AP19576811 «Development of technology for obtaining a conditioned product from highly dispersed dust of ferroalloy production» – p.m. Issagulova D.A.

Relevance

Ferroalloy production generates a significant amount of by-products, such as slag, residues of fine fractions of raw ore materials and finished products (ferroalloys), sludge, dust, and various other materials. The use and processing of these materials can reduce the consumption of primary natural resources, thereby increasing the efficiency of the main production process and reducing environmental pollution.

The greatest environmental risks are posed by technogenic wastes from the metallurgical sector of ferroalloy production, which primarily consist of fine-dispersed materials in the form of dust and sludge from various stages of manufacturing.

One of the main methods for enlarging powdery substances is briquetting—a process that requires energy only to shape and compact the briquettes, without the need for thermal energy for agglomeration. Briquetting is the most cost-effective and compact method of pelletizing various dusty materials. Therefore, briquetting production waste using presses becomes economically feasible.

***The goal of the project* is** to develop a new technology for producing ferrosilicon briquettes from fine dust generated in ferroalloy production using a new complex binder material.

Expected and Achieved Results

As a result of the project implementation, the following outcomes are expected:

– A new composition of briquetted ferrosilicon will be obtained;

– A new technology for producing strong briquettes from dust will be developed;

– The interaction mechanism between fine ferroalloy production dust and the new complex binder material will be determined.

Achieved results to date:

As a result of the literature review on the issue under study, the objectives and tasks of the research have been formulated.

Initial samples of a marketable product from fine dust (FD) have been obtained. A series of further studies is planned to examine the complete compositional characteristics and chemical properties of the resulting product.

This work is a preliminary study aimed at determining the optimal parameters. Two different binders and two different compositions were tested.

The study shows that this process can be extended to the reuse of other loose solid wastes from ferroalloy production and offers a comprehensive solution for the recycling of bulk solid wastes.

Achieved Results

For the year 2023 – Work was carried out to assess the feasibility of developing the ferroalloy industry in the Republic of Kazakhstan through the production of marketable products from ferroalloy dust.

Key global trends in the development of the ferroalloy industry were identified. Data on binder compositions and their chemical properties were collected.

Ferrosilicon (FeSi) is used in the steel industry as a modifier added during smelting, as a deoxidizer, and as a melting agent in the production of steel and cast iron.

Information analysis shows that a significant amount of waste is generated during ferroalloy production, including fine ferroalloy dust and other materials. Their utilization and processing can reduce the consumption of primary raw materials, increase production efficiency, and lower environmental pollution.

However, the scale of waste recycling in ferroalloy production remains relatively low. The recycling and reuse of waste as secondary resources are currently relevant and necessary.

The conducted information analysis showed that methods of waste utilization during ferroalloy smelting at production sites are still insufficiently explored. Briquetting is a promising method for secondary processing. Briquettes introduced into furnaces must have certain mechanical and chemical properties. However, there is no standard for determining the suitability of briquettes used in smelting, and no optimal binder has yet been established for waste use.

Thus, by experimenting with different binders, it is possible to find an effective method for briquetting ferroalloy production waste, including fine dust, to obtain strong briquettes and improve the assimilation of alloying elements during their subsequent use.

Work was carried out to produce sample dust-based briquettes from ferrosilicon with a grain size of 0–3 mm using liquid glass as a binder. Ferrosilicon production is an energy-intensive process requiring significant amounts of electricity and raw materials such as ore, quartz (quartzite), fluxes, and reducing agents like coke, coal, and biomass.

The process also generates residues such as filter dust (silica fume), scrubber sludge, and slag. A convenient and cost-effective way of using ferrosilicon dust is briquetting and granulation. High pressing forces result in strong, non-crumbling briquettes.

One article was published in a journal included in the KOKSON database.

One article was published in a journal indexed in the Scopus database with a CiteScore percentile of 35.

One patent for a utility model was obtained in the Republic of Kazakhstan.

For the year 2024 – Research was carried out on the use of various components as binders.

One of the key aspects in the briquetting of fine ferroalloy production dust (FAPD) is the correct selection of the binder component. The binder must provide sufficient plasticity for briquette formation, ensure mechanical strength after appropriate treatment (e.g., drying), and not significantly alter the chemical composition of the briquette so that it complies with the relevant GOST standard for the specific ferroalloy.

A significant amount of research has been devoted to identifying a suitable binder and developing a briquetting charge composition based on FAPD. The optimal binder composition was selected based on the mechanical and chemical properties of the resulting briquettes. The optimal formulation of the final product was determined.

A complex binder composed of liquid glass and bentonite clay was proposed. Various ratios of these additives were studied. The probable strengthening mechanism involves the encapsulation (coating) of dispersed dust particles with clay and their strong adhesive bonding in a liquid glass medium.

