

## ANNOTATION

dissertation for the degree of Doctor of Philosophy (PhD)  
in the educational program 8D07203 – «Metallurgy»

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### **DEVELOPMENT OF THE TECHNOLOGY FOR THE ENRICHMENT OF OXIDIZED COPPER ORES USING A MODIFIED REAGENT**

#### **Relevance of the dissertation work.**

The mining and metallurgical complex plays an important role in the world, and in particular in Kazakhstan, too, and is the basis of the country's economy. Kazakhstan is one of the ten leading world producers in the extraction and production of mineral raw materials and has huge reserves of copper ore. 6% of the world's explored copper reserves are located in the bowels of Kazakhstan.

Enrichment is an important stage in the processing of copper ores and traditionally copper raw materials are enriched by flotation. But the use of this method in the processing of oxidized copper ores is inefficient. The problem is caused by the natural hydrophilicity of oxidized copper minerals, which necessitates the search for new technologies.

Due to the insufficient efficiency of flotation methods, combined processes are of great importance, of which only the LSF process (leaching - sedimentation - flotation) and sorption-filtrationless technology are used in domestic practice. These processes have significant difficulties in implementation, as they require special expensive equipment and are dangerous for the ecological situation of industrial regions.

The latest development of Kazakh scientists is a method of flotation enrichment of oxidized copper ores with preliminary sulfidization with a modified sulfiding agent.

The technology proposed for development provides for preliminary sulfidization of oxidized copper ore with a reagent-modified sulfidizer without heating, and subsequent froth flotation in the flotation cell.

The feedstock is oxidized copper ores, which can replenish the raw material base of the copper industry. However, until now, oxidized copper ores are not processed, but stored in dumps, which increases the cost of developing copper deposits and complicates the environmental situation around these deposits. In this regard, this work is relevant both from an economic and environmental point of view.

**The purpose of the work** is to develop an effective technology for the flotation enrichment of oxidized copper ores with preliminary treatment of raw materials with a modified reagent.

To achieve the goal, the following **tasks** were solved:

- to investigate the material composition of oxidized copper ore and determine the chemical, granulometric composition of mineral raw materials;
- to conduct a thermodynamic analysis of the interaction of the components of ore sulfidization with a modified reagent;
- to develop a scheme for sulfiding and flotation of oxidized copper ore using the experiment planning method;

- to determine the optimal conditions for sulfiding oxidized copper ore modified with a reagent and flotation of prosulfided ore;
- test the developed technology in integrated laboratory tests.

**The scientific novelty of the study is as follows:**

- carrying out a thermodynamic analysis of the interaction of the modified reagent with oxidized copper minerals - malachite, azurite and chrysocolla. Establishment of the fundamental possibility of sulfidation of these minerals with a modified reagent at room temperature;
- justification of the effectiveness of using the modified reagent by the results of laboratory studies on sulfidization and flotation of oxidized copper ore from the Zhezkazgan deposit;
- study of the kinetics of ore sulfidation with sodium polysulfide and modified reagent at room temperature;
- determination of optimal conditions for sulfidation of oxidized copper ore with a modified reagent;
- conducting research on the flotation of oxidized copper ore from the Zhezkazgan deposit with preliminary sulfidization with a modified reagent in a mill.

