, evacuated; then reagents were supplied and processed in agitation and aeration modes (Figure 1).

Sodium butyl xanthate (consumption 5 mg/dm^3) was used as a collector. Foaming agent consumption is 15 mg/dm^3.

Monomineral flotation was performed at different dispersion ability of chalcopyrite, galena, sphalerite, and pyrite minerals: - 0,074 + 0,044 mm; - 0,044 + 0,020 mm; - 0,020 + 0 mm. Foaming agents were supplied in the form of solutions (basic mode) and the form of a water-air microemulsion.

RESULTS AND DISCUSSION

The optimal dimensions of the water-air microemulsion were obtained at concentrations of 2,5 mg/cm^3 for T-92, 5,0 mg/cm^3 for BTF-163 (Figures 2, 3).

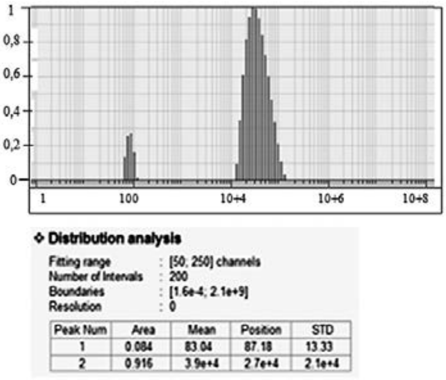


❖ **Distribution analysis**

Fitting range : [50; 250] channels
Number of Intervals : 200
Boundaries : [1.6e-4; 2.1e+9]
Resolution : 0

Peak Num	Area	Mean	Position	STD
1	0.148	124.1	118.0	62.42
2	0.104	564.8	535.6	219.5
3	0.484	6.2e+4	3.7e+4	4.5e+4
4	0.265	3.1e+7	8.9e+5	1.2e+8

Figure 2 Distribution of microbubble particles (T-92, 5 mg/cm^3)



❖ **Distribution analysis**

Fitting range : [50; 250] channels
Number of Intervals : 200
Boundaries : [1.6e-4; 2.1e+9]
Resolution : 0

Peak Num	Area	Mean	Position	STD
1	0.084	83.04	87.18	13.33
2	0.916	3.9e+4	2.7e+4	2.1e+4

Figure 3 Distribution of microbubble particles (BTF-163, 2,5 mg/cm^3)

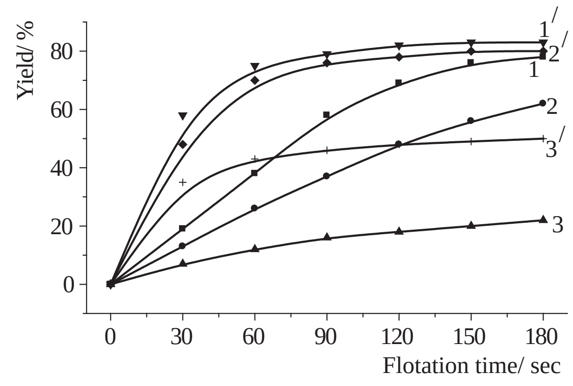
Optimal distributions were obtained at concentrations of T-92 5,0 mg/cm^3, BTF-163 2,5 mg/cm^3.The average particle size of microbubbles is 27 µm, the content (fraction) of these particles is 63,5 % for T-92 solution with a concentration of 2,5 mg/cm^3 (Figure 2). The average particle size of microbubbles is 22 µm, the content (fraction) of these particles is 87,6 % for a BTF-163 solution with a concentration of 2,5 mg/cm^3 (Figure 3).

Monomineral flotation results versus time are shown in Figures 4-7.

In Figures 1-3 corresponds to the size of minerals 1) - 0,074 + 0,044 mm; 2) - 0,044 + 0,020 mm; 3) - 0,020 + 0 mm in the basic mode, "1$^{/}$;2$^{/}$;3$^{/}$"corresponds to the size of minerals using microemulsion.

