INTRODUCTION

General description of work. This dissertation focuses on the development of new chemical formulations including boron trioxide , aluminum, potassium nitrate and various flux additives. The purpose of these compositions is to create an environmentally friendly technology for the production of aluminum boride alloys and clinkers for high-alumina cements.

As part of the study, the parameters of combustion processes were determined under conditions of self-propagating high-temperature synthesis (SHS), which is characterized by high energy intensity. Experimental work was carried out to study the influence of various factors on the synthesis process of aluminum borides, including the particle size of the components, the degree of compaction of the initial mixture, the amount of reducing agent used, as well as the presence of fluxing and energy-intensive additives.

Based on the research results, the composition of the charge was selected and optimized, taking into account the degree of reduction of each component and the effectiveness of the reducing agent. This made it possible to improve the synthesis process and increase its efficiency.

Relevance of the dissertation research topic. The modern economy sets itself the task of energy saving as one of its main priorities. Metallurgy, as one of the most resource-intensive industries, is actively looking for ways to reduce the consumption of energy and material resources. This trend is reflected in the desire to minimize costs.

During the physical and chemical processing of raw materials, in addition to the main products, by-products are formed that are not the purpose of the production process. However, secondary materials, such as metallurgical slag, can be used as main or additional components for the production of related products.

The technology of self-propagating high-temperature synthesis (SHS), which we have developed for the production of alloys in mechanical engineering, complies with the principles of waste-free production. This innovative method is based on the energy generated by chemical reactions during SHS, which marks a new approach in scientific research. The SHS process is characterized by ease of implementation, minimal procedural steps, reduced energy consumption, and the ability to produce high purity products. This approach highlights the growing need to implement technologies that make the most efficient use of natural resources while protecting the environment, especially in the context of modern manufacturing, where much of the raw materials are often turned into waste.

To achieve these results, it is necessary to create optimal conditions for controlling physicochemical interactions in metallurgical systems. This represents a multicriteria optimization problem, which remains key in the theory and practice of metal and alloy production.

Modern methods for producing aluminum borides, such as the aluminothermic process in a furnace, synthesis using elemental forms, electrolysis in a molten medium, vapor deposition, electrochemical processes in halogen oxide melts and the reduction of boron oxide with potassium tetrofluoroborate in cryolytic melts, are often characterized by significant energy costs and long processing times, as well as the need for sophisticated equipment. In addition, these methods generate waste that requires recycling, which incurs additional costs. These characteristics highlight the need for more efficient and environmentally friendly production methods in this area.

In the research presented in this paper, the technology for the production of aluminum borides is carried out through the heat generation of exothermic reactions between a reducing agent and an oxidizing agent. These reactions take place outside the furnace in cast iron crucibles, making the process fast and environmentally friendly. An aluminothermic slag is formed as a by-product, which has properties that allow it to be used in the production of high-alumina clinkers.

Optimization of the process of synthesis of aluminum borides by the SHS method includes the creation of a recipe for obtaining slag with certain physicochemical characteristics. These characteristics, such as fluidity, low viscosity and density, contribute to effective phase separation, the formation of a homogeneous alloy with high yield and boron recovery.

The purpose of this research is to develop an environmentally friendly and waste-free self-propagating high-temperature synthesis (SHS) technology for the production of aluminum borides. This technology uses energy-intensive components such as KNO_3 and a combination flux consisting of CaF_2 and KBF_4. The developed technology is intended for the creation of abrasives and the production of clinkers for high-alumina cements.

The tasks defined within the thesis to achieve this goal:

1. Determination of the initial composition of the charge: conducting phase and elemental analysis, sieve analysis and studying the thermodynamic characteristics of systems including boron trioxide , aluminum, potassium nitrate and calcium fluoride. The purpose of this stage is to optimize the production process, including taking into account heat loss and thermodynamic combustion parameters (temperature, speed, heat release) using the HSC Chemistry program .

2. Preparation of raw materials: mechanochemical activation of raw materials to accelerate exothermic reactions. Assessment of physical and mechanical factors affecting the yield of aluminum boride alloy, especially in the presence of feldspar.

3. Study of factors influencing the kinetic and energy characteristics of the synthesis: study of the influence of the particle size distribution of the charge materials, the amount of reducing agent, fluxes and energy additives to optimize the yield of the target product.

Optimization of technology for producing aluminum boride charge: development of technology using energy-intensive additives and calcium fluoride, as well as creation of technological process regulations in accordance with GOST for the production of solid compositions.

Main provisions submitted for defense:

1. Thermodynamic equilibrium model: A model has been developed that predicts changes in thermodynamic parameters such as enthalpy (H), entropy (S), heat capacity (Cp), equilibrium reaction constant (Kr), as well as Gibbs energy parameters in the temperature range from 500 to 1900 K. This made it possible to determine the macrokinetic conditions for the SHS synthesis of aluminum boride,

taking into account the physicochemical parameters of the feedstock using the HSC Chemistry program .

2. Particle size distribution and compaction of components: Study of the particle size distribution and degree of compaction of the components of the reducing agent (Al), oxidizing agent (B_2O_3) and fluoride salts CaF_2 to ensure the complete flow of the charge melting process. This leads to the formation of mobile liquid slags, which contribute to effective phase separation and enrichment of the alloy with boron up to 92.81%.

