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Ibraev I.K. * and Ibraeva O.T.

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Article

Drainless Technology for Processing High-Moisture Iron-Containing Sludge and Dust

Ibraev I.K. * and Ibraeva O.T.

NJSC "Karaganda Industrial University"; ibraevik@yandex.ru; ibraevaot@yandex.ru
* Correspondence: ibraevik@yandex.ru

Abstract: PURPOSE. Development of a drainless energy-saving technology for the processing of high-moisture iron-containing sludge from metallurgical production. RESEARCH METHOD. The regularities of the combined process of chemical dehydration of high-moisture iron-containing sludge by powdered waste of lime and dolomite, hardening and agglomeration by pressing in a single technological cycle on the developed experimental plant are studied. In the course of laboratory studies, the temperature of the mass, the rate of dehydration, the chemical composition of the mixtures, the appearance of the resulting briquettes, the weight loss during agglomeration, the humidity of the mixtures, and the mechanical strength of the briquettes were carried out. RESULTS. New patterns have been established that have made it possible to develop a non-firing method for producing iron-containing material and self-healing briquettes. The essence of the method, which is one of the main provisions of scientific novelty, is to combine the processes of dehydration, self-hardening of the mixture with the process of shaping by applying external pressure to the hardening mixture in molds to obtain agglomerated material in the form of briquettes in a single technological cycle. The proposed technology does not require drying and firing, and a set of strength properties occurs as the material is cooled in air during the day. A new energy-efficient and drainless method for the production of iron-containing briquettes has been developed, which combines the processes of chemical dehydration and agglomeration in one technological cycle. CONCLUSION. The proposed project and technology will allow organizing production for the processing of high-moisture iron-containing sludge and obtaining a complex iron-containing material as a secondary metal-containing raw material for metallurgical plants for the production of steel and rolled metal. and dolomite dust of dry gas cleaning) as dehydrating and binding materials, as well as screening of coke and coal as a reducing agent. The proposed technology also solves the problems of environmental pollution and land acquisition for storage of production waste.

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Introduction

Metallurgical production is technologically accompanied by the formation of a significant amount of various wastes, reaching 30% of steel production. It consists of about 80% slag, and about 20% dust and other waste.

Processing and disposal of man-made waste is important not only from the point of view of their use as an alternative source of raw materials, but also from the point of view of environmental protection. At the same time, the waste often surpasses the ores extracted from the bowels in terms of technological qualities. However, despite the huge resource potential, mining waste in Kazakhstan is used mainly as a raw material for the construction industry, but even here no more than 10% of the annual volume of their formation is processed.

This applies to high-moisture iron-containing sludge from metallurgical production. Due to the lack of effective technologies for dehydration and agglomeration, they are usually stored in ash and slag storage, where they mix with other sludge and dust, and their metallurgical value is lost.

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About 95-100 thousand tons of iron-containing sludge from blast-furnace and oxygen-converter gas cleaning, containing 35-45% of iron and other oxides of elements (calcium, magnesium) important for metallurgical processes, is produced annually at ArcelorMittal Temirtau JSC and is not used and stored in ash and sludge accumulators and dumps. About 100 thousand tons of iron-bearing sands with a content of 50-75% iron are annually produced at Aluminum of Kazakhstan JSC, which are also stored in sludge fields. Given the trend of constant decline, the iron content in natural iron ore concentrates (45-50%), iron-containing agglomeration material obtained from high-moisture iron-containing sludge and dusty waste from lime production and raw dolomite roasting can serve as an alternative secondary material for partial replacement of iron ore concentrate. This will reduce the need for natural iron ore and fluxing materials. This is possible if there is a technology for preparing iron-containing sludge for metallurgical processing.

Today in Kazakhstan, millions of tons of iron-containing sludge from various industries are stored in ash and slag storage facilities, and technogenic deposits of iron-containing materials are being formed, which could serve as secondary metallurgical raw materials and a partial substitute for natural iron ore raw materials. In addition, they are usually located in close proximity to metallurgical enterprises.

