

ANNOTATION

Dissertations for the degree of Doctor of Philosophy (PhD) in the educational program 8D07201 – Metallurgy

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RESEARCH AND DEVELOPMENT OF TECHNOLOGY FOR THE PRODUCTION OF METALLIZED AGGLOMERATE FROM STEELMAKING WASTE

Relevance of the thesis topic. In Pavlodar region, steel is smelted at the electric steelmaking enterprises of KSP Steel LLP and Casting LLP with a capacity of over 1.5 million tons of products per year. The products of KSP Steel LLP are seamless pipes, fittings, and at PF Casting LLP the main products are grinding balls, and this plant also produces fittings. Steel is smelted in high-power electric steelmaking furnaces DSP-25 and DSP-60. The starting material for steel production is mainly ferrous scrap, scraps, and iron-containing additives. The molten steel, after out-of-furnace processing and refinement of the metal to a given chemical composition, is sent to continuous casting machines. When the workpiece passes through crimping units (rolling mills), a large amount of scale is formed (rolling scale). Rolling scale accounts for the largest amount of waste at the electrometallurgical plants of KSP Steel LLP and Casting LLP. At the enterprises of the steelmaking industry, iron-containing waste remains unsuitable in sufficiently large volumes. In this regard, the need to solve the problem of involving steelmaking waste in steel production, for example, rolling scale, is of particular relevance..

The purpose of the dissertation work. Research and development of physico-chemical bases, technologies of agglomeration of rolled scale and application of the resulting agglomerate for smelting cast iron and steel.

Scientific novelty of the obtained results: In this work, for the first time:

- the dynamics of changes in the phase composition of the sinter during sintering in the presence of dolomitized limestone has been established, with the formation of a number of intermediate phases: merwenite $\text{Ca}_3\text{Mg}(\text{SiO}_4)$ and diopside $\text{CaO}\cdot\text{MgO}\cdot 2\text{SiO}_2$, contributing to an increase in the melting point of the final slag during iron smelting;

- the effect of magnesium oxide on the physico-chemical properties and phase composition of the resulting fluxed agglomerate was evaluated and the optimal consumption level of dolomitized limestone in the amount of 4-12 % for rolling scale was identified;

- experimental data on the activation energy of processes occurring during agglomeration of rolled scale have been obtained by methods of nonisothermal kinetics. The analysis of these data showed that the processes of thermal decomposition of the minerals of the agglomeration charge proceed in a certain sequence with the formation of fayalite, monticellite, forsterite and merwenite $\text{Ca}_3\text{Mg}(\text{SiO}_4)$;

- the kinetic characteristics of the reduction of iron by carbon from rolled scale have been obtained by thermogravimetric method. The apparent activation energy of the charge reduction process based on a non-fluxed and fluxed dolomitized limestone metallized agglomerate was 105.775 and 69.9105 kJ/mol, respectively.

The novelty of the research results: Research has established the patentability of scientific and technical developments. The novelty is confirmed by obtaining a patent: "A patent for a utility model. 7818. The Republic of Kazakhstan. C22B V1/16 (2006.01). Charge for agglomerate production / Zhunusov A.K., Bykov P.O., Zhunusova A.K., Kenzhebekova A.Ye. – No. 2020/0952.2; application no.02.11.2022; publ.17.02.2023, bulletin no. 7.

The main provisions submitted for defense:

- results of calculation of thermodynamic data and modeling of phase equilibria in multicomponent oxide systems performed using thermodynamic-diagrammatic analysis;

- results of computer thermodynamic modeling in Chemistry 9.0 for reactions of interaction of fluxes with metal and inclusions;

- the results of the study of derivatograms, radiographs, microanalysis, qualitative and quantitative elemental composition of metallized and fluxed agglomerate;

- the results of an experimental study of the effect of dolomitized limestone on the metallurgical properties and agglomeration process of rolled scale, the strength of the agglomerate, and studies of solid-phase transformations during sintering of rolled scale and the resulting agglomerate using non-isothermal kinetics;

- results of an experimental study of the kinetics of reduction and metallurgical properties of metallized and fluxed agglomerate;

- the results of experimental tests of the technology of agglomeration of rolled scale and smelting of fluxed agglomerate for the reduction smelting of cast iron;

- the results of pilot tests of technology for agglomeration of rolled scale and steel smelting in an induction furnace using metallized agglomerate as a substitute for lightweight scrap.

