Boehmite Bauxite Usage at Low Temperature Digestion an Case of Study at Alumar Refinery

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Abstract

Boehmite and gibbsite are the major aluminum oxide components in bauxite. These minerals have different dissolution kinetics and solubility under Bayer process conditions and therefore, require different digestion conditions for optimal recovery. The amount of each mineral present in an ore defines the refinery conditions required, affecting mainly red side area design: milling, digestion and clarification. Boehmite is not dissolved under low temperature digestions and subsequent to digestion may promote precipitation of dissolved alumina, causing several impacts such as increasing mud loads on clarification and increased recovery losses. This paper describes the effects, financial impacts and operational strategy of using a boehmitic bauxite blended with gibbsitic bauxite processing in low temperature digestion at Alumar Refinery.

Keywords: Boehmite, Gibbsite, Alumina Refinery, Aluminium oxides, Bauxite processing.

1. Introduction

The most important aluminous minerals in bauxite are gibbsite ($Al(OH)_3$), boehmite ($AlO(OH)$) and diaspore ($AlO(OH)$), however gibbsite requires lower digestion temperature to be dissolved (typically ~145ºC) as compared to boehmite and diaspore (typically >240 ºC), Equation (1 – 2). Accordingly, alumina refineries are usually designed to specifically process one type of bauxite. While boehmitic bauxites are usually processed using ‘high temperature’ digestion conditions (to recover boehmite) in theory a boehmitic bauxite could be processed in a low temperature plant with no or minimal process impact if the boehmite levels were sufficiently low, even though this boehmite content is not dissolved [1], increasing residue amount to clarification.

$$Al(OH)_{3\,(s)} + NaOH_{(aq)} \leftrightarrows NaAl(OH)_{4\,(aq)} \tag{1}$$

$$AlOOH_{(s)} + H_2O_{(l)} + NaOH_{(aq)} \leftrightarrows NaAl(OH)_{4\,(aq)} \tag{2}$$

Alumar refinery (Figure 1) is a consortium owned by Alcoa, South 32 and RioTinto and is designed to typically consume gibbsitic Amazonian bauxite. Therefore, the refinery operates low temperature digestion to optimize alumina extraction and energy consumption.

