

Research On The Extraction Of Iron Oxide From Iron-Bearing Tailings Of Concentrating Plants

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Abstract: World practice shows that today many metallurgical plants have developed cost-effective methods of processing raw materials. This is due to the fact that the steel industry in the world today has a strong growth trend. At the same time, there is a reduction in the amount of iron in the ore by 30-25% and the use of traditional furnaces and technologies that do not meet modern requirements. Uzbekistan also needs to reconsider a number of unresolved issues in the metallurgical sector. The most effective way to achieve high production results is to improve the enrichment technology used to smelt poor iron-containing ores that meets today's requirements, and even more so. Therefore, in the production of steel, special attention is paid to improving the technology of concentrators.

Keywords—iron, iron oxides, recycling of tailing, magnetic separation, incineration.

1. INTRODUCTION

According to the literature, a method of direct recovery of metal-bearing material is known, which is carried out by means of a metal-bearing material loading device to the shaft furnace. delivery consists of heating and recovery, carbonization with a return gas formed in the in-layer conversion zone. When natural gas from the bottom of the mine is heated in the heating zone by the heat removed by the exhaust gas from the recovery zone of the metal-bearing material in the heating zone, it is recovered by the material containing the heated metal [1,2,3].

Another well-known method is the direct reduction of iron oxides, in which the in-layer conversion takes place in the inner cavity of the furnace, in the in-layer conversion zone. The furnace has heating, reduction zones, in-layer conversion, carburization and cooling, in which the relevant technological operations are carried out. To start the production process, the initial return gas is used, produced and heated in an empty converter located outside the furnace. When the temperature required for the conversion process is reached in the zone inside the layer conversion process, the converted gas mixture is fed and converted into a return gas.

The disadvantages of the above methods are that they are used as a natural gas reducing agent in reducing iron oxides. It is currently more expensive than coke [4,5,6].

The aim of this study is to obtain sulfur-free metallized ores (granules) using coke-free technology. Reducing the overall cost of producing iron ore and obtaining a metal (i.e. iron) cord from waste tires. This is achieved by using large amounts of carbon, hydrogen and sulfur car tire waste instead of coke, coal and natural gas, which play a reducing role [7,8].

2. EXPERIMENTAL PART OF RESEARCH

2.1 RESEARCH MATERIALS

Iron ore stored in the non-ferrous and ferrous metal ore processing plant of the Almalyk Mining and Metallurgical

Combine was selected as the objects of research [9]. The chemical composition of the waste of the concentrator of JSC AMMC is presented in Table 1.

Table 1. Chemical composition of wastes of concentrator of JSC "AMMC" selected for the experiment,%

Fe	Si	Al	Mg
52,7	25,42	4,98	1,55
Na	Zn	Pb	Co
2,07	2,23	0,643	0,131
Ca	Cu	K	S
4,54	0,871	2,75	0,688
Mn	Ti	Mo	Zr
0,312	0,273	0,358	0,457

The values in Table 1 show that the chemical composition of the concentrator waste is significantly higher (i.e., 52.7%). In addition, the amount of silicon is significant (25.42%). This indicates that the material composition of this material is mainly composed of oxygenated compounds of iron and silicon [10,11,12].

In order to separate the silicate iron from the concentrator waste, it is first necessary to remove the iron from the silicate. In this study, an assimilation method was used to separate iron oxide from iron silicate. Lime (CaO) was selected as a reagent to displace iron oxide from the silicate composition [13-18].

2.2 RESEARCH METHODS

In order to extract iron oxide from the concentrator plant waste, it is necessary to determine in the form of a compound of iron in the raw material. To do this, the quantitative analysis method was used in this study. The ratio of the percentages of iron and silicon in the initial material, measured in 100 g, was determined: $n_{Fe} = 52.7 / 56 = 0.941$ mol, $n_{Si} = 25.42 / 28 = 0.907$ mol. In this case, the $n_{Fe} : n_{Si}$ mole ratios are 1: 1. This indicates that the compound of iron and silicon that corresponds to this ratio is a mineral containing $FeO \cdot SiO_2$ or $FeSiO_3$. Thus, the lime-assisted process was carried out with

FeSiO₃ - an iron (II) -metasilicate compound. ThermoBase-2.15 and Microsoft Excel were used to determine the thermodynamic values of chemical reactions in the iron (II) -metasilicate and lime systems, and to create their Ellingham graphs [19,20].

