

ANNOTATION

dissertation work

« DEVELOPMENT OF TECHNOLOGY FOR OBTAINING A METALLIZED PRODUCT FROM AN ORE-COAL DISPERSED MIXTURE»,

submitted for the degree of Doctor of Philosophy (PhD)

specialty 6D070900 – «Metallurgy»

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The purpose of the dissertation is to study the possibility of obtaining a metallized product from an ore-coal dispersed mixture for its further use as a charge in steel production and the development of its technology.

Research objectives

- preliminary sampling, study of chemical and granulometric compositions of iron-containing technogenic raw materials;
- conducting thermodynamic analysis of obtaining a metallized product;
- obtaining an oiled sludge from oiled rolling scale for further use as a component of the charge to obtain a metallized product;
- conducting laboratory studies to obtain a metallized product, developing technology.

Research methods

The main methods of research and analysis used in the performance of dissertation work include:

- The study of chemical and granulometric compositions of iron - containing technogenic raw materials and charge components was carried out by studying chemical analysis and granulometric composition;
- using the method of orthogonal planning of experiments to build a mathematical model to determine the optimal parameters of the experiments, thermodynamic modeling was performed using the HSC-5.1 software package, the Reaction Equations subprogram of which allows you to calculate ΔH , ΔS , ΔG and K_r reactions, and the Equilibrium Compositions subprogram allowed you to simulate the interaction in the studied system with an equilibrium quantitative distribution of substances in the system under study;
- the sludge was obtained from oiled rolling scale using a vacuum filter and a tubular furnace. The obtained parameters ensure sufficient oil removal regardless of the amount of starting oil in the scale;
- the process of obtaining a metallized product was carried out in two stages: 1) solid-phase reduction of a mixture of rolled scale with converter sludge with carbon in a horizontal tubular electric furnace SUOL-045; 2) remelting of the resulting metallized product in a Tamman furnace. A study was also conducted to obtain a metallized product based on JSC "Qarmet".

The main provisions (proven scientific hypotheses and other conclusions that are new knowledge) submitted for defense

- the results of the study of chemical and granulometric compositions of iron-containing technogenic raw materials, a mathematical model for planning experiments for obtaining a metallized product;
- the results of the thermodynamic analysis of obtaining a metallized product;
- the results of laboratory production of an oiled sludge from oiled rolling scale for further use as a component of the charge to produce a metallized product;
- the results of laboratory studies conducted to obtain a metallized product, X-ray phase analysis, technology development and construction of a technological scheme for obtaining a metallized product.

Description of the main results of the study

As a result of theoretical and experimental studies:

- a study of the mechanism and kinetics of the reduction of metals from solid oxides by solid carbon was carried out; stoichiometric carbon costs for the reduction of metals were calculated;
- a mathematical model was built, as a result of which the optimal ratios of consumables for conducting experiments were determined;
- a complete thermodynamic simulation was carried out and the effect of temperature on the change in Gibbs free energy during the interaction of iron oxides with carbon was studied. A complete thermodynamic analysis of the interaction of a mixture based on concentrate, sludge, and rolled scale with solid carbon was also carried out. It has been established that practically all iron Fe (98-99%) passes into the elemental state at a temperature of 1000 °C. Analyzing all the data obtained, during the interaction of concentrate (LGMK, SSGPO), converter sludge, rolling scale with solid carbon, it is possible to obtain elemental iron at temperatures in the range of 1000-1100 °C;
- experimentally, a semi-product in the form of a precipitate with an oil content of less than 1 % was obtained from oiled rolling scale for further use as an important component in the production of high-quality steel;
- laboratory work has been carried out to obtain a metallized product. As a result of the reduction, a metallized product (resembling spongy iron) was obtained with a degree of metallization exceeding 92% and a FeO content of 7,84-11,31%. The amount of metallic Fe after recovery at 1000 °C is 92% (in LGMK 92,7%, in SSGPO 98,4%). After analyzing the quality of the samples obtained, it was concluded that the metal obtained from a mixture of concentrate, rolling scale and converter sludge has minimal harmful impurities and a smaller amount of slag was formed during its melting. Based on the analysis of the results of experimental studies on the preparation and reduction smelting of ore-coal charge based on rolled scale and converter slurries, a technology for their processing for the smelting of high-quality steel has been developed;
- a technological scheme for obtaining a metallized product from a dispersed ore-coal mixture has been constructed.

Substantiation of the novelty and importance of the results obtained

Scientific novelty of the dissertation work:

- for the first time in the process of processing metallurgical waste, a metallized product for steel production was obtained as a mixture of rolled scale and converter sludge;

- for the first time, a mathematical model for obtaining a metallized product from a technogenic dispersed ore-coal mixture was constructed, the effective parameter for obtaining a metallized product by thermodynamic modeling was determined;

- as a result of large-scale laboratory work (on the basis of JSC "Qarmet"), an optimal technological scheme for obtaining a metallized product has been proposed.

