Experimental Study on Mineral Phase Transformation - Low Intensity Magnetic Separation of High Iron Red Mud of Guinea Bauxite

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Abstract

The total Fe content (TFe) of a bauxite residue (red mud) obtained from Guinea bauxite by low temperature digestion is 39.45 %, which was found mainly in the form of alumogoethite and hematite. Alumogoethite accounts for 56.59 % of iron minerals. It was difficult to obtain quality iron concentrate with TFe content greater than 56 % by direct magnetic separation process. In order to develop an effective recovery of iron minerals from red mud, systematic tests of iron mineral recovery were carried out by adopting the process of "preconcentration and quality improvement - mineral phase transformation - low intensity magnetic separation" in this paper. The results showed that the red mud preconcentration and quality improvement technology could achieve the enrichment of iron and reduction of the amount of red mud. The preconcentrate after the mineral phase transformation and weak magnetic separation of iron, the magnetization of low intensity magnetic iron containing minerals reaches more than 80 %, the iron concentrate yield was 34.41 %, and the TFe content was 56.40 %, which was more than 4 % higher than the current imported red mud iron concentrate. This promises a feasible technical path for large-scale production of high iron red mud based on Guinea bauxite and provides technical support for an economic and efficient utilization of a Guinea bauxite.

Keywords: Guinea bauxite, High iron red mud, Alumogoethite, Preconcentration and quality improvement, Mineral phase transformation.

1. Introduction

Red mud has been the main waste residue obtained during the production of alumina by the Bayer process. It has been difficult to utilize due to its strong alkalinity and complex phase composition. Therefore, it has been mostly stacked for disposal. According to statistics, every 1 ton of alumina produced is associated with 1-2 tons of red mud [1,2]. At present, the global stock of red mud exceeds 4 billion tons (as dry matter) and is increasing at a rate of 180 million tons per year [3-5]. The conventional red mud storage is associated with the risk of pollution of water, soil and the atmosphere, and has the potential of safety hazards. This comprises an urgent problem to be solved for the high-quality development of the alumina industry [6].

According to the statistics of China Nonferrous Metals Industry Association, the amount of red mud produced in China in 2022 was 105 million tons, and the amount of red mud by using Guinea bauxite to produce alumina was 24 million tons per year, accounting for more than 20 % of the amount of red mud produced. In 2022, the comprehensive utilization of red mud in China was 8 million tons, and the comprehensive utilization rate was only about 7.5 %. The TFe content in red mud obtained from bauxite originated from Guinea is relatively high, which can generally reach more than 35 %. With the consumption of high-quality iron ore resources in China, red mud can be considered as a secondary resource for comprehensive recovery and utilization of iron minerals [7-9]. The proportion of alumogoethite in iron-bearing minerals in the red mud from digestion of Guinea bauxite is more than 50 %. Due to the weak magnetism of alumogoethite, the grade of iron-bearing minerals cannot be increased to more than 56 % TFe by conventional magnetic separation, gravity separation and other conventional separation methods. These products cannot meet the quality requirements of iron concentrates. At the same time, due to the high viscosity of red mud, the high moisture of filter cake and the difficulty of dewatering, the energy consumption of drying and roasting was relatively high, so it was necessary to develop innovative technologies for the comprehensive recovery and utilization of iron minerals.

This paper mainly focuses on the problems of high-iron red mud of Guinea bauxite, such as difficult dewatering, high energy consumption of drying and roasting, high content of alumo goethite, and the difficulty in obtaining quality iron concentrate by conventional magnetic separation. The continuous experimental study of red mud iron separation was carried out to provide a technology for the large-scale production of high-iron red mud concentrate.

2. Tests

2.1 Test Material

The test material was high-iron red mud produced by an alumina enterprise in Guangxi using Guinea bauxite. The results of chemical composition analysis and mineralogical phase analysis of the sample are shown in Table 1 and Table 2.

Table 1. The chemical composition of high-iron red mud.

Element	Al_2O_3	SiO_2	Fe_2O_3	TFe	TiO_2	K_2O	Na_2O	CaO	MgO
Content, %	16.8	5.49	56.35	39.45	5.52	0.08	2.19	1.5	0.06

Table 2. The mineralogical phase analysis of high-iron red mud.

Mineral	Alumogoethite	Hematite	Quartz	Sodium hydrate alumino-silicate	
Content, %	36.5	28.0	2.2	9.9	
Mineral	**Anatase**	**Rutile**	**Boehmite**	**Gibbsite**	**Calcite**
Content, %	1.2	4.3	8.5	3.0	2.6

It can be seen from the analytical results of Table 1 and Table 2 that the iron content in the red mud was high, and the TFe content was 39.45 %. The iron minerals mainly exist in the form of alumogoethite and hematite, among which alumogoethite accounts for 56.59 % of the iron-bearing minerals, and it was difficult to recover the iron minerals by high intensity magnetic separation process.

2.2 Technological Process

The continuous test process block flow diagram of iron separation of high-iron red mud of Guinea bauxite is shown in Figure 1.

Table 4. Analytical results of iron phases in red mud after high temperature mineral phase transformation.

Iron mineral phase	Content,%	Distribution,%
Iron in magnetite	24.96	49.01
Iron in martite	16.88	33.14
Iron in hematite and alumogoethite	8.03	15.77
Iron in carbonates	0.1	0.20
Iron in free ferrous iron	0.73	1.43
Iron in sulfides	0.03	0.06
Iron in iron silicate	0.2	0.39
mFe	42.23	82.92
TFe	50.93	100

It can be seen from Table 4 that after the preconcentrate was submitted to heat treatment, the weakly magnetic alumogoethite and hematite were mainly converted into magnetite and martite. The distribution of magnetic iron (mFe) was 82.92 %, and the magnetization effect was better.

4. Conclusions

The content of TFe in the red mud obtained by a low-temperature digestion of a bauxite in Guinea was 39.45 %, and the iron minerals mainly were found in the form of alumogoethite and hematite. The alumogoethite accounts for 56.59 % of the iron minerals, and it was difficult to recover the iron minerals by high intensity magnetic separation process.

The magnetic susceptibility of weak magnetic iron-bearing minerals was more than 80 % by using high temperature mineral phase transformation of red mud, which solves the technical problem that it cannot be obtained quality iron concentrate by conventional magnetic separation technology from red mud of a Guinea bauxite. Through the continuous test of iron separation from red mud, the yield of the iron concentrate was 34.41 %, and the content of TFe was 56.40 %. This has proven a technical path for the large-scale production of high-iron red mud concentrate from Guinea bauxite and has provided technical support for the economical and efficient utilization of Guinea 's bauxite.

Although the mineral phase conversion technology presented in this paper has the advantages of short roasting time and low CO concentration, but its roasting temperature was high, so it needs to be further studied in terms of reducing the roasting energy consumption and the production cost.

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