On the other hand, at full-cycle metallurgical enterprises, which include ArcelorMittal Temirtau JSC, a large amount of fine calcium- and magnesium-containing dust is formed during the firing of limestone and raw dolomite in the form of lime and dolomite dust, which are excellent dehydrating and binding materials and, as a rule, they are not in demand, and are stored in ash and sludge storage facilities.

Solving the problem of developing a technology for dehydrating high-moisture fine ferrous sludge, as well as developing complex composite self-healing materials as alternative sources of raw materials, can serve as the basis for creating resource-saving, low-waste, closed, environmentally safe and waste-free metallurgical processes that solve not only the problems of raw materials, the maximum involvement of production waste in economic turnover, but also environmental problems of the region.

1. Literature review

In world practice, technologies for the production of iron-containing briquettes are known, but they differ from the technology we offer, using expensive and complex technologies (thermal, vacuum) of preliminary dehydration and multi-stage agglomeration technologies, which are energy-intensive and expensive technologies. [1–4]. The closest to the proposed technology is the production technology of metallurgical self-healing briquettes of the Russian company EcoMashGIO. In contrast to the proposed technology, iron-containing sludge with a moisture content of 15-20% is used; it is applicable for stale sludge taken from the sludge storage. In essence, the proposed technological scheme of "EcoMashGIO" does not exclude the transportation of iron-containing pulp along a multi-kilometer sludge pipeline and storage in sludge reservoirs. In addition, cement is used as a binder and strengthening material in the EcoMashGIO technology, which increases the cost of a metallurgical briquette. [5,6].

The prerequisites for the development of this project were the new patterns established by the authors in the processing of high-moisture iron-containing sludge and calcium- and magnesium-containing materials (lime, dolomite dust) for chemical dehydration of sludge, hardening of the mixture, by the type of mixing cement with water, with the production of stone-like material in the form of fine sand . When high-moisture sludge is mixed with dehydrating materials due to the exothermic reaction of active calcium and magnesium oxides with sludge moisture, the temperature of the system rises to 95-110 0 C, and part of the moisture evaporates and is removed in the form of steam [7–10].

This version of the technology was introduced at JSC "ArcelorMittal Temirtau" in the water supply workshop for dehydration of oily scale using powdered lime and dolomite waste to produce lime scale for sintering production [9].

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2. Research methodology

To study the processes of combining the operations of dehydration, hardening and agglomeration of iron-containing sludge, a laboratory installation was developed (Figure 1) and experiments were carried out to study the conditions that ensure the production of iron-containing briquettes suitable for steelmaking [11,12].

In the process of mixing and subsequent exposure, the temperature of the mass, the rate of dehydration, and the chemical composition were measured.

The shaping process was carried out on a laboratory hydraulic press with a force of 125, 180 and 280 kN. Cylindrical briquettes with a diameter of 50 mm and a height of 60 mm, produced under laboratory conditions, had a strength of 94, 265, and 505 kN/cm^2, respectively, and a density of 2.7 kg/cm^3. The amount of fines less than 5 mm when dropped onto a steel plate from a height of 2 m was 0.6%.