3. Recipes: Development of optimal formulations, including 15.0-20.0% KNO_3 (energy-intensive additives) and 6.0-11.0% mixed flux (CaF_2 and KBF_4), to accelerate the processes of penetration and combustion of the charge. This increases the efficiency of the yield of target products - aluminum boride and high-alumina slag, demonstrating the yield of the alloy up to 92.81% and the transfer of boron into the alloy up to 98.41%.

4. Technological regulations and clinker synthesis: Development of technological regulations for waste-free technology for the production of aluminum borides and the synthesis cycle of high-alumina clinkers. Clinkers have the following percentage composition: Al_2O_3 – 69.44%; CaO – 22.57%; Fe_2O_3 – 1.40%; MgO – 1.56%; K_2O+Na_2O – 0.62%; B_2O_3 – 0.085%; TiO_2 – 0.11%; SiO_2 – 0.62%, as well as the gaseous phase of CO_2 – 18.80%. This composition corresponds to the KVTs-60 brand of high-alumina clinker.

The object of this study is high-energy compositions based on systems of boron trioxide , aluminum, potassium nitrate (saltpeter) and calcium fluoride (fluorspar).

The subject of the study is to determine the conditions for the synthesis of target materials using the method of self-propagating high-temperature synthesis. As part of the study, the granulometric composition of the components and the degree of compaction of the charge are studied, which is necessary to ensure the complete completion of the process and effective phase separation of the products, in order to obtain a high boron content in the alloy core.

The study also examines recipe options that affect the yield of target products, in particular aluminum boride and high-alumina slag. Particular attention is paid to optimizing the synthesis of aluminum boride within the framework of this technology.

Research methodology. In order to achieve the objectives of the study, various methods were used: thermodynamic calculations using the HSC Chemistry program , thermogravimetric analysis, measurement of combustion rate, X-ray diffraction analysis, determination of combustion temperature, as well as laboratory experiments for the synthesis of target products such as aluminum boride and high alumina slag.

The novelty of this work lies in the use of the method of self-propagating high-temperature synthesis and mechanochemistry to obtain an aluminum boride alloy from a mixture of boric anhydride powders, aluminum and fluxes. Key innovative aspects of the work include:

• Development of a formula for a charge based on systems of boron and aluminum trioxide , potassium nitrate and calcium fluoride;

• Modification of traditional methods for producing aluminum boride alloy with the study of the influence of formulation factors in systems containing boron trioxide , aluminum, potassium nitrate and calcium fluoride;

• Identification of patterns of how recipe factors affect the yield of target products, including aluminum boride and high-alumina slag.

Theoretical significance.

The theoretical significance of the dissertation lies in the possibility of expanding the use of self-propagating high-temperature synthesis to obtain high-purity materials for multifunctional purposes from raw materials of natural origin, man-made and household waste of the Republic. The SHS process is not energy-intensive since the synthesis process is implemented using the heat of exothermic reactions of the reacting components, it is waste-free, allowing the use of reaction by-products in the national economy. The proposed technology is easy to implement and hardware design, energy-saving, environmentally friendly.

Practical significance of the work.

The practical value of the research is due to the need for the development of various industries, such as mechanical engineering, nuclear energy, metallurgy, rocketry and others that require high-energy materials. The development of a method for producing such materials that have high energy characteristics, and the implementation of this process in an environmentally friendly and waste-free manner, is of great economic and industrial importance. This is especially true for Kazakhstan, which has an extensive raw material base of borides. The production of diborides in Kazakhstan based on local raw materials using energy-saving, environmentally friendly and waste-free technology can ensure the economic security of the country.

Approbation of work.

- *Материалы международной научно-практической конференции «Современные тенденции развития химической технологии и инженерии в пищевой и легкой промышленности» посвященной 80-летию академика НАН РК Кулажанова Куралбека Садибаевича. 23 февраля 2023 года*
- *Материалы III Международной научно-практической конференции «SCIENCE AND BUSINESS-2021».*
- *XI МЕЖДУНАРОДНОГО БЕРЕМЖАНОВСКОГО СЪЕЗДА ПО ХИМИИ И ХИМИЧЕСКОЙ ТЕХНОЛОГИИ. 19-20 ноября 2021 г.*
- *LXXIV Международная научная конференция. Актуальные исследования в современном мире. 26-27 июнь 2021г.*
- *Материалы международной научной конференции студентов и молодых ученых «ФАРАБИ ӘЛЕМІ», Алматы, Казахстан, 6-8 апреля 2021 года. – С. 99*

Personal contribution of the author. Consists of staging and conducting experiments , determination methods analysis and ways solutions supplied practical and theoretical tasks , generalization and interpretation received results , writing articles and reports .

Publications. The results of the dissertation work published 14 scientific articles, of which 2 articles were published in a publication included in the Scopus Database ; 3 scientific articles in journals recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Education and Science of the Republic of Kazakhstan; 3 articles in materials of international scientific conferences, 3 certificate of entering information into the state register of rights to objects protected by copyright, utility model patent No. 7075.

Connection with research activities and government programs.

The topic of the dissertation presented for defense *, "Creation of a waste-free technology for obtaining target materials using the heat of exoenergetic reactions using the SHS method* ," was carried out within the framework of a fundamental research project: " Grant funding" IRN AR08857190 on the topic " Creation of a waste-free, high-energy technology for obtaining target materials for mechanical engineering using heat of exothermic reactions of reacting substances using the SHS method."

Scope and structure of work . The dissertation is presented on 103 pages and includes 27 figures and 35 tables. The work consists of an introduction, a literature review, a description of research objects and methods, results and their discussion, a conclusion and a list of used sources of 108 titles.