Issue IV, 22 November 2021
e-ISSN 2707-9481
ISBN 978-601-323-252-2
Institute of Metallurgy and Ore Beneficiation, Satbayev University, Almaty, Kazakhstan
https://doi.org/10.31643/2021.13

Bondarenko Igor Vladimirovich
Institute of Metallurgy and Ore Beneficiation JSC,
Satbayev University Almaty, Kazakhstan
Email: i/bondarenko@imio.kz
https://orcid.org/0000-0002-2554-2311

Kuldeyev Yerzhan Itemenovich, Institute of Metallurgy and Ore Beneficiation JSC,
Satbayev University Almaty, Kazakhstan
Email:kuldeev_erzhan@mail.ru
https://orcid.org/0000-0001-8216-679X

Beneficiation of fine chromite slurry at Donskoy Mining and Beneficiation Plant JSC on concentration tables to produce hard chromite pellets

Abstract: Processing industrial products and technogenic waste is an important task in the mining and metallurgical industry. In Kazakhstan, the processing of chrome ore from the Kempirsay group of deposits has produced more than 15 million tonnes of slurry tailings containing up to 30 wt% chrome oxide. The best results in the world for the processing of fine chromium raw materials are shown by Turkish enterprises with the use of the separation of slurries by size classes and beneficiation on concentration tables. The authors conducted researches for beneficiation of chrome slurry from Dubersay tailings pond (Kazakhstan) with the use of similar technological methods that enabled to obtain concentrates with chrome oxide content of 51 wt% and increasing the yield of beneficiated fine-graded chrome concentrates by 14% as compared with the existing beneficiation process. Strong chromium pellets with a crushing resistance of over 5000 N/pellet were produced from the rich chromium concentrates with the use of the ferrofluxing iron-calcium-silica binder technology by roasting the composition consisting of rich chromium concentrate, ferrous diatomite, and intermediate products and wastes of the chromium industry.
Keywords: chrome production slurry, environmental impact, chrome slurry beneficiation, concentration table, rich chrome concentrate.

Cite this article as: Bondarenko I.V.; Kuldeyev E.I. (2021). Beneficiation of fine chromite slurry at Donskoy Mining and Beneficiation Plant JSC on concentration tables to produce hard chromite pellets. *Challenges of Science*. Issue IV, pp. 91-94. https://doi.org/10.31643/2021.13

Introduction

Mining, ore beneficiation, and smelting of ores and concentrates are accompanied by the formation of rock dumps and off-balance ores, tailings ponds, and slag dumps. The long-term development of ore deposits associated with mining, concentration, and metallurgical smelting leads to the accumulation of large amounts of waste in the form of stockpiled tailings and metallurgical slags, dumps of substandard ores and host rocks, industrial effluents, forming large-scale dumps and water settling tanks - technogenic mineral formations (TMF) [1-2].

The stored reserves of valuable components in the tailings are comparable with the natural deposits in terms of accumulation amount and content of valuable components that determine the reasonability of their categorization as technogenic deposits.

The beneficiation processes of chromite ores are accompanied by a considerable yield of finely dispersed chrome concentrates obtained by gravitational, flotation, as well as magnetic methods. These concentrates cannot be effectively processed by smelting due to low gas permeability and high dust loadings in the furnaces. Fine chromite slurries containing up to 30 % chrome oxide from different technological beneficiation lines of two concentration plants of DMBP JSC are sent to the Dubersay slurry storage facility. The total amount of slurry stockpiles at Dubersay exceeds 12 million tonnes. In small quantities, slurry from the slurry pond is processed by gravity concentration methods at the beneficiation facilities of Akzhar-

Chrome LLP, with rich concentrate going to the Aktobe Chromium Compounds Plant JSC. During this processing, the slurry with 25% Cr_2O_3 content is returned to the Dubersay slurry pond [3].

In this connection, the enterprises of TNC "Kazchrome" JSC perform works on improvement of processes directed on the decision of existing industrial problems. In the beginning, the simplest technology of gravitational enrichment of finely dispersed material on screw separators and briquetting of chrome material was applied. However, the hardness of the briquettes was low and did not allow them to be transported over long distances. Then the technologies of roasting "raw" pellets on a flexible belt of roasting machines and producing sinter on a sintering machine were implemented. However, technological solutions for roasting of fine chrome concentrate proved to be inefficient due to inappropriate choice of charge composition, frequent failures of technological equipment due to high roasting temperature - 1350 ^oC that resulted in low crushing resistance of roasted pellets and sinter with a high yield of defective pellets of sintered product. For example, in flexible belt roasting machines, due to non-compliance with the technological firing regime, with the planned yield of rejected pellets up to 3% of the total quantity, the reject rate was higher than 10% [4].

The positive experience of the Republic of Turkey on beneficiation of fine chrome raw materials (slurry) by a separate division of chrome raw materials by size classes and their beneficiation on concentration tables are known in the chrome industry. This beneficiation technology enables to receive rich chrome concentrates and tailings with the content of Cr_2O_3 not more than 3-5% [6-7]. However, it is important to obtain not only rich (not less than 50% by weight Cr_2O_3) but also agglomerated chrome raw material for further reduction electrofusion [5-8].

Russian scientists have proposed and tested the technology for iron-ore mineral sintering where cheaper Callovian clays are used as sintering material.