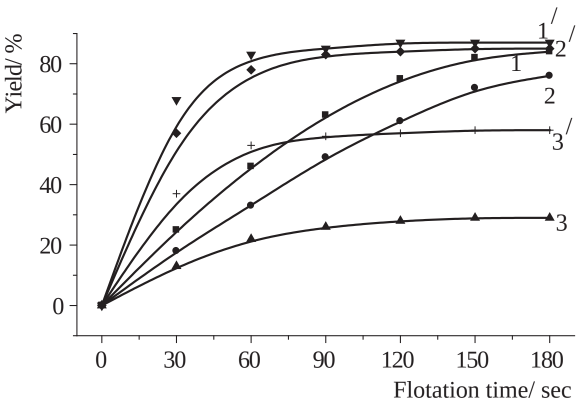
The research results showed that the mineral yield increases from 78 to 83 % during flotation of chalcopyrite with a dispersion ability of - 0,074 + 0,044 mm with the microbubbles additional use; the mineral yield increases from 62 to 80 % with a dispersion ability of - 0,044 + 0,020 mm; the mineral yield increases from 22 to 50 % with a dispersion ability of - 0,020 + 0 mm.

The mineral yield increases from 84 to 87 % during flotation of galena with a dispersion ability of - 0,074 + 0,044 mm with the microbubbles additional use; the mineral yield increases from 76 to 85 % with a dispersion ability of - 0,044 + 0,020 mm; the mineral yield



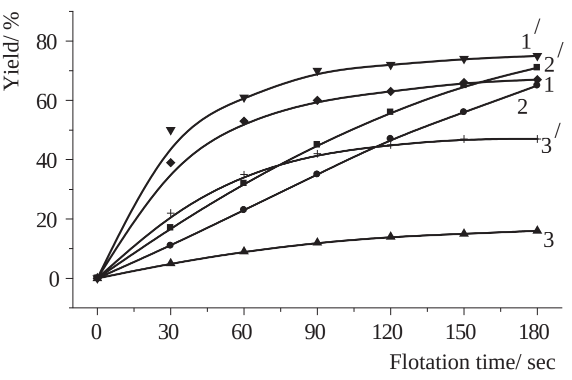
Note: 1 - size - 0,074 + 0,044 mm;
2 - size - 0,044 + 0,020 mm;
3 - size - 0,020 + 0 mm
$1^{/}$ - size - 0,074 + 0,044 mm using microemulsion;
$2^{/}$ - size - 0,044 + 0,020 mm using microemulsion;
$3^{/}$ - size - 0,020 + 0 mm using microemulsion

Figure 4 Flotation time dependence of the chalcopyrite flotation ability



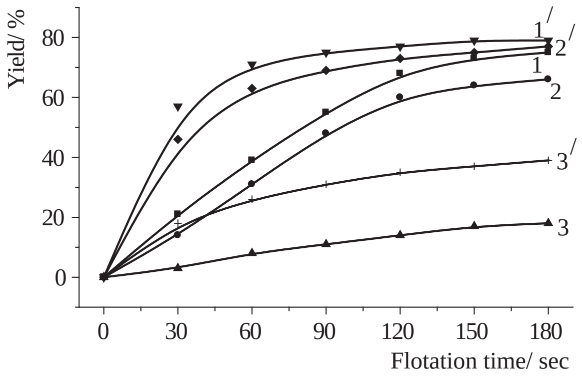
1, 2, 3, $1^{/}$, $2^{/}$, $3^{/}$ see Note below Figure 4.

Figure 5 Flotation time dependence of the galena flotation ability



1, 2, 3, $1^{/}$, $2^{/}$, $3^{/}$ see Note below Figure 4.

Figure 6 Flotation time dependence of the pyrite flotation ability



1, 2, 3, $1^{/}$, $2^{/}$, $3^{/}$ see Note below Figure 4.

Figure 7 Flotation time dependence of the sphalerite flotation ability

increases from 29 to 58 % with a dispersion ability of - 0,020 + 0 mm.

The mineral yield increases from 71 to 75 % during flotation of pyrite with a dispersion ability of - 0,074 + 0,044 mm with the microbubbles additional use; the mineral yield increases from 65 to 67 % with a dispersion ability of - 0,044 + 0,020 mm; the mineral yield increases from 16 to 47 % with a dispersion ability of - 0,020 + 0 mm.

The mineral yield increases from 75 to 79 % during flotation of sphalerite with a dispersion ability of - 0,074 + 0,044 mm with the microbubbles additional use; the mineral yield increases from 66 to 77 % with a dispersion ability of - 0,044 + 0,020 mm; the mineral yield increases from 18 to 39 % with a dispersion ability of - 0,020 + 0 mm.