3. RESULTS AND THEIR DISCUSSION

After the Almalyk Mining and Metallurgical Combine (AMMC) found that the tailings from the 2nd copper concentrator were in the form of iron oxide and silicate minerals, the tailings were initially separated into magnetic fractions. For the research work, a total of 20 g of concentrator waste from 10 g was initially weighed on an electronic scale. It was then analyzed for granulometric analysis. Accordingly, the first ore was ground in a mortar by dry grinding until the particle size was less than 1 mm (Figure 1).



Fig.1. Granulometric analysis of concentrator waste

When separated by 2 different fractions using a magnetic stone, 8.35 g of non-magnetic fraction remained. Hence, the amount of magnetic fraction is $20 - 8.35 = 11.65$ g. Hence, the magnetized portion of the concentrator waste is a percentage as follows.

$$C_{\text{magnit}}(\%) = \frac{M_{\text{mag}} \cdot \text{frak} \cdot 100}{M_{B.F.Ch}} = \frac{11.65 \cdot 100}{20} = 58,25\% \quad (1)$$

It turns out that iron ore compounds, which can be separated by magnetic separation, make up 55-60% of the raw material in the tailings of the concentrator. Magnetite (Fe₃O₄) is better attracted to magnets, mainly from iron oxides. Due to the dark color of the magnetized part, it was concluded that the main part of the magnetic fraction is a magnetite mineral, because the color of pure magnetite is also black (Figure 2a).

Given the presence of iron in the non-magnetized part, it is determined that the iron is in the form of iron (II) -metasilicate (FeSiO₃).

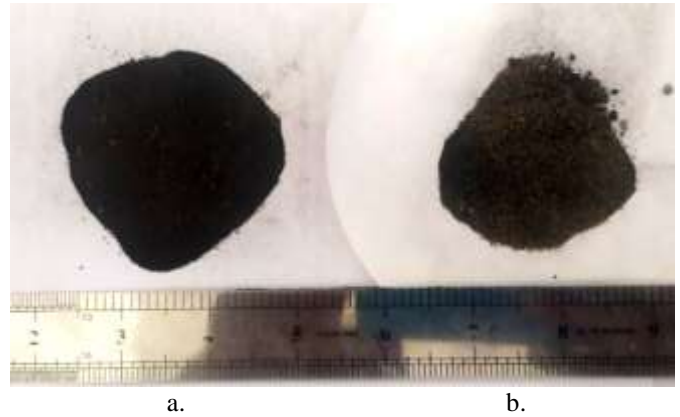


Fig.2. Products of magnetic enrichment of concentrator waste: a - magnetic fraction, b - non-magnetic fraction

It is known that FeSiO₃ is almost insoluble in magnetism due to its low magnetic attraction. It cannot bind to flotation agents due to its high hydrophilicity during flotation. Accordingly, the task was set before the study to convert iron oxide (FeO) and quartz (SiO₂) from minerals in the form of iron (II) -metasilicate to separate compounds. As a result, iron changes from a non-magnetized silicate to a magnetized oxide. In order to do this, in the scientific laboratory of the Department of Metallurgy of Tashkent State Technical University performed the operation of extraction of iron oxide from silicate compound by the action of lime (CaO) on iron (II) -metasilicate. Samples of lime corresponding to a non-magnetic 8.35 g fraction were weighed and a slag was prepared (Fig. 3).



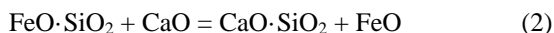
Fig.3. An example of a shale made with a mixture of concentrator waste and lime

The resulting slag sample was placed in a container made of refractory materials and baked in the SNOL-2,5x2,5x2,5 / 3I Mufel oven at 800, 900, 1000 °C for 1 hour (Figure 4).



Fig.4. Incineration of a mixture of non-magnetic fraction of concentrator waste and lime in a muffle furnace

In the process shown in Figure 4, the following chemical reactions take place during the firing of a mixture of lime with concentrator waste in a muffle furnace:



After firing, the samples were again subjected to magnetic separation. (2) Iron (II) oxide (FeO), which is released by the flow of a chemical reaction, is also separated by magnetic separation (Figure 5).



Fig.5. The magnetic fraction of the product formed after lime is added to the non-magnetic part of the concentrator waste

Several studies have been conducted on the consumption of lime in the process in order to support the non-magnetic part of the concentrator waste with lime at different temperatures and time units. According to this, the consumption of lime was 10-120% of the original ore mass. The temperature range was between 800 and 1200 °C. Studies have also been conducted on the flow of the substitution reaction in terms of time and concentration differences. The first 4 samples were incinerated for 30 minutes. and then 4 samples were baked in a muffle furnace for 60 minutes at each

temperature range. The parameters of each experimental sample in the study are presented in Table 2.

