Effect of Bauxite Mineralogy on Bayer Digestion Process Selection

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Abstract

The gibbsite, boehmite, diaspore, kaolin, quartz, goethite and hematite are the main mineralogical composition in bauxite, and the kaolin is the most common form of reactive silica in bauxite at low digestion temperature, while the reactive silica increases due to the quartz attack at middle and high digestion temperature. Three different imported bauxite samples are as an example in the paper. The mineralogical composition of bauxite is analyzed, the available alumina and reactive silica at different temperatures are determined, and the consumption model of raw materials for the three kinds of bauxite at different temperatures are established. According to the bauxite alumina ratio, total soda consumption, mud factor, the cost of bauxite, caustic and lime price, the consumption of raw materials for different bauxite is calculated, and the optimized digestion process is suggested considering suppressed the quartz attack and boehmite reversion.

Keywords: Bauxite mineralogy, reactive silica, raw materials consumption model, digestion process.

1. Introduction

At present, imported bauxites are widely used by alumina refineries in China, mainly from Guinea, Australia, Indonesia, Ghana, Vietnam and Brazil. The mineralogy composition of bauxites is different, and the silica is the most importance of impurities which directly affects the soda consumption, bauxite to alumina consumption (BAR), quality of alumina products, scaling, etc. [1-3]. In this paper, the chemical composition, mineralogical composition, available alumina, reactive silica and quartz attack rate of three kinds of bauxite are studied experimentally. A calculation model of raw material consumption cost was developed by SAMI in order to Bayer digestion process selection. The model was with the chemical and mineralogy composition of bauxites as input conditions, and the quartz attack rate, BAR, total soda loss, mud factor and materials cost were calculated under different temperature.

Supporting the Bayer digestion process selection objective, the concept of whole engineering design process is introduced to provide a new approach for the application of the model. The model introduces a systematic and comprehensive approach to evaluating an optimized process technology through test work, model calculation and economic estimation.

2. Methodology

2.1. Materials

The bauxite samples studied in this paper were provided by different mining supplier. All of them were a mixture of gibbsite and boehmite bauxite. When the three types of ore sample were delivered to the lab, the representative sample was prepared for laboratory digestion sample through homogenization, quartering, splitting, crushing, grinding and screening process.

The synthetic spent liquor used in the digestion test was a mixture of aluminum hydroxide (industrial grade), NaOH (AR), Na_2CO_3 (AR) and sodium silicate (AR).

2.2. Digestion Methods

The digestion tests were performed in the salt bath reactor and oil bath reactor which contained six bombs. The reactor rotated in the speed of 48rpm and the heating mediums were molten salt and oil (Oil bath heating at 150°C or oil bath heating for over 200°C are selected) with a high precision of temperature controlling accuracy of ±1°C.

A certain amount of bauxite sample was weighed out by analytical balance. Pour the spent liquor into the bomb in several times together with the bauxite sample and keep stirring during the whole process. Cover the lid and make the lid tightly secured. Put the bomb into the salt bath or oil bath when the molten salt or the oil in the reactor reaching the reaction temperature. Then start the reactor, driving the bomb rotating with the shaft in the molten salt or oil bath. During the rotation process, the slurry in bomb was evenly blended.

Keep the temperature constant to the required time after the reactor reaching the digestion temperature. Cool the bomb rapidly, and then get the digested liquor and residue by solid-liquid separation. Get the red mud by vacuum filtration after washing the residue by 98°C hot water. The concentration of Al_2O_3, N_T and N_K in digested liquor were measured by chemical titration. The solid compositions were determined by X-Ray Fluorescence (XRF).

2.3. XRF, XRD, LOI

Chemical composition analysis was performed on a Thermo Scientific ARL PERFORM'X 4200 wavelength dispersive X-Ray Fluorescence (XRF) system with molten method.

LOI (100-1000°C) was measured by weight loss of a dried sample using a muffle.

Mineralogical analysis was measured for bauxite samples and residue samples using a Shimadzu Corporation X-Ray Diffraction (XRD) XRD-7000 X-ray diffractometer.

3. Results and Discussion

3.1. Characterization of the Bauxites

The chemical analysis of the major elements present in three bauxites was shown in Table 1. Bauxite was rich in iron oxide, silica oxide and alumina. Mineralogical analysis allowed the identification of several mineral composition (Table 2) and the XRD diffraction charts were shown in Figure 1-3.

Table 1. Major chemical components of the three bauxites（wt%).

No.	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	Na_2O	CaO	K_2O	LOI
Bauxite-1	50.43	10.68	8.65	2.98	0.04	0.069	0.017	25.61
Bauxite-2	46.33	1.73	23.20	2.14	0.04	0.072	0.023	25.87
Bauxite-3	45.24	19.42	7.14	0.90	0.03	0.046	0.017	24.91

The mineralogical composition, especially the content of reactive silica content, had a great influence on the choice of dissolution process. The reaction rate of quartz was related to temperature, retention time, free caustic concentration and molar ratio of solution.

Based on the experimental data, the calculation models of raw material consumption for different bauxites were established. Under the same basic raw material price, low-temperature Bayer process was suitable for treating Bauxite-1 and Bauxite-3. When Bauxite-2 had the lowest raw materials consumption at medium temperature.

The appropriate digestion temperature could be preliminarily determined by the calculation model of raw materials consumption. In the actual engineering design process, besides the above process selection issues, the project investment, depreciation of fixed assets, the difficulty of raw materials acquisition, site location, water source and other issues needed to be considered comprehensively to determine the overall project design plan.

5. References

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