Progress in Research and Development of Alumina Production Technology for Low Grade Bauxite in China

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Abstract

Although China has become the largest alumina producer in the world in recent years, it has a shortage of bauxite reserves, and most of what is available is low grade. As a result, it is very important for China to produce alumina economically from its low grade bauxite. Existing alumina production processes for low grade bauxite, such as Bauxite Flotation followed by the Bayer process and the Bayer-Sinter Series process, as well as the progress of research work into other alternative processes are reviewed in this paper. The development directions for alumina production processes from different kinds of low grade bauxite are also proposed.

Keywords: Low grade bauxite, alumina production, desilication, research and development.

1. Definitions of terms

"A/S": mass ratio of Al_2O_3 to SiO_2 in the solid
"N/S": mass ratio of Na_2O to SiO_2 in the solid
“C/S”: mass ratio of CaO to SiO_2 in the solid
"α_K ": molar ratio of caustic Na_2O to Al_2O_3 in liquor
"NK": caustic concentration of the liquor (as Na_2O)
"NT": total Na_2O concentration of the liquor

2. Introduction

Alumina production capacity and output in China has grown to be the largest in the world, even though good quality bauxite reserves are insufficient to maintain this high production level. There is an estimated 55 - 75 billion tones bauxite resources and 28 billion tons of bauxite reserves in the world, but only 0.83 billion tons of the reserves are in China, according to USGS statistics. The grade of bauxite used in refineries in China has been declining for about 10 years with the rapid development and expansion of the alumina industry. The average A/S (alumina to silica ratio) of bauxite has fallen to below 5 in some Chinese refineries.

The alumina production capacity has increased to more than 70 million tonnes in China, and it has become necessary for the Chinese alumina industry to produce alumina from low and medium grade bauxite in China. It is therefore the most important technical objective for alumina production, to be able to economically segregate silica (the most economically significant impurity), from alumina in Chinese bauxites.

The Bayer and Sinter processes are the basis of alumina production processes utilised in China. The alumina production process and desilication product are quite different between these processes. Desilication products most commonly found in Bayer and Sinter processes are shown in Table 1.

Table 1. Desilication products commonly found in Bayer and Sinter processes.

Desilication Product	A/S	N/S	C/S	Process
$Na_2O{\cdot}Al_2O_3{\cdot}1.7SiO_2{\cdot}H_2O$	1	0.608	0	Bayer
$3CaO{\cdot}Al_2O_3{\cdot}xSiO_2{\cdot}(6\text{-}2x)H_2O$	1.7	0	2.8	Bayer
$2CaO{\cdot}SiO_2$	0	0	1.87	Sinter

Fundamental characteristics of the Bayer process are low energy consumption, low resource utilization efficiency and high alkali consumption. For the Sinter process it is high energy consumption, high resource utilization efficiency and low alkali consumption. Since the size and cost of the energy consumption difference is generally the dominant economic factor, alumina output is produced mainly by the Bayer process globally, including in China, where 95 % of alumina produced is by this process.

The basis of research and development on new technology and processes for low grade diasporic bauxite in China is still the Bayer process. One way of classifying existing and new technologies and processes for low grade bauxite based alumina production is to divide them into the categories; Pre-process, Mid-process and Post-process. Pre-process is where bauxite is treated before the Bayer cycle, and the technical and total economic metrics of the subsequent Bayer process are improved in line with the better quality raw material fed to it. Mid-process is where the Bayer cycle is optimized and post-process is where the red mud is reprocessed. A simple diagrammatic sketch of the Bayer process is shown, and the classification of new and existing processes for low grade diasporic bauxite shown in Figure 1.

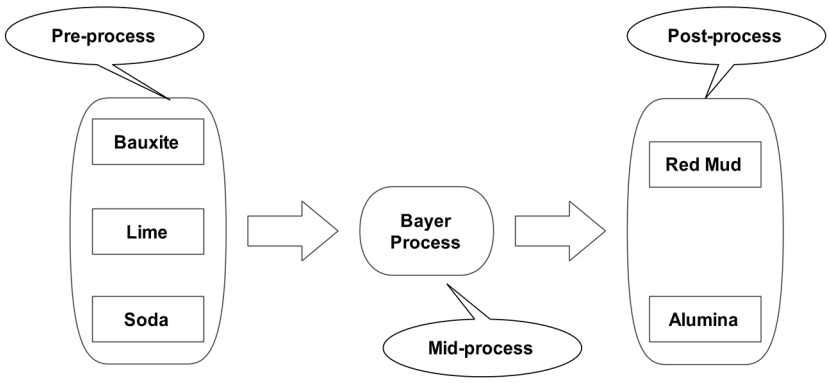

Figure 1. Types of new processes for low grade diasporic bauxite.

Many research and development projects on alumina production from low grade diasporic bauxite have been carried out over many decades, and there has been good progress. Some new processes have been used in refineries. The new technologies for the use of low grade diasporic bauxite are reviewed and some suggestions for the research and development directions for different kinds of low grade diasporic bauxite are presented in this paper.

3. The Progress of Research on Alumina Production from Low Grade Bauxite

3.1 Pre-Process

3.1.1 Bauxite Washing - Bayer Process

Washing to improve its grade is not useful for most Chinese diasporic bauxites, but it is useful

mainly non-kaolinite silica, while those in Shanxi are mainly kaolinite. The bauxite in some Guizhou mining areas and most of the mining areas under the coal contains high sulfur minerals, and these sulfur minerals which have detrimental effect on the production process which need to be eliminated or mitigated. The content of Fe_2O_3 in the bauxite in Guangxi and Yunnan is higher, so the comprehensive recovery and utilization of Fe_2O_3 simultaneously in the process of extraction of alumina should be considered.

For the bauxite where the silica containing minerals are non-kaolinite minerals, such as the low grade bauxite in Henan, the further systematic optimization of flotation desilication technology should be the development direction to maximize economic benefit. Both the A/S and N/S ratio in red mud could be reduced when Flotation is followed by the Bayer process.

For the bauxite in which the main silica containing mineral is kaolinite, such as the low grade bauxite in Shanxi, it is difficult to control both the A/S and N/S ratio in red mud at lower levels when using the Bayer process to produce alumina, so the further systematic optimization of flotation desilication technology, new technology of wet series process, chemical desilication technology and series process should be regarded as the development direction of alumina production technology. For the bauxite resources in some mining area, the comparison of different technologies should be carried out to determine the optimal process. In the process of optimization of series process, it is necessary to focus on the dry-feeding technology in order to reduce the energy consumption of the production system greatly.

The accumulation of sulfur in the production system will not only affect product quality but also cause the corrosion of equipment for preheating and digestion when fed to the Bayer process directly. Consequently, for the low-grade bauxite with high sulphur, such as some mining areas in Chongqing and Guizhou, new or improved desulphurization and desilication processes using ore beneficiation or desulphurization by calcination followed by chemical desilication prior to the Bayer process is recommended to use the high sulfur bauxite efficiently and economically.

For the low grade bauxite with high iron, such as some mining areas in Guangxi and Yunnan, the extraction and recovery of iron should be integrated with the alumina production process, to use the high iron bauxite comprehensively and to realize the maximum economic benefits.

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