Effect of Pre-Desilication Time and Temperature on Desilication Behavior of Low-Silica Guinea Bauxites

Sagar S. Pandit[1], Rajanikant Jadhav[2], Mahantesh Hiremath[3] and Pavan Kumar Singh[4]
1. General Manager – Bayer Process Development
2. Deputy Engineer – Bayer Process Development
3. Deputy Engineer – Analytical Development
Hindalco Innovation Centre – Alumina, Hindalco Industries Limited, Belagavi, India
4. General Manager – Technology & Process (Alumina), Hindalco Industries, Belagavi, India
Corresponding author: sagar.pandit@adityabirla.com

Abstract

Desilication of Bayer liquor is a very important process step in achieving acceptable levels of silica content in liquor to precipitation in order to minimize process scaling issues and to produce alumina of acceptable quality.

Pre-desilication (holding bauxite slurry at elevated temperatures prior to digestion) is a common process step being followed by many alumina refineries. One of the Hindalco's alumina refinery processes bauxites of different quality, available from the indigenous as well as imported sources. One such imported bauxite source, which has been stabilized and has been in use consistently at the refinery is Guinea.

A detailed processability study was done and the conditions were optimized before using this bauxite source. However, over the period there were visible deviations from the performance, which required understanding (in detail) the desilication behavior and then adjusting the process conditions to achieve the desired process efficiencies in the refinery.

This study identifies the optimum process conditions to be followed by the refinery, through statistically designed laboratory experiments for the Guinea bauxite samples containing low levels of silica. The desilication efficiency is evaluated considering predesilication temperature (90–95 °C) and time (16–22 h), and response being silica ratio, silica supersaturation and silica attack. To achieve the targeted silica ratio, silica supersaturation and silica attack values, pre-desilication and low-temperature digestion conditions are optimized for each of the low silica bauxites. This provides the refinery with flexibility of selecting the most appropriate process conditions based on the properties of bauxite being processed.

This paper presents the details of the studies conducted with various bauxite samples from Guinea, the results obtained, and the process conditions finalized.

Keywords: Bauxite, Desilication, Guinea, Kaolinite, Silica.

1. Introduction

All bauxites contain silica in various amounts mainly as kaolinite and some parts in the form of quartz. Depending on the digestion temperature chosen for treating particular bauxite, all of kaolinite and some part of the quartz react with caustic at elevated temperatures. Desilication is the phenomenon of silica content in bauxite reacting with caustic and its re-precipitation as sodium aluminium silicate, commonly called Bayer sodalite. Optimum desilication is desired essentially to control silica content in liquor going to hydrate precipitation stage. High level of silica content in liquor adversely affects liquor heater performance through formation of sodalite scale and increasing silica contamination in hydrate product.

One of the refineries of Hindalco was processing bauxites from the west coast mines of India. Over the years, the bauxite mines were depleted and hence the bauxite source shifted to a combination of imported and indigenous bauxite from India. Through various bauxite processability studies, the bauxite sources were optimized, and the major imported bauxite source used was from Guinea. Since the Guinea bauxite was a low silica bauxite requiring a longer predesilication (PDS) residence time and accordingly the plant desilication section was upgraded to include more tanks. Visible plant performance deviations appeared over time which were obviously due to the bauxite reactivity under the plant conditions. This required understanding (in detail) the desilication behavior and then adjusting the process conditions to achieve the desired process efficiencies in the refinery.

This paper presents the details of the studies conducted with various bauxite samples from Guinea, the results obtained, and the optimum process conditions that were identified.