Table 2. Experimental values of lime consumption with concentrator waste

No	Concentration or waste mass, g	Consumption of lime, g	Temperature, °C	Time, min
1	10	1	800	30
2	10	3	850	30
3	10	5	900	30
4	10	7	950	30
5	10	8	1000	60
6	10	9	1050	60
7	10	10	1100	60
8	10	12	1200	60

At the values given in Table 2, the interaction of limestone with concentrator plant wastes was studied. The results obtained are presented in Table 3.

Table 3. The degree of separation of iron oxide in the product obtained after firing

No	Consumption of lime, g	Temperature, °C	The amount of magnetic fraction released after firing, g	Separation rate of iron oxide, %
1	10	800	0,92	62,8
2	30	850	1,87	67,6
3	50	900	2,78	72,1
4	70	950	3,56	76,0
5	80	1000	4,63	81,4
6	90	1050	4,52	80,8
7	100	1100	3,95	78,0
8	120	1200	3,14	73,9

The experimental results presented in Table 3 are shown graphically in Figure 6.

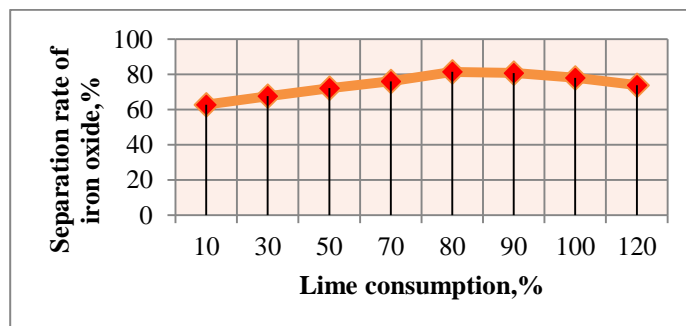


Fig.6. Dependence of lime consumption during firing on the degree of separation of iron oxide

From the graph shown in Figure 6, it can be seen that initially, as the consumption of lime increased, the chemical process accelerated and a relatively large amount of iron oxide was released as a result of the reaction. When the consumption of lime was 80% of the initial ore mass, the degree of separation of iron oxide was found to be the maximum value in general - 81.4%. The increase in lime consumption again had a positive effect on the chemical reaction. However, it was found that iron oxide has a negative effect on the rate of decomposition. It follows that the optimal consumption of lime in the process of extraction of iron oxide (FeO) from calcium (iron) -metasilicate using calcium oxide was 80% of the initial ore mass. The process required a temperature of 1000 °C for optimal flow.

4. CONCLUSION

Based on the results of research on the technology of extraction of ferrous metals from concentrator waste, the following conclusions are made:

1. Based on the analysis of local and foreign literature on the processing of waste from concentrators, the classical pyrometallurgical and hydrometallurgical technologies for the separation of iron and its compounds from waste were studied, and their advantages and disadvantages were identified.

2. Copper production has been found to generate large amounts of oxidized waste during flotation enrichment of sulfide copper-molybdenum ores and after magnetic enrichment of iron ores. Chemical analysis of the waste showed that it contained large amounts of oxidized iron compounds. Quantitative analysis showed that the iron in this material is mainly in the form of iron (II) -metasilicate (FeSiO₃).

3. In order to facilitate the separation of iron from the concentrator waste, a technology was developed to support the iron silicate with lime, due to the need to convert it from silicate to oxide. This developed technology serves to develop a more efficient technology for processing waste from concentrators.

4. In the course of the research, the thermodynamic aspects of the process of liming the wastes of copper concentrators containing iron were studied. Accordingly, a mechanism of chemical phenomena occurring in the regions of interaction of iron (II) metasilicate and lime has been developed. Based on the mechanism of chemical reactions developed, each chemical reaction that occurs in the process was analyzed from a thermodynamic point of view.

5. According to the results of thermodynamic analysis, the limiting stage between the chemical reactions that take place in the iron (II) -metasilicate and lime system is the phase of diffusion of iron silicate and lime molecules. Due to this, the temperature required for the complete interaction of iron silicate with lime was 1598 K (1325 °C). It is at this temperature that the equilibrium constants of all chemical reactions have high values, as evidenced by the study of the kinetics of the process.

6. The process of metallization of the obtained iron concentrates was carried out by carbothermal recovery and the main technological parameters of the production of metallized granules were determined.

7. In the production of metallized granules, lime was used as a desulfurizer, and KPS-3 brand petroleum coke was used as a reducing agent.

8. After rounding of the materials, the obtained granules were processed in tubular furnaces rotating at a temperature of 1150 - 1350 ° C for heat treatment.

9. The metallized granules were sent to a magnetic separator and a rich iron concentrate was obtained. The degree of metallization of the resulting product was 80-95%.

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