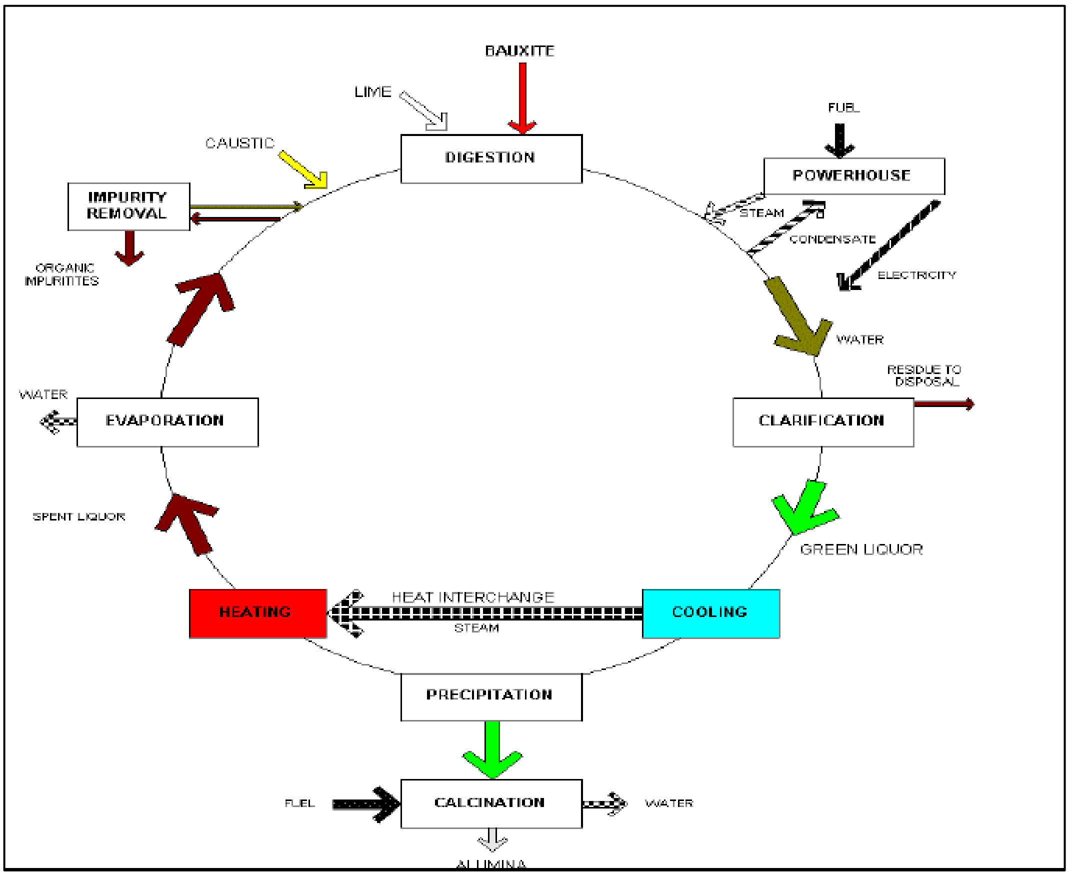

Figure 1. Alumar refinery flowsheet.

During 2017 Alumar received two shipments of bauxite with boehmite content above typical levels when compared to the current Amazonian bauxite. This paper describes the methodology used to process this bauxite and its impacts to the process at a low temperature digestion plant.

2. Methodology

Several risks were involved for the trial. Adding a different bauxite into the process presented operational risks that could result in adverse financial impacts. Therefore, laboratory trials were performed to identify and quantify the risks. The major risks were identified as increased residue load (due to lower available alumina), increased unextracted alumina (boehmite would not dissolve in the low temperature digesters), variations in settling behavior due to bauxite mineralogy and bauxite blending (a stable bauxite blend is required for optimal operation). A Design of experiment (DoE) was developed to quantify the risks and develop countermeasures to define optimal processing conditions. The DoE is summarized as showed in Figure 2 below:

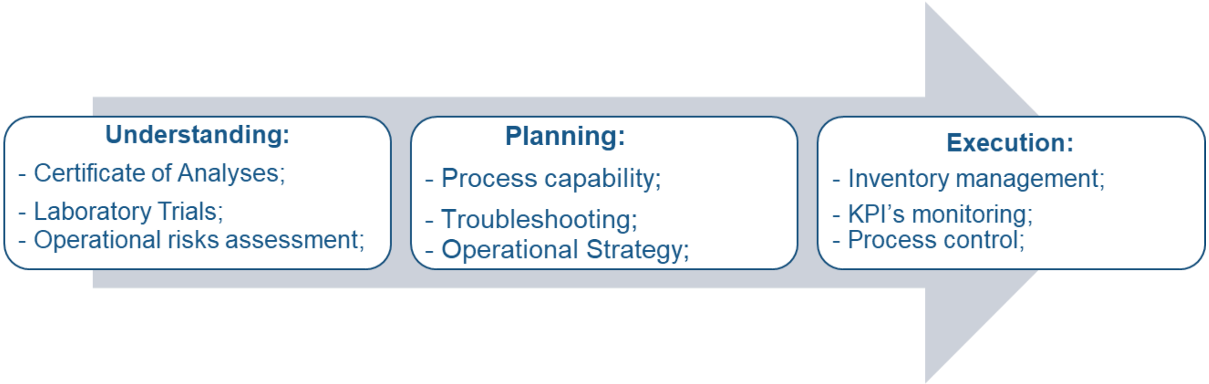

Figure 2. Design of experiment summary.

2.1. Laboratory Trials

Flocculant performance is a key factor to ensure stable thickener and washer operation stability. The low available alumina content of the “New” bauxite was likely to affect flocculation due to the higher solid~~s~~ concentration in the feedwell. Furthermore, the boehmite content and different mineralogy of the mud could affect flocculant performance. Laboratory settling test [2] were performed to evaluate new bauxite performance. The variables evaluated were overflow clarity, settling rate and compaction. The tests were conducted using current bauxite and new bauxite digested under simulated process conditions to provide the best direct indication of new bauxite performance.

