IMPACT OF JAMAICAN BAUXITE MINERALOGY ON PLANT OPERATIONS

Desmond Lawson¹, Ab Rijkeboer², Lawrence J. Andermann Jr.³, Austin Mooney¹

¹West Indies Alumina Company, Kirkvine Works, Kirkvine P.O., Manchester, Jamaica.
²Rinalco, Helmlaan 16, 2244 AZ Wassenaar, The Netherlands
³SNF Holding Company, One Chemical Plant Road, P.O. Box 250, Riceboro, GA 31323, USA

Keywords: Bauxite, Red Mud, Aluminous Goethite, Gibbsite Auto-precipitation, Boehmite Reversion, Phosphorus, Calcium, Causticity.

Abstract

Over the period 2003 to 2006 the bauxite feed to the Kirkvine refinery has undergone a dramatic change in composition with severe impact on plant performance. Surprisingly, the change in composition is not directly evident from the XRF analysis of the major elements, which showed that the total Al₂O₃, Fe₂O₃ and LOI contents of the bauxite remained largely unchanged. A more detailed examination however, shows a remarkable change in Al₂O₃ distribution over the various minerals, indicative of a substantial change in bauxite mineralogy. Over the same period significant changes in plant behaviour were experienced with respect to, notably alumina recovery, mud settling and liquor chemistry.

Introduction

The Kirkvine refinery is a low temperature digestion plant located in the centre of Jamaica. It commenced operations in 1953 and is the oldest alumina refinery on the island. Over the period 2003 to 2006 the performance of the refinery came under intense pressure because of mounting difficulties in the mud circuit. The main direct causes were a gradually increasing mud factor and a gradual deterioration of the mud settling characteristics. The mud factor increased because the available alumina content in the bauxite decreased, from about 45% in early 2004 to about 42% by the middle of 2006, while at the same time the alumina recovery dropped by more than 6%. Plant production became constrained by the capacity of the mud circuit and the production rate decreased by 9%.

Change in bauxite composition

The XRF based elemental composition of the bauxite does not reveal any clues about the underlying drastic change in the bauxite character (see Figure 1). The main constituents, total Al₂O₃, Fe₂O₃, TiO₂, SiO₂ and LOI, remained on their usual levels. The only change was an increase in P₂O₅, which doubled, from 0.6 to 1.2%. However, below that surface a different picture emerges when the mineralogy is examined, e.g. on the basis of the alumina distribution over the various mineral phases (see Figure 2).

Available alumina

Al₂O₃ present as gibbsite dropped from 44.5% to 41%. The decrease in available alumina content was less, from 45% to 42%, because the auralinite content of the bauxite had increased. Crandallite, Ca₆Al₉(PO₄)₄(OH)₂·H₂O, readily dissolves in Bayer liquor and is the source of soluble phosphate in Kirkvine bauxite. Phosphate is removed from the liquor through reaction with calcium. The reaction requires considerable more calcium than the crandallite itself can deliver. The extra calcium can be supplied for this purpose in just about any form [1]. The reaction product, carbonate-apatite does not contain alumina, hence all alumina in crandallite reports as available alumina. Nowadays 2.5% of the available alumina in Kirkvine bauxite is associated with crandallite. This is 1.1% Al₂O₃ on dry bauxite basis.

Figure 1. Elemental composition of Kirkvine bauxite feed.

Aluminous goethite

The iron substitution for alumina is usually much greater in the goethite lattice than in the hematite lattice. This is also the case in Kirkvine bauxite. In the absence of sufficient data before February 2005, no differentiation has been made in Figure 2 between alumina in goethite and alumina in hematite.

The alumina content in iron minerals has increased significantly, from 1.2% to 3.6%, which clearly underlines the sharp increase in goethite content of the bauxite. At the same time the colour of the bauxite mined changed from reddish to yellowish, an observation which Jamaican alumina producers generally regard as bad news.

The term used hereafter for the alumina in iron minerals is “goethitic alumina”, although strictly speaking this includes a modest amount of alumina in hematite.
Relationship with $P_2O_5$
Total CaO in bauxite over the review period has typically been 0.6 – 0.7% except for an excursion between March 2004 and March 2005 when it was higher, with peak values just over 0.9%. Calcium is essentially present in two forms: calcite and crandallite. The distribution of CaO over these two minerals is shown in Figure 3.

![Figure 3. Calcia distribution in Kirkville bauxite feed.](image)

As already shown in Figure 2, the increase in crandallite coincides with the increase in alumina tied-up with iron minerals. This suggests a certain association between crandallite (soluble phosphate) and goethite. The correlation is not perfect, but definitely there (see Figure 4). This is in line with Grubbs [2] observation that yellow bauxites contain more $P_2O_5$ than red bauxites.

![Figure 4. Correlation between sol-$P_2O_5$ and goethetic alumina.](image)

Impact on Plant Operations

The change in bauxite mineralogy has impacted on various aspects of refinery operation, namely on alumina and soda losses, liquor causticity and mud sedimentation characteristics. This paper focuses on the effects that have a predominant liquor chemistry flavour, namely the impact on alumina loss and the impact on liquor causticity.

Impact on Alumina Loss

The increase in alumina loss is broken down over the various categories in Figure 5. Gibbsite precipitation in the mud circuit, which increased from 3% to 5%, represents the largest loss. This is closely followed by boehmite reversion (according to the analytical methods applied), which showed the largest increase, from 1.5% to 4 – 4.5%.

![Figure 5. Alumina losses per category.](image)

Gibbsite precipitation losses
The possible reasons for the rise in gibbsite precipitation losses in the mud circuit that are to be considered include:

1. Increased supersaturation;
2. Reduced stabilizing effect from calcium;
3. Increased unextracted gibbsite in the mud;
4. Increased presence of other seed material in the mud;
5. Increased mud factor.

1. Supersaturation
The increase in losses could not be explained on the basis of supersaturation, as can be seen in Figure 6. The digestion A/C ratio had been reduced considerably since the end of 2005, but the losses stayed at a high level.

![Figure 6. Gibbsite losses with mud and supersaturation.](image)

2. Liquor stability, soluble calcium and phosphorus control
It is a generally accepted fact that soluble calcium has a stabilizing effect on pregnant liquors [3]. Phosphorus in liquor is thought to interfere with this process, because it readily reacts with the calcium in liquor to form carbonate-apatite [1]. Hence, a