The Hydrochemical Series Process for Low Grade Diasporic Bauxite

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Abstract

The principles of a hydrochemical path for processing low grade diasporic bauxite, laboratory digestion results from processing three low-grade diasporic bauxites, along with industrial test results are presented in this article. The reactions of Si-minerals during hydrochemical treatment of Bayer red mud is studied using XRD, SEM and energy-dispersive XRF. The transformation of cancrinite in the Bayer red mud into Fe-hydrogarnet results in very low A/S (Al_2O_3:SiO_2) and N/S (Na_2O:SiO_2) in the treated residue. It is beneficial to use high iron bauxite for the best results, which included A/S = 0.54 N/S = 0.02, Na_2O = 0.28 % achieved in the treated residue. The 'Hydrochemical Series Process' has lower energy consumption, higher recovery of alumina and lower caustic consumption, making it suitable to deal with low grade diasporic bauxite, and recovery of soda from high iron Bayer red mud.

Keywords: Hydrochemical Series Process, Bayer residue, Desilication Product, Fe-Hydrogarnet, High α_K caustic solution

1. Introduction

China is the world's largest alumina producer, accounting for around 55% of global production in 2019. It is also a bauxite resource-poor country, with bauxite imports reaching 100 million tonnes in 2019. There is however, more lower grade bauxite in China. With the shortage of bauxite resources and the lower grade of bauxite produced in China, a new alumina production process is being studied and developed to deal with the available lower grade diasporic ores, to achieve a higher alumina recovery and lower energy and caustic consumptions [1]. It has become an important problem to be solved in China's alumina industry.

At present, the treatment of low-grade bauxite has two main directions. One approach is to improve the ore grade, where options include silica reduction by flotation, and chemical dressing roasting pre-desilication [2,3]. After improving the ore grade, the bauxite is processed in a Bayer refinery. Another path is Bayer processing of low-grade bauxite and subsequent treatment of the red mud produced. One way to treat red mud is to recover caustic and alumina from Bayer red mud by sintering referred to as the 'Series' method, or 'Improved Innovative Series Method' [4]. In addition to these options, a 'Hydrochemical Series Process' for the recovery of caustic and alumina from Bayer red mud using a high molecular ratio alkaline solution [5, 6] has been proposed.

This paper introduces the technical basis of the Hydrochemical Series Process, the results achieved by treating three low-grade bauxites with high molecular ratio alkali solution, and the results of industrial testwork. The particular application to high-iron bauxites for caustic recovery from Bayer red mud is examined.

2. Hydrochemical Series Process Testwork

To test and demonstrate the Hydrochemical Series process, the lower grade bauxite ores were first processed in a simulated Bayer process digestion, before mud settling and washing. The resulting Bayer red mud (or 'bauxite residue') was then treated by a hydrochemical extraction process which includes digestion in a high caustic/low alumina liquor, with the addition of lime at normal temperature and pressure to leach alumina and liberate caustic soda from the Bayer red mud.

The lime solids or 'dealuminising slag' produced from the digestion/extraction of the Bayer red mud is recycled to the Bayer digestion, as a substitute for the usual digestion lime addition. The aim of the Bayer digestion is then to maximize recovery of alumina from both the primary bauxite ore and dealuminized slag. To simulate these steps, the next batch of Bayer red mud was treated by recirculation, and the dealuminized slag was added into the Bayer digestion step as an additive. The caustic soda required to maintain liquor caustic for the whole Bayer cycle is added into the red mud dissolution step. The process flowchart is shown in Figure 1.