2. Conceptual Approach

The desilication process starts with the kaolinite ($k.SiO_2$) dissolution and is completed by Bayer sodalite precipitation, as described in the following simplified reactions [1]:

$$Al_2O_3\ 2SiO_2\ 2H_2O + 6NaOH \rightarrow 2Na_2SiO_3 + 2NaAlO_2 + 5H_2O \quad (1)$$

$$6Na_2SiO_3 + 6NaAlO_2 + Na_2X + 12H_2O \rightarrow 3(Na_2O\ Al_2O_3\ 2SiO_2\ 2H_2O)Na_2X + 12NaOH \quad (2)$$

Incorporation of a PDS step, wherein bauxite slurry is held in atmospheric tanks at somewhat elevated temperatures (80 to 95 ºC) for long duration ranging from 8 to 24 hours has become a widespread practice in alumina refining. Process conditions in PDS step as well as those in digestion are adjusted/controlled in an optimum way so as to ensure that the silica content in liquor after digestion is within acceptable limits. In any operating refinery, the digestion conditions like temperature and residence time are almost fixed and can be varied only in a very narrow range. Hence, optimization of desilication is mainly achieved through optimization of PDS conditions. Though the aim of desilication is to achieve the lowest silica content in liquor, which would be equivalent to the theoretical solubility of silica under the given conditions, it is not practically possible to achieve the same under normal operating conditions. Hence, to find out the practical limits, that would be considered as acceptable, two terminologies are defined (as given below):

a) Silica Ratio = [Actual silica content in liquor at certain conditions / Equilibrium silica content under the same conditions] [2]

b) Silica Supersaturation, g/L SiO_2 = [Actual silica content in liquor - Equilibrium silica content]

It is a common practice to calculate the Equilibrium silica content using the Oku-Yamada equation [3,4] as given below:

$$\textit{Equilibrium silica content, g/L } SiO_2 = 1.58 \times 10^{-5} \times C \times A \quad (3)$$

where:
C Caustic concentration, g/L Na_2CO_3
A Alumina concentration, g/L Al_2O_3

Practically, in the Hindalco alumina refineries, it has been observed that if Silica Ratio is controlled below 1.27 and Silica supersaturation below 0.15, desilication can be considered as acceptable [5].

Thus, the impact of PDS residence time on the achieved THA extraction from the PDS-LTD laboratory studies with the Guinea bauxites was confirmed by the predictive model using plant data. Hence based on the results, the PDS residence time was adjusted to 16–17 h from the original level of 22 h to achieve the desired desilication as well as extraction efficiency.

4. Discussion:

This study focusses on determining the optimum desilication conditions for low silica Guinea bauxite. PDS-LTD studies conducted under varying conditions of temperature and time showed that a PDS at 95 °C for 22 h, and an LTD at 145 °C for 45 minutes, the target silica ratio (< 1.27) and silica supersaturation (< 0.15 g/L) were achieved, as well as a higher THA extraction. However, over the years, a drop in THA extraction efficiency was observed when Guinea bauxite shipments were processed in the refinery under these optimised conditions. Hence the desilication conditions were studied again in detail by varying the PDS residence time, while keeping other parameters constant. This was made possible because of the flexibility of operation in the refinery at varying PDS residence times.

THA extraction efficiency was dropping by ~1.2–1.3 % with an increase in the PDS residence time from 16 h to 20 h. For further investigation, a predictive model was developed for estimating the THA extraction. The model results showed that, of all the process parameters analysed, only bauxite quality parameter such as k.SiO_2 long with PDS residence time are found to be significant. This further confirmed the findings from the PDS-LTD optimisation tests. Hence based on the studies and the predictive model, the PDS residence time in the refinery was reduced to 16–17 h to optimise desilication efficiency and maximise THA extraction. This resulted in steady operation of the refinery.

Hence, we can conclude that bauxite k.SiO_2 content and PDS residence time both have a significant impact on the desilication efficiency, even though the bauxite is from the same source. This study is a convincing demonstration that it is imperative to study the desilication and digestion performance of the bauxite samples on a regular basis to verify the performance and accordingly optimise the desilication and digestion conditions, in order to ensure both a steady refinery operation and an optimum bauxite utilisation.

5. References

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