ABSTRACT

for dissertation work on the topic:

"IMPROVING OF TECHNOLOGY OF CONVERTING OF COPPER-LEAD MATTES BY SULFIDING",

submitted for the degree of Doctor of Philosophy (PhD)

according to the educational program 8D07204 - "Metallurgical engineering"

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The aim of the dissertation work is to improve the technology of converting copper-lead mattes by direct processing of high-sulfur copper concentrate in converters together with matte and its simultaneous use as a sulfidizing agent, which provides deep extraction of copper into blister copper and related metal impurities (lead, arsenic, antimony, etc.) - into the dust.

The object of research is the process of converting copper-lead mattes of the Kazzinc LLP.

The subject of the study is the theoretical and practical features of the process of converting copper-lead mattes in the conditions of Kazzinc LLP; thermodynamics of copper-lead mattes; physical and chemical patterns that occur during the interaction of the components of copper-lead matte with high-sulfur copper concentrate; distribution of metals between conversion products during joint processing of mattes with high-sulfur copper concentrate.

Research objectives:

- based on a systematic analysis of the current state of converting copper and polymetallic mattes, making a choice to improve the process of converting copper-lead mattes and scientific substantiation of the direction of research. Establishment of key problems of converting copper-lead mattes in Kazzinc LLP, which reduce the quality of the obtained products.
- conducting research on the forms of presence of metals and the behavior of copper, lead and related metal impurities (Pb, As, Sb) during converting copper-lead mattes in the conditions of Kazzinc LLP.
- study of the equilibrium thermodynamics of the system copper-lead matte - gas phase under conditions of controlled values of P_{O2} and P_{S2}, typical for the process of converting industrial matte.
- study of the solubility of oxygen in copper-lead mattes with the establishment of quantitative ratios of wuestite (FeO) and magnetite (Fe_3O_4) in them.
- development of technology for converting copper-lead mattes together with high-sulfur copper concentrate.
- carrying out a feasibility study with the calculation of the economic efficiency of a new technology obtained from the conversion of copper-lead mattes together with high-sulphur copper concentrate.

Research methods. The work uses a comprehensive approach that combines the use of modern approaches to thermodynamic calculations and new research methods using technical tools and high-precision instruments: atomic absorption

analysis (PinAAcle spectrometer, PerkinElmer), optical emission analysis (inductively coupled plasma spectrometer Agilent 710 ES), thermogravimetric analysis (MettlerToledo analyzer), X-ray phase analysis (PANalytical X'Pert PRO X-ray diffractometer), structural analysis (JEOL Ltd. JSM-6390LV scanning electron microscope), IR spectroscopic analysis (FT IR spectrometer -801 from Simex).

The main provisions (proven scientific hypotheses and other conclusions that can be counts as new knowledge) submitted for defense:

– Results of thermodynamic analysis of reactions occurring during the joint processing of copper-lead mattes together with high-sulfur copper concentrate.

– Results of studies on the distribution of copper, lead, arsenic and antimony between products obtained under the conditions of converting copper-lead mattes together with high-sulfur concentrate.

– Kinetic patterns of sublimation of arsenic, antimony and lead under the conditions of converting copper-lead mattes together with copper concentrate.

– Thermodynamics of the Cu–Pb–Fe–S–O system under controlled P_{O2} and P_{S2} values. Results on the solubility of oxygen in copper-lead mattes.

– Optimal parameters and technological indicators of a new technology for converting copper-lead mattes by direct processing of high-sulfur copper concentrate in converters and its simultaneous use as a sulfidizing agent.

Description of the main results of the study:

- New data on the solubility of oxygen in copper-lead mattes have been obtained. For the first time, the quantitative ratios of FeO and Fe_3O_4 in copper-lead mattes were established, and the mechanism of their formation was recommended. It has been established that a decrease in the PbS content in copper-lead mattes leads to an increase in the FeO content and a decrease in Fe_3O_4. It has been shown that, at elevated PbS concentrations, oxygen anions bound in wuestite are replaced by sulfur anions bound in PbS. Oxygen bound into magnetite is practically not replaced by sulfur. Quantitative mathematical models have been constructed that predict the content of FeO and Fe_3O_4 in real copper-lead mattes depending on changes in their composition.

- On the basis of thermodynamic analysis of interaction reactions between high-sulfur copper concentrate components and copper-lead matte, the possibility of using the concentrate as a sulfiding agent to improve the quality of converter slag and blister copper is shown. When converting copper-lead mattes together with high-sulfur copper concentrate, a high extraction of Pb, Zn, As and Sb into dust was achieved: 97.62; 95.77; 91.0 and 75%, respectively. The copper content in the slag is reduced from 2.5 up to 1.3 wt.%; magnetite - from 18 to 10 wt.%.