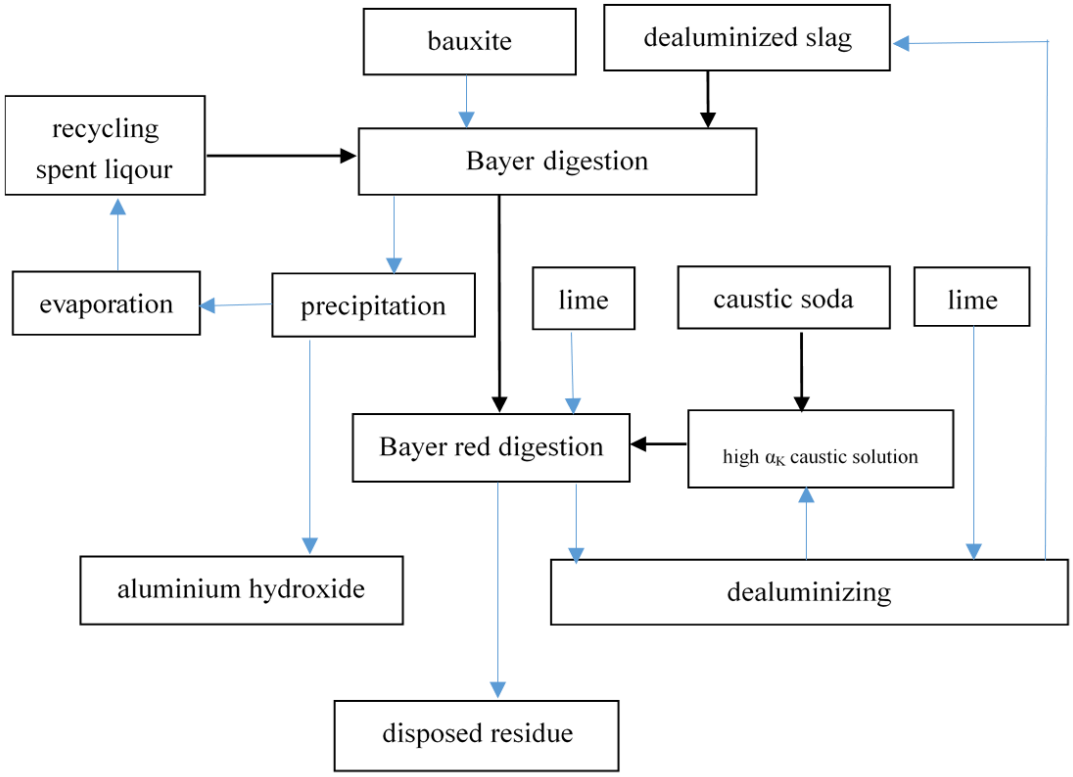

Figure 1. Process flowchart.

The key to the process is that caustic soda and alumina can be recovered effectively by hydrochemical treatment of Bayer red mud with a high α_K (high Na_2O/low Al_2O_3) Bayer liquor, with the red mud A/S reduced to less than 0.8, and N/S to below 0.1. The results from the treatment of Bayer red mud from three different bauxites is described below.

3. Results of Hydrochemical Series Process Testwork

The chemical composition of the three bauxites (A, B and C) treated by the Hydrochemical Series Process is shown in Table 1. Tests were performed with a Bayer liquor N_K (caustic as Na_2O) of 130 g/L, and a temperature of 260 °C. The addition rates of lime, expressed as a C/S ratio ($CaO:SiO_2$) to the Bayer red muds tested was 0.4, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.4, 2.8.

Table 6. Comparison of Hydrochemical Series and Bayer processes.

Process	Bayer process	Hydrochemical Series process
A/S of the treated red mud	1	0.54
Recovery of Al_2O_3	75 %	86.5 %
Bauxite consumption t/t Al_2O_3	2.96	2.57
N/S of the treated red mud	0.3	0.05
Chemical soda consumption kg Na_2O/t Al_2O_3	99.9	14.4

Table 6 shows alumina recovery is much improved at 86.5 %, and dramatically reduced caustic soda consumption of only 14.4 kg Na_2O. The alumina recovery is more than 10 % higher, and the caustic soda consumption is less than one-sixth of the Bayer process alone.

7.2 Prospects for application

The Hydrochemical Series process is characterized by a low energy consumption, high alumina recovery, low alkali consumption, and due to its lower soda content, the red mud produced can be much more easily utilized. The process is suitable for treating low-grade bauxite, especially high-iron bauxite, and Na_2O recovery from high iron Bayer process red mud .

8. References

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