2.2. Operational Strategy

Two methods to blend New bauxite was used, both were used successfully, however each has its own limitations, differing incapacity and extra operational activities;

New bauxite was added using an excavator (see Figure 3), at a controlled dosage (scoops/hour). This method introduced potential variability (mainly operator to operator), however the maximum possible dose rate was 5 % of the total blend, therefore blend composition was almost constant.

Figure 3. Excavator adding bauxite directly to conveyor belt.

The preferred strategy was to blend new bauxite on the bottom of stockpiles (build up small piles and cover with typical Amazonian bauxite) as is shown in Figure 4. This blend requires extra mobile equipment to distribute the bauxite over the patio, but by doing so, it was possible to include 30% of new bauxite into the blend; Using topography and the known bauxite apparent densities allowed blend values to be determined.

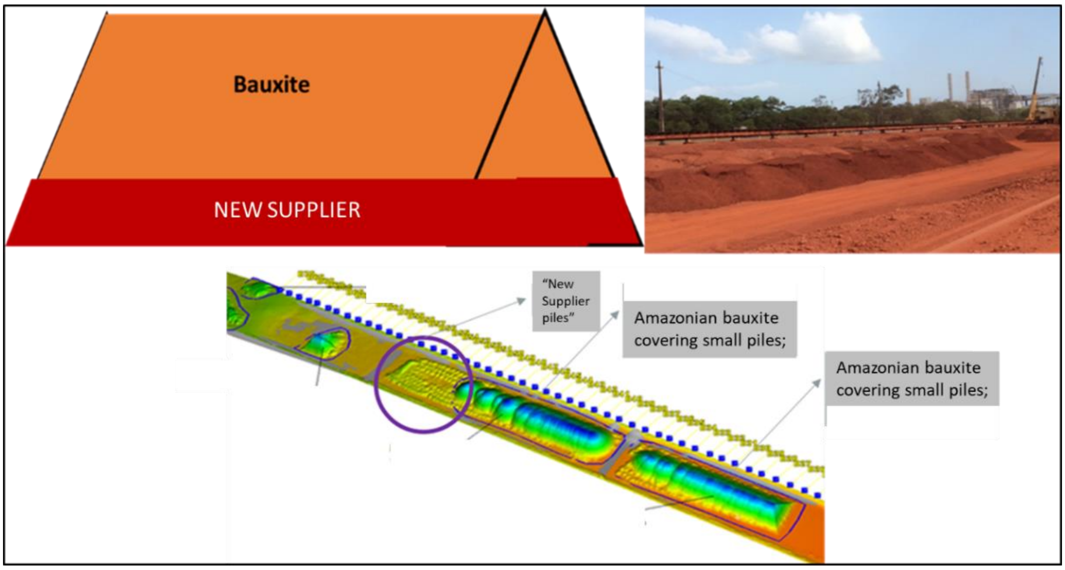

Figure 4. Ideal blend and the small piles schematic.

2.3. Bauxite Blend Calculation

Blend was calculated in two different ways; by number of scoops and by topography measurements of the bauxite stock piles.

2.3.1. Blend Calculation by Number of Scoops

This method required the operator to register separately the number of scoops added to the process, using bauxite apparent density (t/m³) and scoop volume (m³), as follows in Equation (3) below:

$$New\ (tons) = Number\ of\ scoops * Volume\ of\ scoop\ * Density \tag{3}$$

In addition, the bauxite consumption was determined using a weightometer available on site, to determine the daily blend by Equation (4):

$$Blend\ (\%) = \frac{\text{New Supplier}\ (tons)}{Bauxite\ Daily\ consumption\ (tons)} * 100 \tag{4}$$

2.3.2. Blend Calculation by Topography:

Topography measurement gives the volume of the small piles and final covered pile. It was necessary to also know the apparent density for both bauxites, which can be determined by laboratory measurement. Using this method, together with bauxite feed weightometers, the blend calculation represents more accurately the bauxite feed into process and can be followed by Equations (5 – 9).