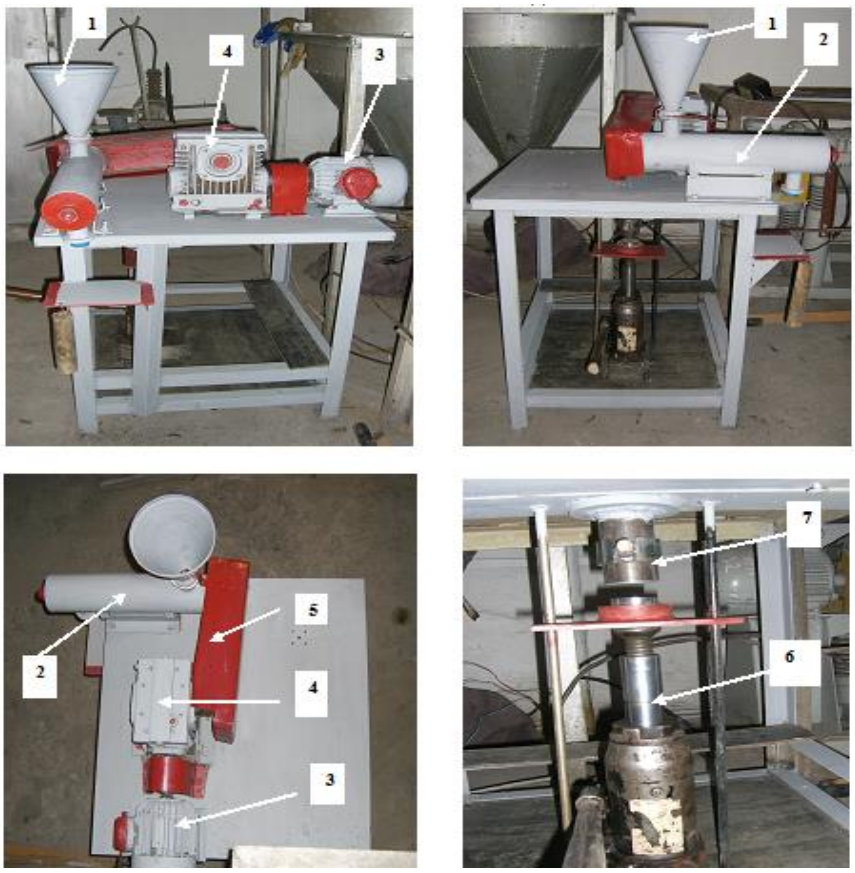

Figure 1. Scheme of a laboratory plant for briquetting iron-containing sludge of a converter gas cleaning. 1- receiving hopper (funnel); 2 - screw mixer (activator); 3 – electric drive; 4 - reducer; 5 - belt drive; 6 - hydraulic press; 7 - cylindrical mold.

3. Research results

Research has established new patterns that have made it possible to develop a non-firing method for producing iron-containing material and self-healing briquettes. The essence of the method, which is one of the main provisions of scientific novelty, is to combine the processes of dehydration, self-hardening of the mixture with the process of shaping by applying external pressure to the hardening mixture in molds to obtain agglomerated material in the form of briquettes. The proposed technology does not require drying and firing, and a set of strength properties occurs in air as the material cools during the day. Innovative patents of the Republic of Kazakhstan have been obtained for the proposed technical solution [13,14].

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As a result of additional research, a new efficient resource-and-energy-saving technological scheme for the production of agglomerated iron-carbon-containing material for metallurgical production technologies has been developed.

The developed innovative technologies for the preparation of wet sludge for processing were presented in the Catalog of the Exhibition of Achievements of the Domestic Industry "Development of the Mining, Metallurgical and Coal Industry"[15], and reflected in the materials of the All-Russian Conference "Research in the field of processing and disposal of industrial waste and from the school of young scientists [16].

4. Discussion of research results

Slurry pulp from wet gas cleaning technology or systems is pumped directly to the proposed plant (Figure 2), where the slurry condenses in pressure hydroclones to a moisture content of 40-50%, and the thickened sludge is sent to the conveyor, where pulverized lime and / or pulverized dolomite, as well as screenings of coke breeze or pulverized coal. From the conveyor, the materials are fed into the screw mixer-activator, where the process of chemical dehydration is carried out. From the mixer, the dehydrated heated slurry-lime mixture enters a roller or vibrating press, where agglomerated material with a residual moisture content of 5-9% is formed. Briquettes are stored on pallets for cooling and holding pressure at ambient temperature. The clarified water from the hydrocyclone is pumped and returned to the process.

