Digestion Laws of Alumina and Organic Carbon in High-Organic Bauxite

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Abstract

A typical low-grade, high-organic bauxite was used to investigate the impacts of lime dosage, digestion temperature, digestion time, molecular ratio of digested liquor (α_k), and caustic soda concentration of spent liquor on the digestion behaviour of alumina and organic carbon in the bauxites. The results demonstrated that the digestion rates of alumina and organic carbon initially increased and then decreased with the increase in lime dosage. Both alumina and organic carbon digestion rates increased with rising digestion temperature. The digestion time, molecular ratio of digested liquor, and caustic soda concentration in recycled spent liquor had negligible impacts on the alumina digestion rate. However, the organic carbon digestion rate first increased and then decreased with extended digestion time and rose initially with increasing caustic soda concentration before stabilizing. In order to achieve higher alumina digestion rates and lower organic carbon digestion rates, with optimal digestion conditions, the actual alumina digestion rate reached approximately 73.2 %, corresponding to a relative digestion rate of around 96.3 %, and the organic carbon digestion rate was about 15 %. This study provides valuable insights for the utilization of similar low-grade, high-organic bauxites.

Keywords: High organic content, Low-grade bauxite, Digestion behaviour.

1. Introduction

As a leading producer of alumina, China's dependence on imported bauxite for alumina production reached as high as 63 % in 2024. However, due to the high prices and transportation costs associated with imported bauxite, inland alumina producers in Shanxi, Henan, Guizhou, and other regions in China have been compelled to use inexpensive but extremely poor low-grade bauxites. Some alumina producers employing the Bayer process have started using bauxite with alumina-to-silica ratios (A/S) below 4.0 [1, 2]. Some of these low-grade bauxites also have high organic content. The effective management of organics is critical for ensuring safe and stable alumina production. Although numerous studies have addressed the removal of organics in alumina production, assessing the digestion behaviour of organic carbon during bauxite digestion is a prerequisite for effectively balancing organic inputs and outputs in the production process and determining the scale of necessary organic removal operating units. Therefore, in the processing of low-grade, high-organic bauxite, it is essential to monitor not only alumina digestion but also the digestion of organics.

In this study, a low-grade bauxite with high organic impurity content was selected as raw material to investigate alumina digestion behaviours. Concurrently, the digestion behaviours of organic carbon in the bauxite were also studied, aiming to provide guidance and reference for alumina refineries seeking quality improvement and efficiency enhancement.

2. Material and Method

2.1 Test Raw Materials

2.1.1 Bauxite

The A/S ratio of the bauxite used in the test was 4.16, and its chemical composition and phase composition are shown in Tables 1 and 2.

Table 1. Chemical composition of bauxite (%).

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO	LOI	TOC
49.85	11.97	20.74	2.05	0.81	0.032	0.057	0.93	11.94	0.48

Table 2. Phase composition of bauxite.

Phase	wt %	Phase	wt %
Diaspore	48.5	Goethite	7.0
Chlorite	22.0	Hematite	4.0
Illite	7.5	Pyrite	1.1
Kaolinite	4.0	Anatase	1.7
Quartz	1.5	Rutile	0.3

2.1.2 Lime

After primary crushing treatment, the lime is mixed evenly and split before the samples are ground, passing through 100-mesh screen, sealed in bags, and then stored in a dryer. The chemical composition of the lime samples is shown in Table 3.

Table 3. Chemical composition of lime (%).

$CaO_{总}$	CaO_f	SiO_2	MgO
90.61	79.63	1.71	1.40

2.1.3 Circulating Spent Liquor

The chemical composition of the circulating spent liquor used in the test is shown in Table 4.

Table 4. Chemical composition of circulating spent liquor (g/L).

Na_2O_T	Na_2O_K	Al_2O_3
259.30	224.16	131.28

2.2 Test Method

For the simulated working conditions of the bauxite used in the digestion test, it is divided into two stages: pre-desilication is performed first, before high-pressure digestion. The pre-desilication of bauxite is carried out in a steel autoclave heated by glycerol, and the high-pressure digestion of the pre-desilicated slurry is carried out in a steel autoclave heated by molten salt. According to the proportioning requirements, add a certain proportion of spent liquor for digestion, bauxite, and lime to the autoclave, after agitating the slurry evenly, cover and seal it,

2) When the bauxite is digested and prepared for production under appropriate lime addition conditions, the organic carbon digestion rate from the ore ranges between 14.76 % and 15.74 %. When the molecular ratio of the digestion solution is below 1.37 and the caustic concentration of the spent liquor exceeds 210 g/L, these parameters have minimal influence on the organic carbon digestion rate. As the digestion temperature increases, the reaction rate of organic carbon in the ore exhibits a pattern of gradual increase, followed by a rapid rise, and then another gradual increase. With prolonged digestion time, the reaction rate initially increases and subsequently decreases. Under the optimal digestion conditions for alumina in the ore, the reaction rate of organic carbon is approximately 15 %.

5. Possible Further Research

1) In order to make a scientific and comprehensive technoeconomic assessment, track specific indicators of the ore in the production of alumina, including technical and economic indicators.

2) Conduct deep optimization of the process parameters that affect the digestion of alumina from the ore based on the test results, further reducing bauxite and soda consumption.

3) Follow up the accumulation and changes of organics in sodium aluminate liquor in the production, and conduct research and application on technologies for the economical and efficient removal of organics.

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