The theoretical justification for the synthesis of ferrosilicate-calcite fluxes, so-called FCF, was proposed in [9, 10] for iron ore pellet production technologies with the use of Callovian clays as binders, the main component of which is mixed formation mineral-like illite-smectite - 58%, mass fraction of montmorillonite component - 12%, kaolinite - 6%, quartz - 14%, calcite - 10%. The authors propose to use a charge composed of industrial waste as an analog of the Callovian clays - slags of refined ferrochrome production, and available natural raw materials - ferruginous diatomite. The composition of the charge was calculated, and studies were performed to produce hardened pellets with the use of the new binder.

The idea of use of sodium bicarbonate in chemical beneficiation of chromium slurry is described in [11]. The technology of chemical chromium slurry beneficiation enables to separate the major part of magnesium oxide from chromium spinelide, thus removing it from the system and beneficiating the chromium raw material in terms of chromium oxide.

Kazakhstan scientists have also proposed the production of ferrofluxing binders to produce hard chrome pellets [12-14].

They have a unique strength (up to 5 325 N/pellet), do not absorb moisture, and therefore do not lose mechanical resistance when they become wet due to the formation of a binding vitreous phase. There is no need for a component breakdown of 0.07 mm; 0.25-0.1 mm is sufficient; as high strength is achieved through the formation of a fluxed ferrosilicate-calcium glass phase.

The technology being developed for the production of hard pellets enables to produce hard chrome oxide pellets with extra hardness and to use inexpensive natural raw materials such as iron-iron diatomite, as well as intermediate products and wastes from chrome production (special coke, mineral parts refined ferrochrome slag and melting in limestone roasting furnace) as fluxes.

At present, the beneficiation technologies of fine chromium raw materials, used at the enterprises of the chrome industry are not effective enough, therefore improvement of technological schemes with the use of advanced technological methods is required.

The main methods used to process chromite ores are gravity beneficiation processes. DMBP uses gravity separation and heavy medium separation processes for beneficiation to produce lumpy concentrate and fine-grade beneficiation on screw separators which concentrate is fed to pelletisers to produce pellets.

Currently, poor chromite ores from different parts of the deposit and technogenic waste dumps are involved in processing that can serve as additional sources of raw materials. The processing of the Dubersay tailings slurry is inefficient, since the processing scheme includes a sequential classification scheme and beneficiation on screw separators, with slurry concentration tables and flotation machines used at the end of the scheme. The existing tailings beneficiation process is complicated and does not take into account the main gravity beneficiation principles, with the result that the beneficiation apparatus receives a stream with a particle size of 0.038 mm to 1.000 mm so that large waste rock grains go into the concentrate, and fine chromite grains go into the tailings.

Research methods and techniques

In this connection, there was a necessity to perform researches to study gravitational beneficiation of slurry tailings from the Donskoy MBP.

We have obtained new data on the process of chromite tailings beneficiation with the use of modern technological equipment that enables separation into narrow fractions of material size with their subsequent gravitational beneficiation on concentration tables.

Laboratory tests were performed on gravitational beneficiation on a concentrating table on the class -0.5 mm to perform laboratory tests on gravitational beneficiation of tailings chrome production selected a sample of Dubersay tailings slurry.

The test pattern includes the following operations: flocculant washing; classification into +0.5 mm and -0.5 mm classes; regrinding of +0.5 mm class; beneficiation on concentration table of -0.5 mm class; beneficiation of industrial product on concentration table; control operation on concentration table of industrial product beneficiation tails; regrinding on concentration table of industrial product beneficiation; classification of slurry (first concentration tails on a concentration table).

Research results

Quality concentrate with 50 % Cr_2O_3 and recovery at the level of 75 % can be achieved as a result of the beneficiation process on the concentrating table of each product separately by size and the subsequent classification of slurry with +0,5 mm class grinding, turnover of classification sands to the beginning of the process.

The resulting fine chrome concentrate was pelletized on a laboratory pelletizer.

The following components were used as a source for the synthesis of a new type of binder: obtained finely dispersed rich chromium concentrate, mineral part of refined ferrochrome slag (source CaO and SiO_2), ferrous forms of diatomite (source SiO_2 and FeO), finely dispersed. special coke (source SiO_2, regulator of pellet heating temperature), liquid glass.

Solid components of the charge were crushed in a laboratory mixer and sifted on a laboratory sieve with a mesh size of -0.25 mm.

The component composition of the mixture was, wt.%: chromium concentrate-88.0; mineral part of slag RFCH-3.0; ferruginous diatomite-4.0; chalky coke-3.0; liquid glass-1.0.

The granules were produced on a laboratory granulator. The size of crude granules is 6 to 10 mm. Untreated granules were kept at room temperature for 24 hours. The hardness of the uncooked temperate granules was 124.6 N/pellet.

The batches of "raw" pellets were roasted at temperatures of 1050-1200° C for 60 minutes in a laboratory muffle furnace.

Obtained roasted pellets (7 pieces in each batch) were tested for crushing resistance on a laboratory press MIP-25R and the average hardness was determined. Average hardness at the temperature of burning on pellet: at 1050 °C -2 854; at 1100 °C - 3980 at 1150 °C - 4 500; at 1 200 °C - 5 330.

The obtained pellets will be used for further laboratory studies with determination of their electrical melting parameters in the furnace.

Conclusions

-The researches have confirmed the possibility to separate individual fractions of chrome slurries by size and their further gravitational beneficiation by size classes to produce a rich chrome concentrate suitable for further production of roasted chrome pellets.

- Roasted hard chrome pellets with a crushing resistance of over 5000 N/pellet are obtained.

- The technology under development improves the economic efficiency of fine chrome slurry processing and increases the extraction of chrome oxide from chrome raw materials in Kazakhstan.

Acknowledgments

The work was performed on Grant No. APO8856229 and supported by the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan.

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