Experimental smelting was carried out at the production sites of LLP "NPO Manganets" and LLP "KMZ named after Parkhomenko", where steel was smelted using test briquettes produced using the developed technology.

A preliminary process flow chart was developed — laboratory tests were conducted to assess the effect of composition and structure of briquettes made from fine ferroalloy production dust.

One article was published in a journal indexed in the KOKSON database.

One article was published in a journal indexed in the Scopus database with a CiteScore percentile of 35.

One utility model patent was obtained in the Republic of Kazakhstan.

For the year 2025 – Laboratory studies were conducted to examine the influence of briquetting parameters on the properties of briquettes made from fine dust (FAPD) generated in ferroalloy production, using iron ore concentrate as part of the charge. The composition of the resulting briquettes corresponds to that of ferrosilicon grade FS50, which makes it possible to use these briquettes as a substitute for standard FS50.

Currently, preparations are underway for technological support of the smelting process at the production site. Work is ongoing to sign a contract with the branch of the National Center for Complex Processing of Mineral Raw Materials (NC CPMR) named after Zh. Abishev, and this process is in progress.

The briquettes were produced from fine ferrosilicon production dust (FAPD) with the addition of iron ore concentrate. Their chemical composition, mechanical properties, and microstructure were investigated.

At present, industrial testing of the developed technology is being prepared, along with the corresponding official report. A manuscript of the monograph has been prepared and is undergoing editorial revisions.

Research Team

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List of Publications for 2023:

1) Омарова А.Е., Исагулова Д.А., Квон СВ.С., Ковалева Т.В. Выбор связующего для производства брикетов из высокодисперсной пыли ферросплавного производства/ **DOI 10.52209/1609-1825_2023_3_79.** Труды университета №3 (92) • 2023. http://tu.kstu.kz/archive/journal/26

2) D.A. ISSAGULOVA, SV.S. KVON, A.E. OMAROVA, T.V. KOVALEVA, V.YU. KULIKOV, A.A. ALINA/ Studying the binder effect on the properties of bri quettes of ferroalloy production waste. ISSN 0543-5846 METABK 63(1) 143-145 (2024). Журнал METALURGIJA 63 (2024) 1, 143-145. Хорватия.

3) Патент на полезную модель. Авторы Омарова А.Е., Исагулова Д.А., Ковалева Т.В., Алина А.А. №8617 от 10.11.2023.

List of Publications for 2024:

1) Erzhan A., Kvon Sv.S., Issagulova D.A., Kulikov V.Yu., Kovaleva T.V. «The possibility of using iron ore concentrate as a binder when briquetting waste of ferroalloy production» // METALURGIJA 63 (2024) 3-4, 454-456. (Хорватия). (Scopus процентиль – 35, CiteScore 1,2), P454-456. - https://hrcak.srce.hr/en/file/456164

2. Патент на полезную модель. № 9155. от 24.05.2024. Способ брикетирования пылевидных отходов, образующихся при производстве ферросилиция. Авторы: Исагулова Д.А., Ержан А., Куликов В.Ю., Квон Св.С., Ковалева Т.В., Адамова Г.Х.

3. Erzhan A.E., Kvon Sv.S., Okishev K.Yu., Isagulova D.A., Kovaleva T.V. The use of clay as a binder in briquetting finely dispersed dust of ferrosilicon production. №4, 2024 г.

List of Publications for 2025:

1) Ержан А., Исагулова Д.А., Квон Св.С., Окишев К.Ю., Ковалева Т.В. Возможность использования брикетов из отходов ферросплавного производства для раскисления и легирования кремнийсодержащих сталей. Журнал Литейное производство. №3/2025. 23-27 стр. ISSN 0024-449X.

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Figure 1 – Experimental Samples