Thus, the presented results show that the supply of a foaming agent in the form of microbubbles to the monomineral flotation process can increase the yield of minerals with a various dispersion ability and accelerate the flotation process by10 - 15 %.

Acknowledgments

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REFERENCES

[1] Tusupbaev N.K., Semushkina L.V., Turysbekov D.K., Bekturganov N.S., Mukhamedilova A.M. Use of modified flotation reagents in the processing of technogenic raw materials, Kompleksnoye ispol’zovaniye mineral’nogo syr’ya (2017) 1, 78-82. http://kims-imio.kz

[2] Malyshev V.P., Katkeeva G.L., Zubrina Yu.S., Oskembekov I.M., Gizatullina D.R. Development of a complex probabilistic-deterministic model of grinding and flotation processes, Kompleksnoye ispol’zovaniye mineral’nogo syr’ya (2017) 1, 47-53. http://kims-imio.kz

[3] Chanturiya, V.A., Kenzhaliev, B.K., Lozhnikov, S.S., Amirova, M.D., Bortsov, V.D. Improvement of mineral processing technology for the ores from sulfur-polymetallic deposits, Tsvetnye Metally (2005) 1, 16-19.

[4] Kenzhaliyev B.K. et al. Extraction of gold from flotation tails of gold-processing plant, News of the national academy of sciences of the Republic of Kazakhstan-series chemistry and technology (2017) 6, 62-69.

[5] Glembotskiy A.V. Flotation of ultrafine particles, Tsvetnye Metally (1978) 7, 112-114.

[6] Sebba F. An improved generator for micron-sized bubbles, Chemistry and Industry (1985) 4, 91-92.

[7] Karger B., Grieves R.B., Lemlich R., Rubin A.J., Sebba F. Nomenclature recommendations for adsorptive bubble separation methods, Separation Science 401 (1967) 2.

[8] Anfruns J.F., Kitchener J.A. Rates of capture of small particles in flotation, Transactions of the Institution of Mining and Metallurgy, Section C: Mineral Processing and Extractive Metallurgy (1977) 86, 9-15.

[9] Glembotskiy V.A., Klassen V.I. Flotation, Handbook of Ore Beneficiation, Moscow, “Nedra”, 1974.

[10] Bocharov V.A., Vigdergauz V.E. Flotation of sulphide finely-dispersed mineral systems, Tsvetnye Metally (1997) 3, 8-11.

[11] Ultarakova D.D., HyreminYu.P., Zagainov V.G. Development of a flotation method with ejector aeration with the gases release from the liquid phase, Industry of Kazakhstan (2007) 2, 58.

[12] Rulyov N.N. Turbulent microflotation: Theory and Experiment, Colloids & Surfaces A: Physicochemical and Engineering Aspects (2001) 192, 73–91.

[13] Rulyov N.N. Turbulent microflotation of ultra-fine minerals, Mineral Processing and Extractive Metallurgy 117 (2008) 1, 32-37.

[14] Calgaroto S., Azevedo A., Rubio J. Flotation of quartz particles assisted by nanobubbles, International Journal of Mineral Processing 137 (2015), 64-70.

[15] Ahmadi R., Khodadadi D.A., Abdollahy M., Fan M. Nano-microbubble flotation of fine and ultrafine chalcopyrite particles, International Journal of Mining Science and Technology 24 (2014), 559-566.

[16] Rulyov N.N., Turysbekov D.K., Semushkina L.V., Narbekova S.M. Combined microflotation of fine dispersed minerals, Tsvetnye Metally (2017) 9, 14-20. DOI 10.17580/tsm.2017.09.02.

[17] Rulyov N.N., Tussupbayev N.K., Turusbekov D.K., Semushkina L.V., Kaldybaeva Zh.A. Effect of microbubbles as flotation carriers on fine sulphide ore beneficiation, Mineral Processing and Extractive Metallurgy 127 (2018), 133-139.

[18] Tussupbayev N.K., Zhantasov N.N., Omarov A.T., et al., Method for multicomponent microflotation of finely-disseminated ores of non-ferrous and precious metals and a device for its implementation, Kazakhstan patent No. 4039 (07.06.2019.)

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