$$New\ (tons) = (No.of\ piles) \times (Small\ pile\ volume\ ) \times Density \tag{5}$$

$$Vol.of\ Amazonian\ bx = Final\ Vol. - \big((No.of\ piles) \times (Small\ pile\ volume)\big) \tag{6}$$

$$Amazonian\ Bx\ (tons) = Vol.Amazonian\ Bx \times Density \tag{7}$$

$$Total\ Pile\ mass\ (tons) = Amazonian\ Bx\ (tons) + New\ (tons) \tag{8}$$

$$Pile\ Blend\ (\%) = \frac{New(tons)}{Total\ pile\ mass\ (tons)} \tag{9}$$

2.4. Process Indicators

Based on the DOE and the current knowledge about the most likely impacts, some key process indicators were monitored in order to make a proper evaluation of the new bauxite’s effect on the process. Some of these indicators were measured online by instrumentation and others by laboratory analyses. The main indicators selected were: mill product size mainly because of lower moisture content and different bond bauxite index of the new bauxite; alumina extraction to evaluate the impact on bauxite consumption; thickeners and washers alumina auto-precipitation, thickener overflow solids concentration to evaluate any filtration flow constraint or hydrate contamination and lastly the process chemicals additives consumption used in clarification. Other parameters such as precipitation yield, ratio control and production will not be discussed in this present work.

3. Results and Discussion

The impacts are represented by averaging process data and grouping with blend values with zones, from 0 to 30 % new bauxite by 5% step in each single group. This way it decreases the noise in the data in each group and therefore shows clearly any positive and negative impacts. Settling test results were obtained comparing both pure bauxite feeds with differing blends of both a polyacrylate and hydroxamate flocculant.

3.1. Laboratory results

3.1.1 – Settling Rate

Lab tests have shown that no great settling rate impacts were observed between the new and typical bauxites using current flocculant with 100% New bauxite addition (Figure 5);

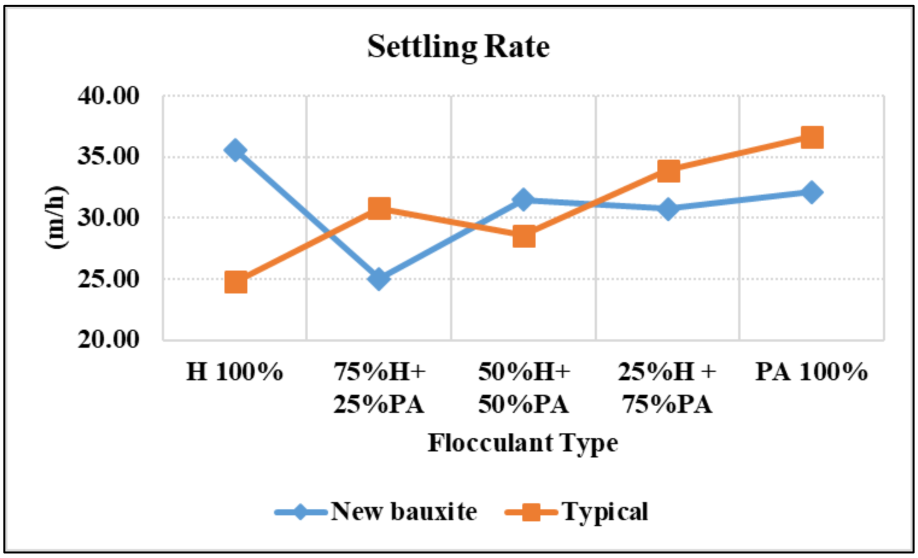

Figure 5. Lab Settling rate results.

3.1.2 – Compaction

Compaction tests showed no significant change between the new and typical bauxites (Figure 6). This lab trial does not include the rake arm effect over mud compaction on thickeners & washers.