Practical significance of the work.

Based on the results obtained in the dissertation, a solution to the problem of metallurgical waste disposal is proposed by developing a rational agglomeration technology, taking into account the composition and properties of rolled scale to produce metallized and fluxed sinter. The technology of rolling scale agglomeration has been developed in two directions:

1) Production of metallized agglomerate for use in steel smelting in an induction furnace;

2) Production of fluxed agglomerate with the addition of 4-12 % dolomitized limestone to the charge for iron smelting. The fluxed agglomerate is suitable for producing cast iron. Cast iron was obtained in a laboratory furnace.

The production of metallized agglomerate was tested at CentrAsia Manufactura LLP (Pavlodar). Metallized agglomerate was obtained at the pilot plant. Pilot industrial smelting of steel was carried out using metallized agglomerate as a substitute for lightweight scrap. Replacing lightweight scrap with metallized

agglomerate by up to 20 % makes it possible to improve the technical and economic performance and technological regime of steel melting in an induction furnace while saving scrap metal.

Publications and approbation of the work. The results of the dissertation work have been published in four Articles, including:

- one article in a journal included in the Web of Science database (Q3):

- Zhunusov A.K., Bykov P.O., Kenzhebekova A.E., Zhunusova A.K., Rahmat Azis Nabawi. Study of the isothermal kinetics of reduction of sinter from mill scale // Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources. 2024; 328(1): 59-67.

- three publications in journals from the list of publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan for the publication of the main results of scientific activity:

- Zhunusov A.K., Kenzhebekova A.Ye., Zhunusova A.K. Ilem otkabyrshygytan temirkeni aglomertay aludy zertteu // Proceedings of the University, 2023. – № 4 (93). – P.61-66.

- Zhunusov A.K., Kenzhebekova A.Ye., Zhunusova A.K., Bykov P.O. Aglomerattyn fizika-khimiya kasiyterine flyusterdi koldanudyn aseri // Proceedings of the University, 2024. – № 2 (95). – P.45-53.

- Zayakin O.V., Kenzhebekova A.E., Zhunusov A.K., Bakirov A.G. Determination of optimal parameters of sintering of rolling scale // Science and Technology of Kazakhstan, 2024. – №3. – P.178 – 188.

A patent for a utility model of the Republic of Kazakhstan has been obtained:

- Utility model patent 7818. The Republic of Kazakhstan. C22B V1/16 (2006.01). Charge for agglomerate production [Text] / Zhunusov A.K., Bykov P.O., Zhunusova A.K., Kenzhebekova A.Ye. – No. 2020/0952.2; application no.02.11.2022; publ.17.02.2023, bulletin no. 7.

The main provisions and results of the work have been tested and reported at three International conferences in the form of reports.:

- Kenzhebekova A.Ye., Zhunusov A.K., Zhunusova A.K. Sovremennoe sostoyanie obrazovaniya i vozmozhnosti pererabotku metallurgicheskikh othodov // Collection of reports based on the materials of the International Scientificpractical conference "XII Toraighyrov readings" (October 2020). – Pavlodar: Toraighyrov University, 2020. – V.6. – P.21-25.

- Zhunusov A.K., Kenzhebekova A.Ye., Zhunusova A.K. Ispolzovanie otsevv Maikubenskogo uglya pri aglomeracii staleplavilnyh othodov // Collection of reports based on the materials of the International Scientificpractical conference "XIV Toraighyrov readings" (October 28, 2022). – Pavlodar: Toraighyrov University, 2022. – V.3. – P.269-273.

- Zhunusov A.K., Kenzhebekova A.Ye., Zayakin O.V., Zhunusova A.K. Bolat balkytu kaldiktarinin aglomeraciyasyn tazhibelik synau // Proceedings of the International Scientific and Practical Conference.: «ULYTAU-Kazakhstan metal cradle of Kazakhstan metallurgy». – Almaty, Satbayev University, 2023. – P.175-179.

The structure and scope of the dissertation. The thesis is presented on 147 pages of printed text and consists of an introduction, five sections, a conclusion, a list of sources used and appendices. The work contains 73 figures, 44 tables, the list of sources used consists of 185 titles and 6 appendices.