

High Iron Diasporic Bauxite Processing Study

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Abstract



A new approach was applied to processing high iron diasporic bauxite which involves firstly pre-processing at low temperature with high α K liquor and then digesting at high temperature with recycled mother liquor. The pre-processing and digestion conditions which affect A/S and N/S of the red mud generated were explored. The bauxite was pre-processed at conditions of 150 °C, NK = 260 g/L and 9% lime addition, before being digested at 260 °C for 60 minutes, resulting in an A/S in the red mud produced of 0.74, with an N/S of 0.12. The pre-processed bauxite and the red mud were analyzed by XRF, XRD and SEM-EDS. The main Silica mineral of both the pre-processed bauxite and the red mud was a hydrogarnet where Al was substituted by Fe and Ti. It was concluded that this hydrogarnet is formed in pre-processing, that it is stable through digestion, resulted in improved diasporic digestion, and is the reason why A/S and N/S in the red mud generated is greatly reduced under the conditions of pre-processing and digestion.

Keywords: Low temperature pre-processing, high temperature digestion, high iron diasporic bauxite, Al substituted by Fe and Ti hydrogarnet.

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
- " α K ": molar ratio of caustic Na_2O to Al_2O_3 in liquor
- "burden α K ": the α K used to calculate bauxite charge
- "NK": caustic concentration of the liquor (as Na_2O)
- "NT": total Na_2O concentration of the liquor

1. Introduction

The removal of soluble silica minerals in the pre-desilication and digestion steps is critical in alumina production in the alkali Bayer process due to the silicate ion's effect on scaling and product quality later in the process. Silica minerals in red mud following the Bayer process when feeding diasporic bauxite are mainly $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 1.7\text{SiO}_2 \cdot n\text{H}_2\text{O}$, where $n \leq 2$ [1,2]. The lowest A/S of red mud in the Bayer process is only 1 in theory, and the N/S of the red mud is 0.608. With the ore A/S decreased, the losses of Al_2O_3 and Na_2O to red mud will increase, and more so the loss of Na_2O . The silica minerals will be changed into $\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot n\text{SiO}_2 \cdot (6-2n)\text{H}_2\text{O}$, where $n \leq 1$ [3], when additional lime is added into Bayer process. This is referred to in China as the "Lime Bayer Process".

The basis of the method for reducing desilication losses by the use of lime was examined in the work of Klan [4] on the reduction in soda losses through the formation of calcium silicates. This process was further developed and patented by Cresswell and Milne of Comalco [5,6,7] in publications between 1982 and 1984. Similar processes were developed in Eastern Europe and Russia and reported by Zoldi et al., 1987 [8], Medvedev et al., 2003 [9], Solymar et al., 1997 [10].

The use of lime with the specific intent of forming hydrogarnets has been further developed in China and reported in 2002 by Gu et al. [11], and Zhao et al., [12]. In a "Lime Bayer" process, the A/S of the red mud is usually above 1.4, and N/S could be 0 in theory. It is suitable to deal with A/S 5-6 of diasporic bauxite. In 2009 Smith [13] points out that as the grade of the bauxite declines, the loss of alumina will greatly increase when the A/S is lower than 4.5, and it is difficult to achieve a real recovery rate of 70% alumina. As the diasporic bauxite ore grade decreases, the Al₂O₃ content will drop, and the Fe₂O₃ content will increase. If silica minerals are transformed into iron hydrogarnet minerals (3CaO·Fe₂O₃·nSiO₂·H₂O) as the main component of red mud, alumina recovery will be greatly enhanced and alkali consumption will be greatly reduced [1,8].

In the high pressure hydration method put forward by the Soviet Union, not only the formation conditions of the hydrated sodium calcium silicate desilication product Na₂O·2CaO·2SiO₂·H₂O, but also generation of iron hydrogarnet were studied in detail. The relationship between the caustic molecular ratio and the saturation coefficient of SiO₂ and the ratio of Fe replacing Al in the iron hydrogarnet (3CaO·Fe₂O₃·nSiO₂·mH₂O) were examined at 280 °C. The work showed that as the caustic molecular ratio increased, the content of hydrogarnet increased, and gradually transformed into iron based products, until eventually close to complete formation of Fe₂O₃ hydrogarnet would be obtained in sodium aluminate solution with $\alpha K = 12\sim 30$.

A hydrothermal method was studied in Hungary where desilication product in red mud is also dominated by iron hydrogarnet. Liu et al reported in 2003 [14] that most of the silica in bauxite can be changed into iron hydrogarnet if being processed with the additives of hydrated calcium ferrite, or calcium ferrite (Li et al, 2006, 2007, 2010) [15,16].

A new method for desilication of high iron bauxite is proposed in this paper, where the A/S of red mud can be reduced to below 0.8 and N/S dropped to below 0.15 by the addition of lime, without other additives. High iron bauxite is first pretreated with high αK liquor, the solid phase after pre-treatment is then digested with Bayer recycling mother liquor. Following this treatment, A/S and N/S in the red mud can be lowered. The solids after pre-treatment and red mud are analyzed and studied by x-ray fluorescence, x-ray diffraction, scanning electron microscopy and energy spectrum analysis. It shows that when the bauxite PG was pretreated with lime in high αK liquor, hydrogarnet was generated where Fe and Ti is substituted for Al. This approach can not only promote diasporic digestion, but the desilication products formed are stable through the digestion process, with the desilication product in the red mud being mainly hydrogarnet where Al is substituted by Fe and Ti. This is the primary mechanism explaining why the bauxite with high iron content studied, pretreated only with lime before digestion, can result in low A/S and N/S of the resulting red mud. This paper introduces the bauxite pretreatment, and subsequent digestion conditions to optimise this process.

2. Experimental

2.1. Materials

2.1.1. Bauxite

The bauxite used is a high ferrous bauxite referred to here as "PG". It was spot-sampled from the plant, and prepared by sub-sampling, mixing and milling. Its chemical and mineralogical composition is shown in Table 1.

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6. References

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