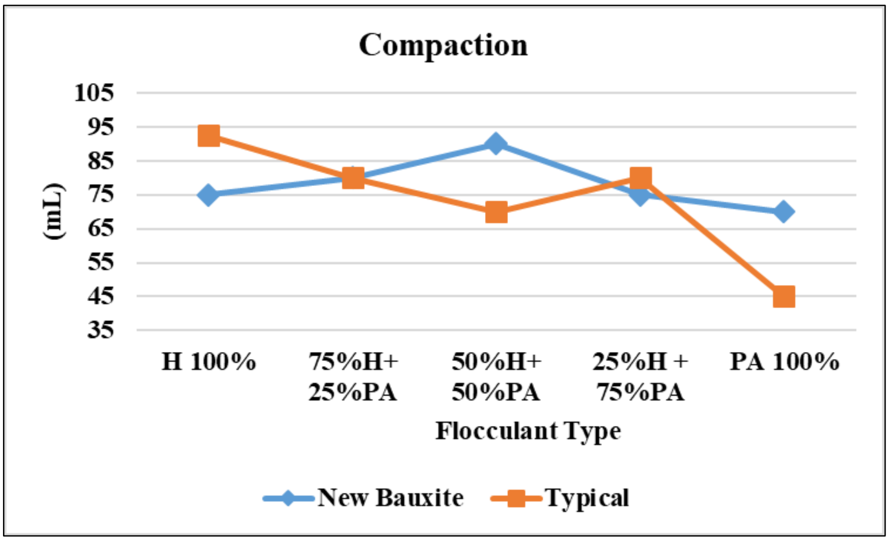

Figure 6. Lab compaction results.

3.1.3 – Thickener Overflow Clarity

The new bauxite showed huge potential negative impacts on thickener overflow clarity, meaning that the new bauxite addition into the process may carry a lot of problems into the filtration area and also could affect alumina quality. The trials also suggested that this effect could be minimized by polyacrylate addition.

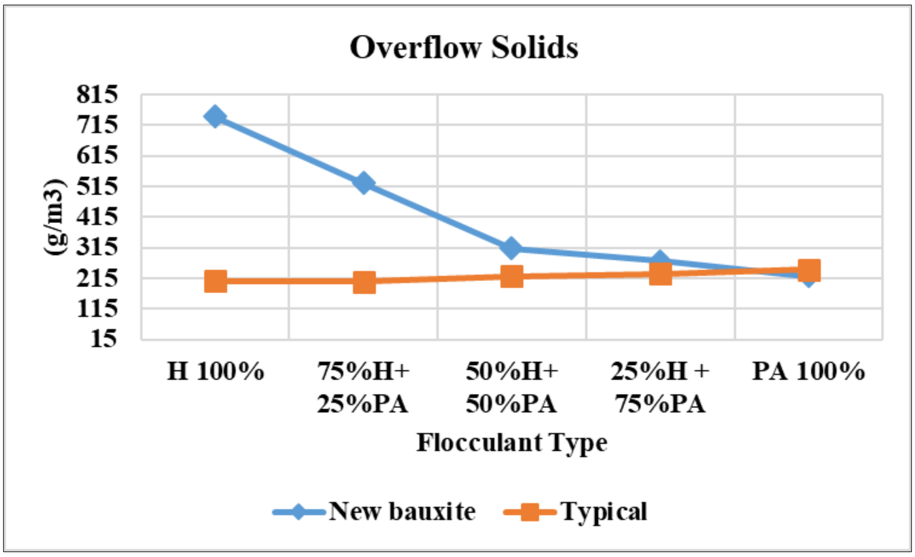

Figure 7. Lab overflow clarity results.

3.2. Refinery Data

3.2.1. Milling

During the trial, milling product quality (Figure 8) was clearly affected by the new bauxite feed to the refinery, probably due to the high working index. No changes were made to the mills during the period observed.