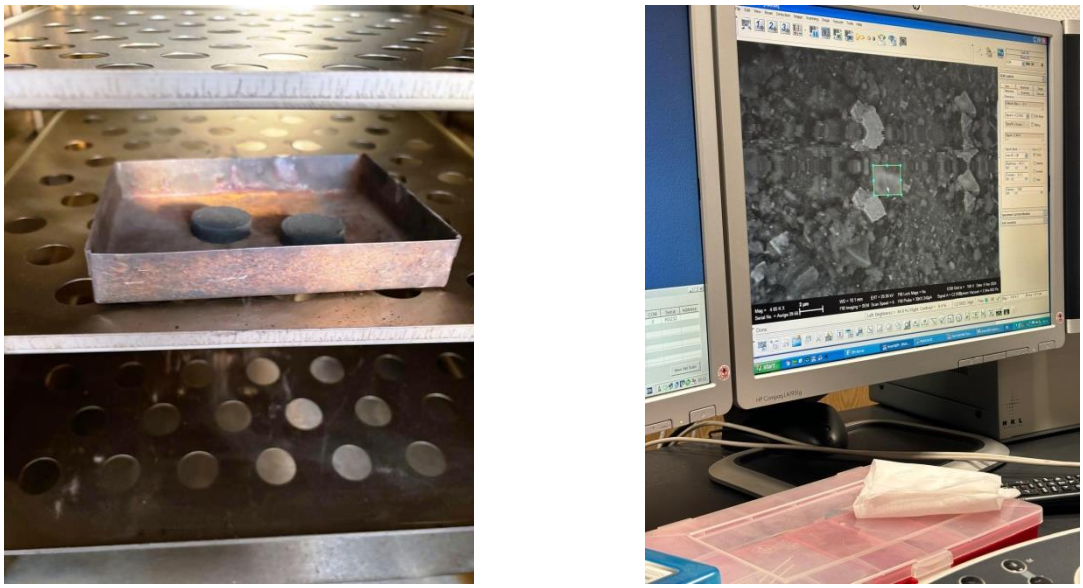

Figure 2– Experimental Procedure

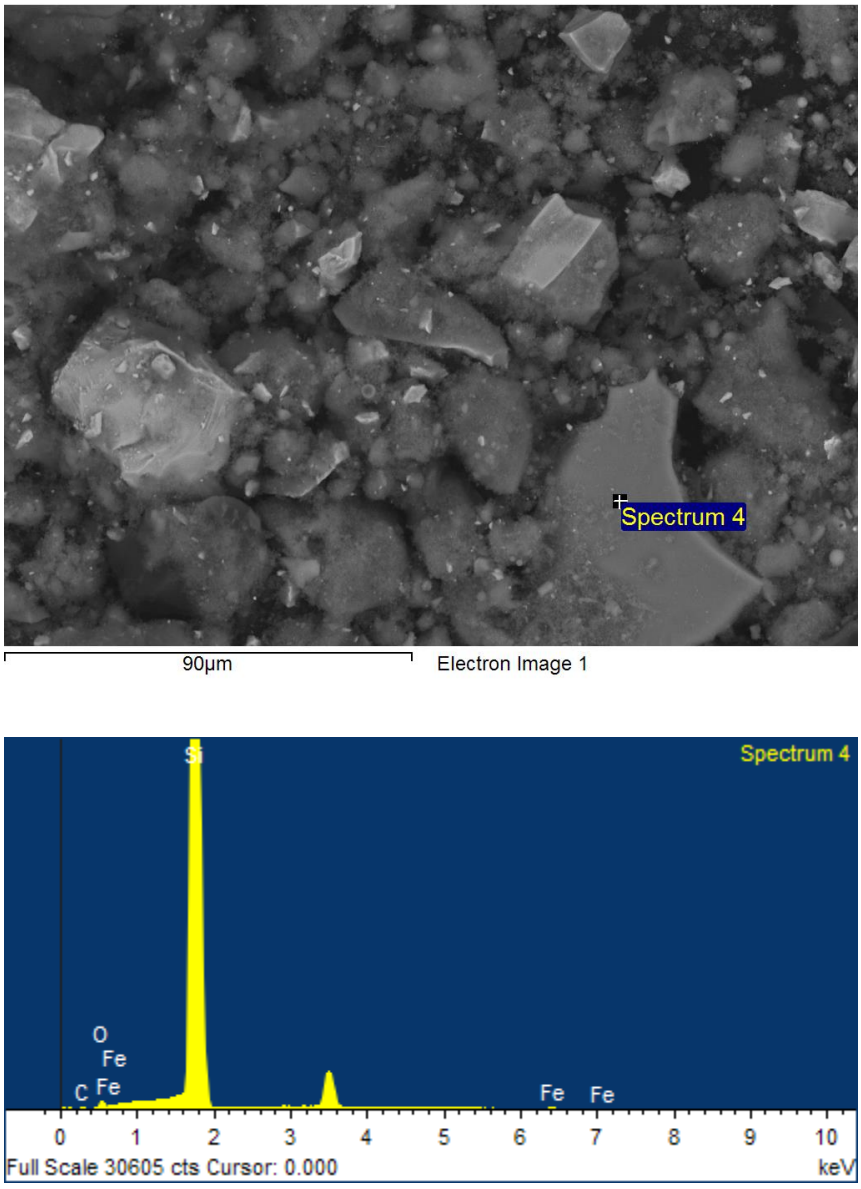

Figure 3 – X-ray Structural Analysis

Information for Potential Users

The results obtained serve as a foundation for more detailed research on the development of pressing and drying regimes using Kazakhstan-originated fine-dispersed dust (FDD) for the production of a marketable product.

Field of Application

Metallurgy, ferroalloy production.

Information Update Date: 01.07.2025