The research results obtained on the basis of the dissertation work have the following practical significance:

- reducing the cost of steel by including a metallized product from a dispersed ore-coal mixture in steelmaking;

- cleaning of metallurgical waste from land plots occupied by dispersed ore-coal mixtures;

- processing of oiled rolling scale and converter sludge, completely discharged into ash and sludge accumulators, in the conditions of JSC "Qarmet".

The practical values of the above-mentioned dissertation work make it possible to significantly increase the volume of their processing (dispersed ore-coal mixture, rolled scale and converter sludge), as well as reduce the environmental burden in places of concentration of harmful waste.

Compliance with the directions of scientific development or government programs

The topic of the dissertation corresponds to the specialized scientific direction "New multipurpose materials based on natural raw materials and man-made waste" and the priority "Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures" of the National Scientific Council under the Government of the Republic of Kazakhstan.

Description of the doctoral student's contribution to the preparation of each publication

The author's personal contribution consists in carrying out the main volume of theoretical and experimental research outlined in the dissertation work, including the development of theoretical models, experimental research methods, research, analysis and presentation of results in the form of publications and scientific reports.

8 scientific papers have been published on the topic of the dissertation, including: 3 (three) articles in peer-reviewed scientific publications on the scientific direction of the dissertation topic, indexed in the Science Citation Index Expanded database Web of Science (Clarivate Analytics) and CiteScore in the Scopus database (Elsevier); 4 (four) articles in collections of International and Republican scientific and practical conferences and 1 (one) monograph.

Information about the main publications indexed in the Science Citation Index Expanded of the Web of Science database (Clarivate Analytics), in a peer-reviewed scientific publication with a CiteScore percentile in the Scopus database (Elsevier) on the topic of the dissertation:

1. Mukhametkhan, M., Mukhametkhan, Y., Tleugabulov, S., Zhabalova, G., Shevko, V. / Thermodynamic interaction of concentrate, sludge and mill scale from carbon // *Metalurgija*. – 2021, 60(3-4), pp. 289–291;
2. Mukhametkhan, M., Mukhametkhan, Y., Zhabalova, G., Kamkina, L. Investigation of physico-chemical characteristics of iron-containing technogenic raw materials in the conditions of JSC “AMT” *Metalurgija*. 2023, 62(1), pp. 129–131.
3. D. Yessengaliev, M. Mukhametkhan, Ye. Mukhametkhan, G. Zhabalova, B. Kelamanov, O. Kolesnikova, B. Shyngysbayev, L. Aikozova, K. Kaskataeva, Ye. Kuatbay Studies of the Possibility of Improving the Quality of Iron Ores and Processing of Technogenic Composite Iron-Containing Waste of Metallurgical Production *J. Compos. Sci.* 2023, 7(12), 501; <https://doi.org/10.3390/jcs7120501> (registering DOI) - 02 Dec 2023.

Information about the reports reported and discussed on the results of the dissertation work at International and National scientific and practical conferences:

4. Tleugabulov, S., Mukhametkhan, M. Reducing smelting of ore – coal iron ore raw materials without carburization // Proceedings of the X International Scientific and practical Conference "Competitiveness of the nation - the main condition for improving the welfare of the people", dedicated to the 55th anniversary of Karaganda State Industrial University, Part 1. November 29-30, 2018. RK. Temirtau: KGIU. 2018, pp. 23-29;

5. Айткенов Н.Б., Мухаметхан М., Тлеугабулов С.М. Технология получения рудоугольных окатышей из смеси конверторного и угольного шламом и восстановительной плавки стали// Proceedings of the XLIX Republican scientific and practical conference "Youth of the XXI century – the key factor of competitiveness of Kazakhstan in the modern world", dedicated to the Year of Youth in the Republic of Kazakhstan on April 11-12, 2019. RK. Temirtau: KGIU. 2019, pp. 10-16;

6. Мухаметхан М., Жабалова Г.Г., Камкина Л.В. Исследование прямого восстановления железа твердым углеродом// Proceedings of the LI International Scientific and practical Conference "Youth, science and technology: ways of improvement and integration", dedicated to Science Day on April 14, 2021. RK. Temirtau: KIU. 2021, pp. 80-84;

7. Mukhametkhan M., Mukhametkhan Ye., Zhabalova G., Kamarova S. Thermodynamic modeling. Complete thermodynamic analysis// Proceedings of the XI International Scientific and practical Conference dedicated to the 30th anniversary of independence of the Republic of Kazakhstan "Innovative technologies and engineering" November 25-26, 2021. RK. Temirtau: KIU. 2021, pp. 10-15.

Information about the monograph:

8. Жабалова Г.Г., Онищенко О.Н., Мухаметхан М. Теплофизическая обработка тонкодисперсных отходов производства для получения металлизированного продукта. Караганда: ТОО «Санат-Полиграфия», 2022.-97 стр.