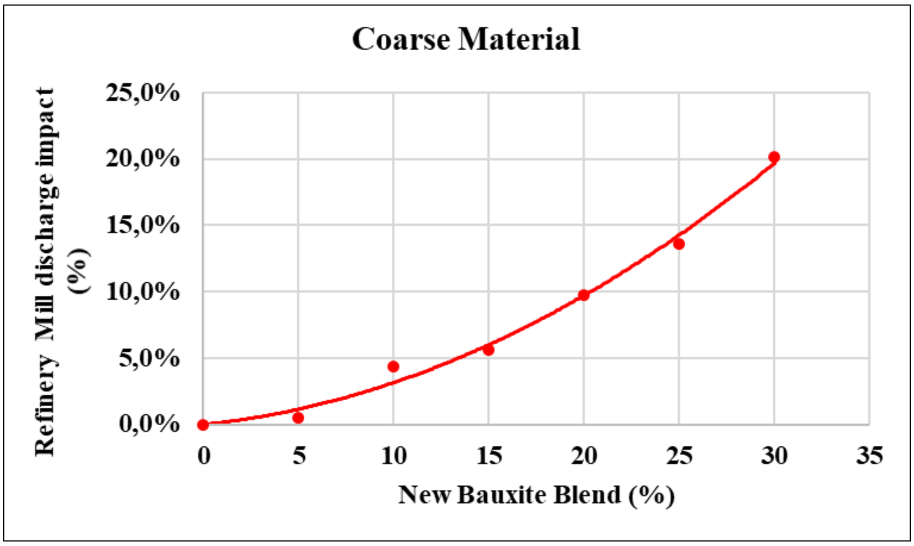

Figure 8. Refinery mill discharge impact.

3.2.2. Alumina Extraction

Clearly during new bauxite addition, extraction losses got worse (Figure 9), with a higher proportion of new bauxite added. The cause of this effect could not be isolated.

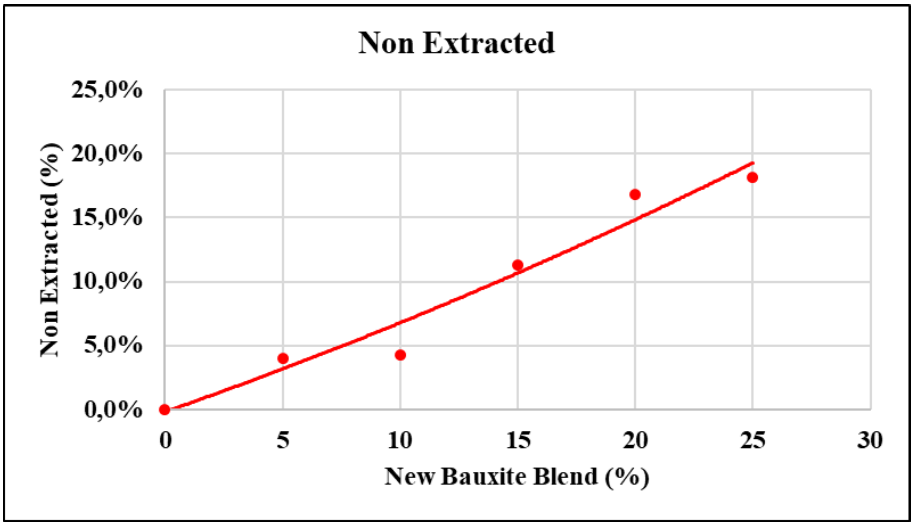

Figure 9. Refinery extraction impact.

3.2.3. Autoprecipitation

Autoprecipitation (Figure 10) was affected by higher mud bed levels in washers and as expected by higher extraction losses.

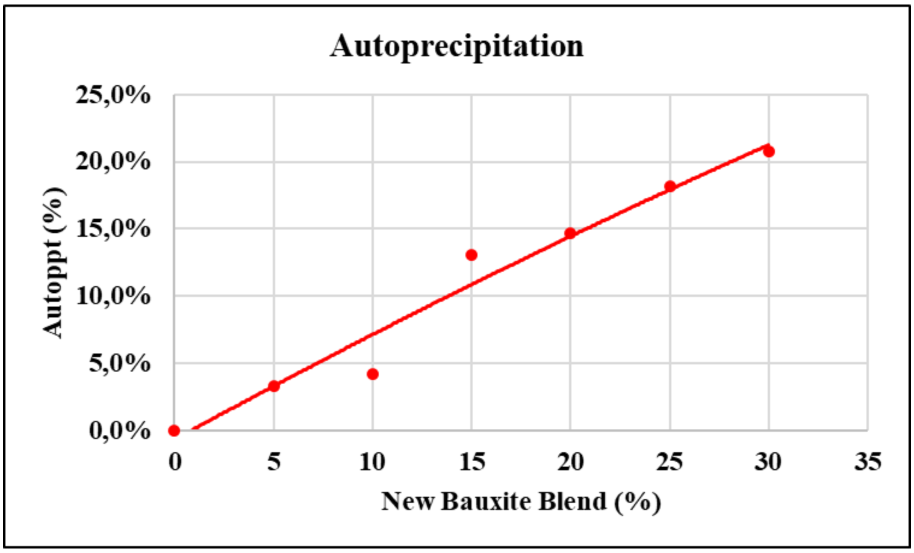

Figure 10. Refinery autoprecipitation impact.