- For the first time, mathematical models have been built that allow predicting the distribution of metals and the temperature of the process of converting copper-lead mattes together with high-sulfur copper concentrate, depending on the composition of the initial and obtained products, as well as the duration of the process.

Substantiation of the novelty and importance of the obtained results.

The current state of copper production is characterized by the fact that raw materials with a low content of non-ferrous and a high content of associated harmful metal impurities are involved in processing. This led to the production of complex polymetallic mattes with a high content of harmful impurities. Their further processing by converting led to an increase in emissions of harmful substances into the atmosphere and increased the burden on the environment and human health. From a technological point of view, the quality of converting products, such as blister copper, converter slag and dust, has significantly decreased due to the concentration of associated metal impurities in them. This problem acquires particular relevance in the conditions of converting copper-lead mattes of lead production at Kazzinc LLP, where the mattes are characterized by an increased content of harmful metal impurities: up to 25% lead, up to 4% arsenic and up to 1.0% antimony. As a result of converting such mattes, blister copper is obtained with a low copper content (96-98%) and a high content of impurities (As, Sb, Pb, etc.). Turnover converter slags of the 1st conversion period contain up to 35% lead, up to 3% copper and up to 1.5% (in total) arsenic and antimony. Due to the absence of an alternative method for processing copper-lead mattes, converting remains the main process for obtaining blister copper in the general technological scheme of copper and lead production of the Kazzinc LLP.

The new technology for converting copper-lead mattes developed in the work can significantly improve the quality of the converting products due to the deep extraction of copper into blister copper, and associated metal impurities (lead, arsenic, antimony, etc.) into dust, by direct processing of high-sulfur copper concentrate in converters together with matte and its simultaneous use as a sulfidizing agent.

Compliance with the directions of development of science or government programs.

The scientific and technical analysis of the existing technology for converting copper-lead mattes showed a low recovery of copper into blister copper ~ 80% and a redistribution of Pb, As, Sb between the converting products in the direction of deterioration, which led to the decrease in the quality of the products obtained. It is shown that the low recovery of copper is due to increased distribution of copper into converter slag up to 15%, and insignificant, up to 5%, its transition to dust. The distribution of lead in blister copper is ~1.5%. At the same time, the extraction of lead into dust is at a low level and amounts to 40%. Up to 60% of lead from its total amount is concentrated in the converter slag. The situation with the distribution of arsenic and antimony is somewhat different. The main part of arsenic up to 70% turns into dust. 22% is concentrated in the converter slag, the remaining part - 7%, is distributed into blister copper. 26.2% of antimony passes into blister copper, which is four times higher than that of arsenic. As a result of the low sublimation of antimony, its distribution into dust is insignificant, and is only 40%. The rest of antimony - up to 36%, is concentrated in the converter slag.

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Description of the contribution of the doctoral student to the preparation of each publication.

The author's personal contribution consists in setting the goal and objectives of the work, conducting experimental studies, processing and analyzing the results, formulating conclusions, writing articles and abstracts.

On the topic of the dissertation, 7 scientific papers were published in peer-reviewed scientific journals and publications determined by the Higher Attestation Commission, including: in the WOS database - 1 article, in the Scopus database - 2 articles, in the RSCI database - 1 article, in journals recommended by KOKSON MON RK - 3 articles.

The main results of the dissertation work were reported and discussed at the International scientific and practical conferences:

1. Dosmukhamedov N.K., Zholdasbay E.E., Kurmanseitov M.B., Argyn A.A., Abzhan K. Research of influence of temperature and partial pressure of oxygen on the solubility of copper and lead in slags. International Conference Process Management and Scientific Developments. Birmingham, United Kingdom, December 19, 2019. P.139-149.
2. Досмухамедов Н.К., Аргын А.А., Жолдасбай Е.Е. Поведение соединений меди и сопутствующих металлов-примесей в процессе конвертирования медно-свинцовых штейнов. Сб.научных статей Межвузовского научного конгресса «Высшая школа: Научные исследования». Москва. 2020. С.127-139.
3. Досмухамедов Н.К., Егизеков М.Г., Аргын А.А., Жолдасбай Е.Е. To the Thermodynamics of Copper-lead matte. International University Science Forum Science Education Practice. Part 1. Toronto, Canada. 2020. P.167-175.
4. Dosmukhamedov N.K., Zholdasbay E.E., Argyn A.A. Losses of copper and precious metals with slag in mine smelting of copper-, lead containing raw materials. Collection of scientific papers on materials X International Scientific Conference General question of world science. Amsterdam, 31.07.2020. P. 22-30.
5. Dosmukhamedov N.K., Kaplan V.A., Zholdasbay E.E., Argyn A.A. Cu, Pb, Zn And As Distribution In The Slag Treatment Process. MOLTEN 21, 11th International Conference on Molten Slags, Fluxes and Salts. 21-25 Feb. 2021, Seoul, Korea.