ABSTRACT

of **Pazylova Dana Temirbekovna's dissertation work**

on the topic "Development of a technology for extracting non-ferrous metal chlorides from lead slags using distiller waste", submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D072000 – "Chemical technology of inorganic substances"

The relevance of the topic under study. In modern conditions, when the issue of protecting the environment from harmful industrial impacts has become particularly acute all over the world, research in the field of processing various industrial wastes, in particular lead slags and a waste formed at the producing soda ash – distiller waste, is becoming more important.

Currently, the problem of distiller waste disposal is very relevant for all countries that produce soda ash using this method. The existing technologies for processing, recycling and using this industrial waste solve the problem only partially due to the large amount of the waste generated, so when obtaining 1 tonne of soda ash, 9-10 m^3 of distiller waste is formed. As a result, the waste is mainly accumulated in sludge collectors or discharged into water bodies located near existing production facilities.

At the same time, in the metallurgical industry of the Republic of Kazakhstan, a significant amount of waste slag has accumulated in the production of lead. At present time, this slag has practically not been fully utilized and has a detrimental effect on the environment. In general, in Kazakhstan, the total amount of non-ferrous metallurgy wastes reaches more than 5 billion tonnes.

In this regard, the proposed comprehensive waste-free technology for processing the waste lead slag using distiller waste as a chlorine-containing agent, that allows us to extract non-ferrous metals in the form of inorganic chlorides and a heat-insulating material, is relevant and timely.

Research purpose and objectives. Scientific substantiation of a non-waste processing of distiller waste and waste lead-containg slag with simultaneous extraction of non-ferrous metals' inorganic chlorides and obtaining a heat-insulating material.

To achieve the purpose, the following **scientific objectives** were solved:

- analysis of the current state of formation, use and processing of distiller waste and waste Zn-Pb-Cu containing slags was implemented;
- physical and chemical studies of distiller waste formed at the soda ash production and lead slags were carried out;
- thermodynamic modeling of the interaction of the distiller liquid's components with the technogenic waste was carried out;
- kinetic regularities and features of the chloride sublimation of non-ferrous metals' chlorides from the waste lead production slag in the presence of distiller waste were studied;
- the optimal parameters of the chloride sublimation of inorganic chlorides of non-ferrous metals with the simultaneous production of a heat-insulating

material from the waste lead slag using distiller liquid as a chlorine agent were determined.

Research objects. Waste from the production of soda ash – distiller waste and waste slag from lead production.

Research methods. The research was implemented by means of the thermodynamic modeling technique (full thermodynamic analysis) using the HSC-5.1 Chemistry software package developed by Outokumpu Research Oy, based on the minimum Gibbs energy principle. Kinetic studies and mathematical planning of experiments were carried out using the rotatable second-order experiment planning design – the Box-Hunter method; the reliability of the experimental results was ensured by the use of modern technical means of physical and chemical analysis – a JEOL brand scanning electron microscope (SEM), an IR Fourier spectrometer Shimadzu IR Prestige-21, an X-ray phase analyzer DRON-3, Q-derivatograph for the differential thermal analysis, and mass spectrometer MSH-3A.

Connection with the plan of scientific research works. The dissertation work was carried out at the department "Technology of inorganic and petrochemical productions" of the M. Auezov South Kazakhstan University in accordance with the plan of state budget research works for 2016-2020 – B-16-02-03 "Research on the development of alternative innovative technologies for concentrating raw materials and manufacturing products of synthesis of inorganic compounds from natural ore and mineral resources and technogenic wastes from various industries" and for 2021-2025 – B-21-03-02 "Development of new promising technologies and improvement of traditional technologies for the production of inorganic products, environmentally friendly fertilizers and plant growth stimulants based on mineral raw materials and industrial waste".