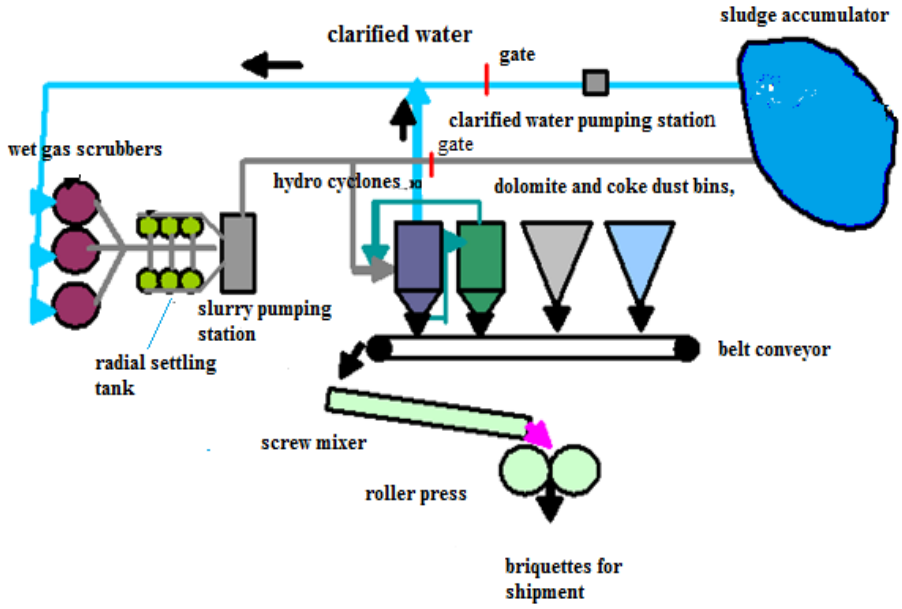

Figure 2. Technological scheme for the production of sludge-lime briquettes for converter production.

The proposed technology, in essence, makes it possible to create a closed water supply system not through a clarification pond (sludge accumulator), but through the proposed installation (separation), which significantly reduces water consumption, labor and energy costs for transporting pulp through a multi-kilometer sludge pipeline to the sludge storage and clarified water back for the technology, as well as the cost of maintaining slurry pumps, slurry pipelines and slurry tanks.

Thus, iron ore sludge in the form of agglomerated composite material can be used as a substitute for iron ore concentrate in the through technology of steel and cast iron smelting. Eliminates the allocation of land for a sludge storage for sludge storage and provides a more complete disposal of man-made production waste.

The proposed project is the basis for the creation of resource-saving, low-waste, closed and environmentally friendly wasteless processes that solve not only the problems of raw materials, the

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maximum involvement of waste in economic circulation, but also environmental problems of production.

The competitiveness of the proposed technology in comparison with similar foreign analogues is as follows:

- exclusion of transportation and storage of sludge in the sludge storage and processing of sludge in the immediate vicinity of the source of formation;

- reduction of labor and energy costs for transportation and storage of sludge, maintenance of sludge pumps, sludge pipeline and sludge collector;

- there is no need to dry the sludge before the production of iron ore briquettes:

- a one-stage process of dehydration, self-hardening and shaping to obtain complex iron-carbon-containing agglomerated material in one production cycle;

- use of waste calcium- and magnesium-containing dusts (pulverized waste) as a dehydrating and binding material, and as a reducer of screenings of coke or coal of own production;

As a result of the project implementation, products will be produced in the form of secondary iron-carbon-containing material and iron-carbon alloy as a substitute for iron ore raw materials and scrap for the production of steel and iron and alloys.

5. Conclusion

The proposed project and technology will allow organizing production for the processing of high-moisture iron-containing sludge and obtaining a complex iron-containing material as a secondary metal-containing raw material for metallurgical plants for the production of steel and rolled metal. (limestone and dolomite dust of dry gas cleaning plants) as dehydrating and binding materials, as well as screenings of coke and coal as a reducing agent.

The proposed technology also solves the problems of environmental pollution and land acquisition for storage of production waste.

The proposed project and technology will make it possible to exclude the storage of iron-containing sludge in ash and sludge collectors and sludge fields, obtain new marketable products and reduce the consumption of natural iron ore and fluxing materials and solve not only technological but also environmental problems of metallurgical production. The proposed processing scheme will reduce environmental charges for waste storage, reduce the amount of off-balance water and groundwater pollution.

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