

ANNOTATION

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

AUBAKIROV ALMAT MUKANOVICH

RESEARCH AND DEVELOPMENT OF COKING TECHNOLOGY FOR LOW-SINTERING COALS TO PRODUCE REDUCING AGENTS FOR THE PRODUCTION OF FERROCHROME

Relevance of the dissertation work's topic is determined by the need to increase the efficiency of using Kazakhstan's coal resources in the context of the energy sector transformation and the growing demand for high-quality reducing agents for metallurgy. In particular, the ferroalloy industry experiences a persistent shortage of carbonaceous materials with high electrical resistivity, high reactivity, and low content of harmful impurities. At the same time, a significant part of local coals, including low-caking and non-caking grades, remains unused in traditional coking technologies. Simultaneously, the need for processing coal fines is intensifying, which creates prerequisites for developing innovative approaches to involving them in production processes to obtain high-value-added products.

The aim of the dissertation work is to develop a technology for obtaining a special reducing agent for ferroalloy production using low-caking coals.

Scientific novelty of the results obtained:

1. A technology for obtaining a new composite carbonaceous reducing agent was scientifically substantiated and developed by combining low-caking coal of the Zhalyn field (G grade) and non-caking coal of the Shubarkol field (D grade) by forming a carbon framework in the microstructure of the special coke;

2. Based on the experimental data obtained in the temperature range of 100-1200 °C, periods of active release of volatile compounds in the range from 350 to 700 °C and the formation of the coke residue framework at 950 °C were identified;

3. The optimal technological range of the charge composition at the level of 75-85 % of Zhalyn field coal was established and quantitatively determined, which ensures the production of special coke with operational properties in terms of structural strength $P_s > 70 \%$, reactivity $CRI > 70 \%$ and a reduced phosphorus content sufficient for the production of high-carbon ferrochrome with a mass fraction of $P = 0,030 \%$;

4. It was established that increasing the proportion of the non-caking component in the coal charge up to 25 % causes a thinning of the pore walls of the composite special coke from 6,48 to 4,67 μm , which leads to a simultaneous decrease in its mechanical strength to 70,4-71,7 % and an increase in reactivity to 71,8-74,4 %;

5. It was experimentally established that the electrical resistivity of the obtained special coke decreases to 7,26 $\text{Om} \cdot \text{cm}$ when the proportion of Shubarkol field coal is increased up to 45 %;

6. It was experimentally established that the increased reactivity (CRI > 70 %) of the composite special coke Zhalyn-75 increases the degree of chromium extraction to 92,1 % and reduces the Cr₂O₃ content in the slag to 4,8 %.

Novelty of the research work results is confirmed by a Patent of the Republic of Kazakhstan: Patent for invention. No. 37429. Republic of Kazakhstan. C10B57/04 (2006.01). "Method for producing special coke" / A.M. Aubakirov, L.B. Tolymbekova, A.K. Zhunusov, E.S. Abdrakhmanov, A.G. Kaliakparov. – No. 2024/0462.1; filed 07.06.2024; published 11.07.2025., bul. No. 28.

Main theses submitted for defense:

- the results of studies of the physico-chemical properties of reducing agents obtained from weakly disintegrating coals;
- scientific justification of the use of low-burning coals;
- experimental studies of the process of obtaining reducing agents using low-purity G grade coals;
- results of ferrochrome smelting in laboratory conditions;
- the results of large-scale laboratory tests on coking and smelting of ferrochrome.

Practical significance of the work lies in the possibility of implementing the developed technology at coal chemistry and metallurgical enterprises, which will allow reducing import dependence on coke, increasing the environmental safety of production and the economic efficiency of coal raw material processing, and also ensuring a stable raw material base for the ferroalloy industry of Kazakhstan through the rational use of domestic raw materials.

Publications and approbation of the work. The main provisions of the thesis were discussed at scientific seminars of the Metallurgy Department.

An invention patent was obtained for the method of obtaining a special coke.

The theoretical and practical results were introduced into the educational process of the NJSC Toraighyrov University.

Certificates of large-scale laboratory tests on coking and smelting of high-carbon ferrochrome have been obtained.

The main scientific results of the work are presented in 6 publications in domestic and foreign publications, including:

- 2 articles in the journal included in the Scopus / Web of science database;
- Aubakirov A.M., Kaliakparov A.G., Tolymbekova L.B. Determination of the quality of special coke as a result of heat treatment of coal from the Shubarkol field // Complex Use of Mineral Resources, 2023. - 326(3): - pp. 96-106. <https://doi.org/10.31643/2023/6445.33>;
- Strakhov V. M., Kaliakparov A.G., Panfilov V. P., Imanbaev S. Sh., Aubakirov A.M. Coke Quality in Medium-Temperature Coking of Fractionated Long-Flame Coal // Coke and Chemistry, 2022, - Vol. 65. - No. 8. - Pp. 316–334. <https://doi.org/10.3103/S1068364X22080051>.

- 3 publications in journals from the list of editions 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;

- Aubakirov A.M., Tolymbekova L.B., Kaliakparov A.G., Khoshnaw F., Kulumbaev N.K. Production of special coke from low-caking coals used in the ferroalloy industry // Science and Technology of Kazakhstan, 2024. - № 1. – P. 123-149 <https://doi.org/10.48081/LDCU7796>

- Aubakirov A.M., Tolymbekova L.B., Kaliakparov A.G., Kh. B. Temirtas, Khoshnaw F. Research of moisture capacity and the process of water saturation of a special coke // Science and Technology of Kazakhstan, 2024. - № 2. – P. 131-141 <https://doi.org/10.48081/RKRP8312>

- Aubakirov A.M., Tolymbekova L.B., Kaliakparov A.G., Kapelyushin Yu.E., Temirtas Kh.B. Ferroqorytpa onerkasibinde totyqsyzdandyrgyshtar alu ushin kujdirgende alsiz birigetin k mirden zhasalghan k mir shikiquramynyn quramyn ontajlandyru // Science and Technology of Kazakhstan, 2025. - № 2. – P. 218-229 <https://doi.org/10.48081/LKVG3705>

- Patent for the invention "Method of obtaining a special coke":

- Patent for invention. No. 37429. Republic of Kazakhstan. C10B57/04 (2006.01). "Method for producing special coke" / A.M. Aubakirov, L.B. Tolymbekova, A.K. Zhunusov, E.S. Abdrakhmanov, A.G. Kaliakparov. – No. 2024/0462.1; filed 07.06.2024; published 11.07.2025., bul. No. 28.

Structure and scope of the dissertation. The dissertation is presented on 132 pages of printed text and consists of an introduction, 4 chapters, a conclusion, a list of references, and appendices. The work contains 45 figures, 40 tables, a list of references with 133 items, and 6 appendices.