**The practical value of the work.**

- The chemical, mineralogical and granulometric composition of oxidized copper ore was studied.
- A thermodynamic analysis of the interaction of the modified reagent with oxidized copper was carried out.
- Schemes for sulfiding and flotation of oxidized copper ore with a modified reagent have been developed.
- The temperature dependence of the standard Gibbs energy of the sulfidation reaction has been determined.
- It was determined that the modified reagent is superior to sodium polysulfide in terms of sulfidization efficiency in the range of 0-1 min. by an average of 40%, in the range of 1-5 minutes. by 55%.
- The optimal conditions for sulfiding oxidized copper ore with a modified reagent were determined: 20-40% of the stoichiometry of the reaction with oxidized copper with a process duration of 1-5 minutes.
- The scheme of ore sulfiding was determined, which excludes forced heating of the pulp and allows the process to be carried out in the mill in parallel with ore grinding.
- Studies were carried out on the flotation of oxidized copper ore from the Zhezkazgan deposit with preliminary sulfidization with a modified reagent in a mill.
- The process of flotation of oxidized copper ore from the Zhezkazgan deposit with preliminary sulfidization of the ore with a modified reagent was studied. The dependence of the extraction of copper into the flotation concentrate on the costs of the sulfidizer and collector (potassium butyl xanthate), the time of agitation of the pulp with the sulfidizer has been obtained. On the basis of partial dependencies, a mathematical model of the process is obtained in the form of a generalized multifactorial equation.

- The optimal flotation conditions were determined - 30% sulfidizer, 500 g/t collector and 4 min. agitation of the pulp with a sulfidizer, which ensures the extraction of copper into the flotation concentrate by 90.2%.

#### **Research methods.**

During the performance of the work, experimental and theoretical studies were carried out, analysis of patent and scientific and technical literature, experiments were carried out using physicochemical, mathematical research methods. To establish the composition of the feedstock and the resulting products, various methods of analysis were used - chemical, X-ray phase, granulometric. The research results were formalized in accordance with regulatory requirements.

Chemical analysis methods were used to study the composition of oxidized copper ore, wt., %:  $Cu_{com.}$  - 1.2;  $Cu_{ox.}$  - 1.08;  $SiO_2$  - 66.57;  $Al_2O_3$  - 9.91;  $CaO$  - 2.01;  $Fe$  - 2.67;  $MgO$  - 1.29;  $S_{com.}$  - 0.08.

The flotation process was investigated by the experimental design method. A mathematical model of the process is obtained in the form of a generalized multifactorial equation.

#### **The main provisions of the work submitted for defense:**

- results of chemical, mineralogical, sieve and spectral analysis of feedstock;
- the results of thermodynamic analysis and the fundamental possibility of the interaction of the modified reagent with oxidized copper;
- results of sulfidization of oxidized copper ore with a modified reagent;
- results of a study on the flotation of oxidized copper ore;
- results of experiments on optimizing the conditions for sulfiding oxidized copper ore with a modified reagent and flotation of prosulfided ore.

#### **Place of performance of research work.**

The work was carried out at the Department of "Nanotechnology and Metallurgy" of Karaganda Technical University, in the laboratory of "Chemistry and Technology of high-silicon materials" of the Chemical and Metallurgical Institute named after Zh. Abishev within the framework of the grant theme 2132/GF "Development of an effective technology for the enrichment of oxidized copper ores using a modified reagent" (performer).

#### **Personal contribution of a doctoral student to writing a dissertation.**

The author participated in determining the purpose of the work and setting research objectives, as well as in writing articles and abstracts. Personally, the author obtained the main part of the scientific and practical results of this work, which determines both the scientific novelty and the practical value of the work as a whole. In addition, the entire complex of applied work on the development of schemes for sulfidation and flotation of oxidized copper ore with a modified reagent was carried out within the framework of grant financing projects, where the author was the executor.

#### **Approbation of the work.**

According to the results of the conducted research, 9 works have been published in domestic and foreign publications, including:

- 1 article in the international scientific journal ("Ore Enrichment" (Russia) – percentile 46;

- 3 articles recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan ("Bulletin of the KarSU Chemistry series" (Karaganda, Kazakhstan), "Integrated use of mineral raw materials" (Almaty, Kazakhstan), "Proceedings of the University" (Karaganda, Kazakhstan);

- 4 reports in international scientific conferences;

- received 1 patent of the Republic of Kazakhstan for the invention "Method of enrichment of oxidized copper ore".

**The structure and scope of the dissertation.** The dissertation work consists of an introduction, the main part of 5 chapters, conclusions, appendices. The volume of the dissertation is 103 pages of typewritten text, the work contains 38 figures, 36 tables, a list of used sources, including 80 titles.