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| Research Article

Development of a Technology for Chemical Refinement of High-Ash Graphite Flotation Concentrates From the Taskazgan Deposit

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Annotation
In this article, the concentrate obtained from a graphite sample of the Taskazgan deposit was processed using thermal and hydrochemical methods. Optimal parameters for the removal of harmful impurities from the flotation concentrate were determined. As a result, using combined methods, the carbon content in the graphite concentrate reached 92.8%, with an ash content of 0.3%. According to the conducted research, the possibility of extracting a high-quality graphite concentrate based on the combined enrichment scheme was established.

Keywords: flotation, thermal and hydrochemical methods, soda, quantity, graphite, acid processing.

Introduction

Today, products made from graphite are considered one of the most in-demand commodities in the market economy as an important industrial raw material. Graphite is widely used due to its unique properties and characteristics. Graphite is utilized in various industries, including:

- ✓ metallurgy (crucible production, casting molds, refractory products, fire-resistant paints);
- ✓ oil and gas sectors (lubricants);
- ✓ electrochemistry (galvanic cells);
- ✓ mechanical engineering (brake pads and linings, smooth mechanisms - bearings and gaskets);
- ✓ stationery products (pencils, paints, papers);
- ✓ equipment for nuclear power engineering.

Graphite is used in the production of alkaline batteries and lithium-ion batteries, which are widely used in devices such as mobile phones, laptops, digital cameras, video cameras, and electric vehicles. Battery production primarily utilizes synthetic graphite, derived from petroleum and coal products. It is also used in the nuclear industry for manufacturing components and parts of nuclear reactors. [1, 3, 4]

In addition to the aforementioned industries, which are the main consumers, graphite is used in the production of explosives for polishing gunpowder, serving as a filler that reduces friction. It is also used as a packaging material for explosives. Graphite is successfully employed as an anti-scale agent in steam boilers. Graphite plastics are finding increasing application in technology as an anti-friction and corrosion-resistant material.

Graphite ores can rarely be used directly by consumers of graphite raw materials. Usually, they undergo preliminary enrichment at mining enterprises. The methods of this processing are established in accordance with the properties of the ore and the requirements of consumers. The use of flotation enables the enrichment of very low-grade graphite ores containing 3-5% graphite.

The Taskazgan deposit, which has industrial significance, due to the peculiarities of its geological structure and material composition of graphite ores, as well as the enrichment of graphite ore, required numerous studies to be conducted [6].

Research Materials and Methods

It is known that graphite is acid-resistant; however, theoretically, it is possible to reduce the amount of harmful impurities in the enriched product by dissolving them in various acids. We can observe that the content of quartz minerals, aluminum oxide, iron oxide, and carbonate minerals, which are considered harmful additives in graphite concentrate, has not decreased to the level required by GOST standards during gravity and flotation processes. For this reason, studies were conducted on the hydrometallurgical processing of the obtained primary concentrate to remove these harmful impurities [2, 6].

To transfer the residual iron and calcium oxides contained in the obtained flotation concentrate into solution, the dissolution of this product was carried out using hydrochloric, nitric, and phosphoric acids (Image. 1).

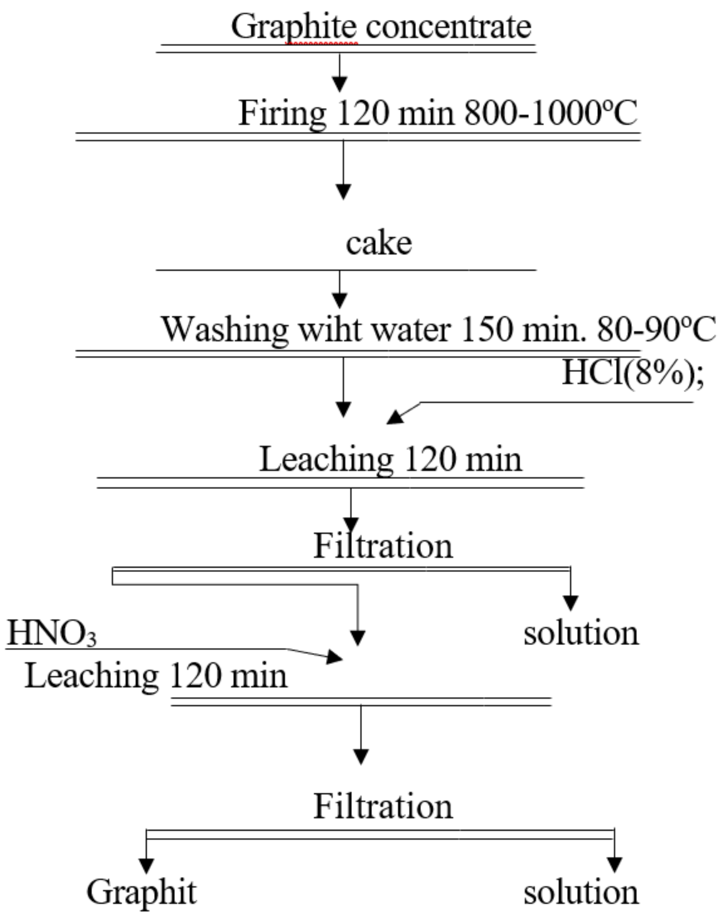

Image 1-. Graphite enrichment processing scheme

Chemical refinement of graphite concentrate [7] consists of 3 main stages:

1) Sintering the concentrate with soda is the most important stage of chemical refinement. Its purpose is to convert waste rock minerals into a soluble form. The success of further hydrochemical processing of the mineral depends on the completeness of the reactions during sintering. In the practice of chemical refinement of graphite concentrates, the sintering of the graphite-soda charge is carried out at a temperature of 900-1000°C.