Scientific novelty of the research:

- the start temperature of the equilibrium chloride sublimation of lead, zinc, and copper from the waste lead slag using distiller liquid was established;
- it was found that under equilibrium conditions, an increase in the chloride sublimation degree of inorganic metal chlorides is observed in the following series $PbCl_2 > ZnCl_2 > CuCl$;
- the kinetic regularities of lead, zinc and copper chloride sublimation and the factors influencing the sublimation process were estabkished;
- it was determined that the chloride sublimation processes proceed in a kinetic mode and an increase in temperature is necessary for their intensification;
- the apparent activation energy of the reaction start period was established; it is 162 kJ/mol for lead and 140 kJ/mol for copper.

The main provisions for the dissertation defense:

- the results of thermodynamic modeling of the interaction of distiller waste's components with the main compounds characteristic of waste lead slags;
- the results of kinetic studies and the main regularities of formation and extraction of inorganic chlorides of lead, zinc, and copper during the interaction of waste lead slag with distiller waste;

- the results of integrated laboratory tests on the oxidizing-chlorinating roasting of the lead-containing slag with the distiller waste to extract inorganic chlorides of non-ferrous metals;

- calculation of the main economic indicators of the extraction of inorganic chlorides of lead, zinc and copper from the waste lead slag using distiller waste.

Practical significance:

- it has been established on an enlarged laboratory scale that the chloride sublimation method allows us to extract 92.9% of zinc, 88.3% of lead and 87.5% of copper as their inorganic chlorides from the lead production slags in the presence of distiller waste.The cinder formed at the roasting contains 0.08% of zinc, 0.03% of lead and 0.06% of copper and it can be used as a heat-insulating material;

- on the basis of the results of theoretical, experimental and enlarged laboratory studies, a technological scheme for the comprehensive processing of lead-containing slags and distiller waste and producing a heat-insulating material was proposed;

- according to the proposed technology, 2 patents of the Republic of Kazakhstan for a useful model were obtained (No. 3154 dated September 17, 2018 “A method for processing lead-containing slags”; No. 4038 dated June 04, 2019 “A method for processing lead-containing slags”);

- preliminary technical and economic calculations show that the cost of processing 1 tonne of the slag with the extracting lead, copper and zinc chlorides and simultaneous obtaining a heat-insulating material in a rotary furnace is 9700 tenge, and the profit is 6915 tenge;

- testing of a backup option for the extracting inorganic metal chlorides from the lead production slags in the presence of distiller waste by agglomeration-chlorination roasting was carried out.

The degree of reliability and approbation of the results.

The results of the dissertation work were obtained using modern research techniques and methods of processing and interpreting data using computer technologies:

- thermodynamic modeling based on the multifunctional software package HSC-5.1, 6 Chemistry;

- the rotatable second-order experiment planning design (the Box-Hunter plan);

- modern methods of processing the results of kinetic studies;

- the enlarged laboratory tests were carried out using a modern installation manufactured by Uralelectropech LLC, equipped with the necessary devices for controlling the technological regime, as well as an automatic process control device.

The degree of results’ reliability is confirmed by a sufficient degree of agreement between the results of thermodynamic analysis, kinetics, and large-scale laboratory tests.

The proposed technology for the extraction of non-ferrous metals’ inorganic chlorides was tested by integrated laboratory tests in the research laboratory

“Perspective metallurgical technologies” of M. Auezov South Kazakhstan University.

The personal contribution of the doctoral candidate consists in the analysis of scientific literature on the topic of the dissertation research, the choice of research and analysis methods, conducting the thermodynamic, kinetic and experimental studies, mathematical and statistical processing the data obtained, interpretation and generalization of the results.

Publications on the dissertation theme. The main provisions of the dissertation research are examined in 10 scientific publications, including 1 paper in an international scientific journal included in the Scopus database, 4 – in scientific journals recommended by the Committee for Quality Assurance in Science and Higher Education, 5 articles – in the materials of international conferences, including 1 article in the materials of a foreign conference. Based on the research results, 2 patents of the Republic of Kazakhstan for a useful model were obtained.

The dissertation structure and volume. The dissertation work is presented on 106 pages of typewritten text, contains 16 tables, 65 figures. The work consists of Introduction, 6 sections, Conclusion, a list of references including 113 titles and 4 appendices.