Research on Digestion Conditions of High Carbonate Bauxite to Improve Performance

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Abstract

In the process of alumina production by the Bayer process, the high concentration of sodium carbonate in the production system will cause a series of problems such as difficult operation, increase of energy consumption, decrease of output, and increase of alkali consumption. In the paper, the effects of lime addition amount, digestion temperature, digestion time and other conditions on the carbonate reaction behavior were studied for a high-carbonate bauxite from Guizhou (China). The changes of A/S (weight ratio of Al_2O_3 to SiO_2), N/S (weight ratio of Na_2O to SiO_2) and TIC (total inorganic carbon) content in red mud under different conditions were analyzed in detail. Based on the digestion performance of bauxite and the exclusion of more carbonate from the liquor, the best technological conditions for this type of bauxite were put forward, which not only can ensure efficient recovery of alumina, but also can remove carbonate from the liquor at low cost, providing guidance for the production organization.

Keywords: Carbonate, Bauxite, Digestion, Reaction behavior.

1. Introduction

With the development of the alumina industry in China, the grade of bauxite decreases rapidly, and gangue minerals in ore increase gradually, especially carbonate minerals. The carbonate species in bauxite react with alkali liquor and enter the production system, resulting in an increase in the concentration of sodium carbonate, which affects all aspects of production, especially the processes of high-pressure digestion, seed precipitation and spent liquor evaporation. The increase in sodium carbonate concentration results in reduced process flow due to sodium carbonate precipitation in the digestion flash train, which requires frequent water injection or liquid washing [1]. The water addition affects the heat balance of the leaching process and the steam consumption increases. The liquor viscosity also increases resulting in an increase of power consumption related to conveying slurry as well as the deterioration of filtration performance and the associated production capacity of vertical plate filters [2], flat plate filters, and the increase of filters downtime for cleaning. With this increase in liquor viscosity, the precipitation efficiency and alumina production also decrease. In the evaporation process, due to the increase in sodium carbonate concentration, the salt discharge pressure of forced circulation evaporator is increased, which leads to the increase of evaporation steam consumption and decrease of evaporative capacity; the evaporator operating cycles are also shortened due to more frequent cleaning.

There are three common ways to eliminate sodium carbonate from a production system: evaporation crystallization method, the causticization of the red mud washing liquor and causticization using barium salt. The evaporation crystallization method is a widely one among alumina plants but this method involves higher implementation cost and reduced evaporation capacity thus making it unsuitable for long-term operation [3–5]. The causticization of the red mud washing liquor involves utilizing a liquor stream suitable for causticization to produce sodium hydroxide from sodium carbonate reacting with lime. But the reduction of the sodium carbonate content in the Bayer process by this method is slow, and the alumina losses are high. It is therefore difficult to achieve the desired effect in a short period by applying this method [6, 7]. The liquor causticization using barium salt takes advantage of the characteristics that most barium salts are insoluble in sodium aluminate liquor to eliminate sodium carbonate. However, barium salts are expensive and regeneration cost is high, additionally, gases and dust harmful to human health are produced in the regeneration process, also impacting the environment [8, 9]. Therefore, how to use high carbonate bauxite reasonably and efficiently is an urgent technical problem to be solved.

In this paper, the existing form of carbonate in a high carbonate bauxite from Guizhou, China, was analyzed. The impact of digestion temperature, residence time, lime addition, and initial spent liquor carbonate content, on the carbonate removal from the liquor and entering the produced red mud was studied and will be discussed. The best process conditions for this type of bauxite were proposed, which not only can ensure efficient recovery of alumina, but also can remove carbonate through digestion red mud at low cost, providing guidance for the production organization.

2. Test Raw Materials

2.1 Bauxite

The bauxite was obtained from an alumina plant in Guizhou, China. The main chemical composition of the bauxite (%) is shown in Table 1, and the main mineral phases are shown in Table 2. It can be seen that this is a high carbonate diasporic bauxite, and the carbonate mineral is siderite, an iron (II) carbonate ($FeCO_3$), sometimes comprising other elements as impurities (e.g. Ca, Mg, etc.) [10].

Table 1. Chemical compositions of bauxite (wt %).

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO	TC	TOC	TIC
47.19	9.25	27.63	2.13	0.72	0.024	0.26	0.49	0.78	0.21	0.57

Table 2. Mineral phase compositions of bauxite (wt %).

diaspore	chlorite	illite	kaolinite	hematite	siderite	anatase	rutile
46	16	7	5	15	8	1.7	0.4

2.2 Liquor

The spent liquor was obtained from an alumina plant in Guizhou, China. The main components are shown in Table 3.

Table 3. Chemical compositions of sodium aluminate liquor.

Na_2O_T g/L	Al_2O_3 g/L	Na_2O_k* g/L	Na_2O_c* g/L	α_k
263.88	133.40	244.00	19.88	3.01

* Na_2O_k represents caustic soda, expressed as Na_2O, while Na_2O_c represents sodium carbonate also expressed as Na_2O

2.3 Lime

The lime used in the experiment was obtained from an alumina plant in Guizhou, China. After grinding, it was roasted and activated. The chemical compositions are shown in Table 4.

As can be seen in Figure 10, under the above test conditions, with an increase of the Na_2CO_3 concentration in spent liquor, the TIC content in the red mud rapidly increased from 0.25 to 0.35 %, and the carbonate removed through the red mud increased from the production process.

5. Conclusions

(1) The bauxite studied was from an alumina plant in Guizhou, China. It is a high-carbonate diaspore type bauxite with siderite as the carbonate mineral.

(2) The study on the bauxite digestion performance and carbonate reaction behavior determined that with an increase of lime addition, the alumina extraction and the TIC content of red mud increased firstly and then decreased. When the lime addition was 7 %, the amount of carbonate in the red mud, and therefore removed through the red mud was the highest. Increasing the digestion temperature and prolonging the digestion time is conducive to the increase of the alumina extraction and the discharge of more carbonate through the red mud. With the increase of sodium carbonate concentration in spent liquor, the carbonate removed from the red mud increased.

(3) Based on the comprehensive consideration of the bauxite digestion performance (namely alumina extraction) and the increase of carbonate carried away through the red mud, the optimal digestion conditions are a lime addition of 5 to 7 %, a temperature higher than 265 °C, and a residence time longer than 50 minutes. With these conditions, not only a better bauxite digestion can be obtained, but also the carbonate evacuated with the red mud can be maximized, creating the best conditions for the production organization.

6. Reference

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