2) Leaching the sinter in an alkaline environment and washing off the alkali. The main components of the sinter, as shown above, are: sodium aluminate $Na_2O·Al_2O_3$, sodium silicate $Na_2O·SiO_2$, and sodium ferrite $Na_2O·Fe_2O_3$. In practice, during the sintering of significant volumes of material, due to local processes, dicalcium silicate $2CaO·SiO_2$, sodium aluminosilicate $Na_2O·Al_2O_3·SiO_2$, and calcium aluminate CaO·Al2O3 can also be formed.

3) Leaching the cake after alkaline treatment in an acidic solution and washing off the acid. Let's consider the processes that result in the purification of the concentrate from waste rock components in the specified sequence. The precipitate after the alkaline processing cycle contains the following components: iron, calcium, and magnesium hydroxides, sodium aluminosilicate, some amounts of calcium silicates and aluminates, and aluminum hydroxide formed by the reaction:

$$3(CaO·Al_2O_3) + 12H_2O = 3CaO·Al_2O_3·6H_2O + 4\ Al(OH)_3$$

The selection of acid for treating the washed precipitate is determined by its material composition, specifically the content of concentrates that form easily soluble compounds with the acid. From this perspective, for processing Taskazgan graphite concentrates, which contain a fairly significant amount of calcium oxide, the most suitable options are hydrochloric acid or a solution of sodium chloride in sulfuric acid.

Results and Discussions

The charge, consisting of graphite concentrate and calcined soda of "chemically pure for analysis" grade, was prepared by dry mixing method.

The charge for sintering was loaded into metal containers made of St3 grade sheet steel, with a rectangular cross-section measuring 120×60×120mm. The container's capacity for the densely packed charge was 780-810g. The material in the container was covered with a lid to eliminate any air gap underneath. To tightly prevent air from entering the container under the edges of the lid, a small strip of soda was sprinkled onto the charge. These measures effectively prevented graphite burnout during the sintering process due to air exposure.

Sintering regime:

- ✓ temperature increase to 900°C over 2-2.5 hours;
- ✓ holding at a temperature of 900-950°C for 8 hours;
- ✓ cooling of the material in the furnace to 500°C and further cooling on the hearth withdrawn from the furnace.

To convert individual components into a soluble form, the resulting sintered product underwent hydrochemical treatment.

The pulp was heated to 45-50°C, and sulfuric acid (specific gravity 1.84) was poured into it while stirring. Further heating of the pulp to 65-75°C occurred due to the heat released during the dissolution of the acid.

Leaching was carried out for 30 minutes at a pulp temperature above 70°C and a S:L ratio of 1:10. After leaching, the pulp was allowed to settle, and the clarified solution was siphoned off. Typically, the clarified solution after acid treatment contained a certain amount of suspended graphite particles. Under laboratory conditions, graphite losses during washing of the acid cake to pH 6-7 were insignificant and did not exceed 1.5-2%.

After acid leaching, the cake was filtered and washed with water until a neutral pH was achieved.

The washed cake was dried at 120°C and analyzed for ash content. From the results of the analyses of the products from the hydrochemical testing of the sinter, presented in Table 38, it can be seen that the above-described treatment at a calculated concentration of hydrochloric acid of 5% allows obtaining graphite with an ash content of less than 1% from an initial flotation concentrate with an ash content of 37%.

As can be seen from the results of the chemical analysis were obtained in the concentrate obtained from the Tashkazgan deposit (%): SiO_2-1,2; $Fe_2O_{3(gen.)}$- 0,02; CaO-<0,5; MgO-<0,5; Al_2O_3-0,24; K_2O-0,11; Na_2O-0,25; P_2O_5-<0,01; TiO_2 - 0,05; MnO-<0,01; SO_3-<0,04; H_2O-0,86; CO_2-0,6.

Conclusion

1. The main distinction between the developed technology and the methods for refining low-ash products lies in the use of soda leaching of the sinter, which provides optimal conditions for the transition of a large quantity of aluminosilicate impurities into solution.
2. As a result of the combined technological processing of the flotation concentrate obtained from the graphite ore of the Toshqazgan deposit, it became possible to produce a high-quality graphite concentrate with a high carbon content and a low ash content.
3. A technology for chemical refinement of high-ash graphite flotation concentrates has been developed, which under laboratory conditions allowed for the production of products containing 0.3% ash with a carbon recovery of 92.8% from the operation.
4. The obtained high-quality graphite concentrate enabled the creation and production of various types of components suitable for use in metallurgy, chemistry, mechanical engineering, electrical engineering, and other industrial sectors.

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