Comparison of Alumina Production Process from Low Grade Refractory Bauxite

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Abstract

The chemical composition and mineral composition of low grade refractory bauxite were studied in this research. The experimental study on the alumina production from low grade bauxite were carried out by Bayer process, chemical desilication of calcination process, (Bayer-Sintering) series process and wet series process, respectively. Under the conditions of temperature 270 °C, 75 min digested time and lime content of 10 %, red mud of bauxite was digested by Bayer method with A/S 1.16, and N/S 0.52, alumina digestion efficiency rate can reach 75.25 %. Under the conditions of calcination temperature 950 °C and 60 min calcination time, the A/S of deposition bauxite and bulk bauxite concentrates can exceed 9 after chemical desilication process, but the digestibility of concentrate is poor. As to the Bayer-digestion of red mud from low grade refractory bauxite using series process, the standard digestion efficiency of alumina and sodium oxide in clinker are 77.58 %, 92.87 %, respectively. When using wet series process, the A/S of red mud and sodium-silicon ratio N/S can reach 0.64 and 0.04, respectively. Besides, the total digestion efficiency of alumina can reach 86.35 %.

Keywords: Low-grade bauxite, Bayer process, Chemical desilication, Wet series process.

1. Introduction

A low-grade refractory bauxite, with lower alumina content and higher carbonate and organic carbon content, is difficult for alumina production [1-3]. The exploratory experimental study on the feasibility of alumina production were conducted, using Bayer process, chemical desilication of calcination process, (Bayer-Sintering) series process and wet series process[4-6].

2. Raw Materials Test

2.1. Bauxite

The chemical composition and mineral composition of low grade refractory bauxite are shown in Table 1 and Table 2.

It can be seen from Table 1 that the content of Al_2O_3, SiO_2, Fe_2O_3 and A/S in low grade refractory bauxite are 39.98%, 8.52%, 27.71% and 4.69 respectively. Compared with diasporic bauxite in other parts of China, total carbon and organic carbon content in bauxite are higher: total carbon content is 0.98%, and organic carbon content is 0.27%.

Table 1. Chemical composition of low grade refractory bauxite, %.

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO
39.98	8.52	27.71	6.06	0.014	0.021	3.43	0.037
P_2O_5	V	Ga	LOI	C_{total}	$C_{organic}$	S_{total}	A/S
0.17	0.062	0.0041	13.45	0.98	0.27	0.039	4.69

Table 2. Mineral composition of low grade refractory bauxite, %.

diasporic	boehmite	kaolinite	hematite	calcite	anatase	rutile
38.5	/	18.5	27.5	6	4	2

From Table 2, it can be seen that the main aluminium-bearing mineral of bauxite is diaspora bauxite; the siliceous mineral mainly exists in the form of kaolinite; the main iron-bearing mineral is hematite; the main titanium-bearing minerals are anatase and rutile, and a small amount of calcite.

In summary, the bauxite is a low-grade diasporic bauxite with high iron, high carbon and kaolinite content.

2.2. Liquor

The cycling liquor used in the test is synthetic sodium aluminate solution, whose main chemical compositions are shown in Table 3. In general, mother liquor 1# is used in the digested test in this research; the mother liquor is used in the wet series process to deal with Bayer red mud.

Table 3. Chemical constituents of cycling liquor for test.

Number	Na_2O_T g/L	Al_2O_3 g/L	Na_2O_k g/L	α_k
1#	258.84	133.8	244	3.0
2#	203.45	11.39	200	28.88

2.3. Lime

Lime is obtained from one production site of an enterprise, in which the reactive CaO is 89.24% and the total CaO is 91.13%.

3. Test Methods

3.1. Digestion Test

Bauxite digested test was carried out in molten salt steel elastic stripper. Based on the ratios of aluminium to silicon in red mud and bauxite, the alumina digestion efficiency is calculated. Detailed formulas are as follows [7]. Digestion efficiency of alumina:

$$\eta_A = \frac{(A/S)_{mine} - (A/S)_{mud}}{(A/S)_{mine}} \times 100 \quad (1)$$

where:
$(A/S)_{mine}$ mass ratio of Al_2O_3 to SiO_2 in mine
$(A/S)_{mud}$ mass ratio of Al_2O_3 to SiO_2 in red mud

3.2. Calcinated-Chemical Desilication Test of Bauxite

According to a certain proportion of ingredients, calcinated bauxite and sodium hydroxide solution were added to the steel bullet in oil bath, and the alkali leaching desilication test was carried out in the steel bullet stripper heated by oil bath.

0.05 and the digestion efficiency of alumina is 85.93 % when the temperature is 240 °C. The A/S ratio is 0.64, the N/S ratio is 0.05 and the digestion efficiency of alumina is 86.35 % when the temperature is 250 °C.

5. Conclusion

The content of alumina in low grade bauxite is 39.88 %, the silica is 8.52 %, the iron oxide is 27.71 %, and the A/S ratio in low grade bauxite is 4.69.

The main aluminum containing mineral in low grade bauxite is diaspora bauxite, the silica containing minerals is kaolinite, the iron containing minerals is hematite and the titanium containing minerals is anatase and rutile. A small account of calcite is also contained. The bauxite is the low grade diaspore bauxite with high iron, high carbon and kaolinite content.

The A/S ratio and N/S ratio in red mud are 1.16 and 0.52, the digestion efficiency of alumina is 75.25 %, the relative digestion efficiency is 95.65 % at temperature of 270 °C, with digestion time 75 min and lime addition amount 10%.

The A/S in the concentrate after chemical desilication can exceed 9 when the calcination temperature is 950 °C and the calcination time is 60 min, but the digestibility of the concentrate is poor.

The standard digestion efficiency of alumina and sodium in the sinter are 77.58 % and 92.87 % when the red mud produced by low grade bauxite in Bayer process is treated by series process.

The A/S in the red mud is 0.64, the N/S ratio is 0.04 and the digestion efficiency of alumina is 86.35 % when the red mud produced by low grade bauxite in Bayer process is treated by wet series process.

The series or wet series process has obvious advantages over the other two technical routes, according to the key technical indexes such as the digestion rate of alumina and the A/S ratio and N/S ratio of the red mud. But in order to select the appropriate technological route for alumina production from the low grade bauxite, further detailed technical and economic analysis are needed.

6. Reference

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