3.2.4. Thickeners Overflow Solids & Process Chemicals Usage

Thickener overflow solids (Figure 11) were not significantly impacted up to 20% however the floc consumption (Figure 12) was increased to keep the refinery under good operation.

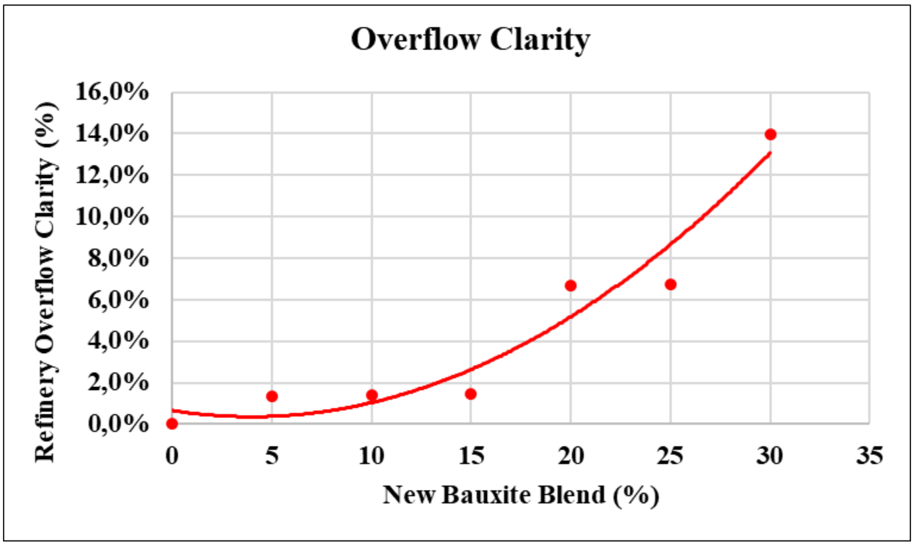

Figure 11. Refinery overflow clarity impact.

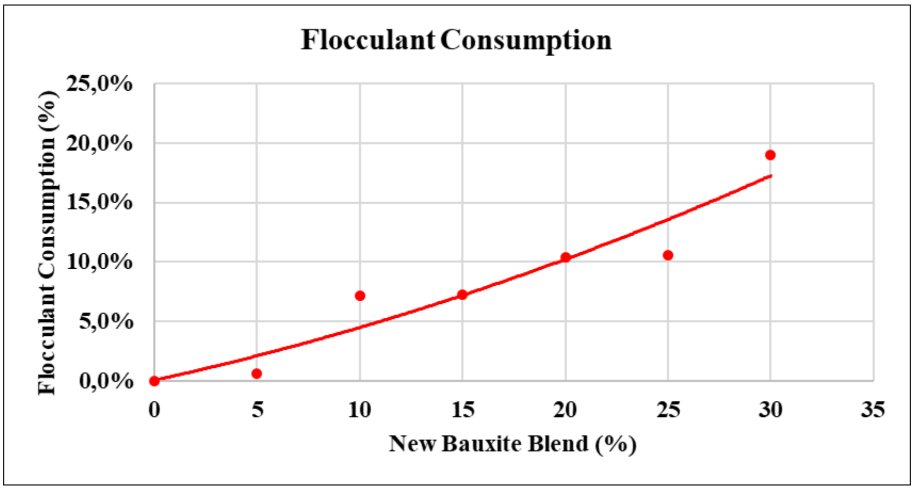

Figure 12. Refinery flocculant consumption impact

3.3. Financial Evaluation

Using ASPEN custom modeler with current refinery input data it was possible to determine the impact of the new bauxite using the data obtained during the trial. Modelling has showed that, given the availability of gibbsitic bauxite with very low boehmite content, the business case of using the “new bauxite” is not attractive when at higher blend usage, mainly due to the high alumina losses in extraction and autoprecipitation.

4. Conclusions

Bayer process is very complex and therefore it is hard to identify the cause-effect relationship of process variables and blended bauxites from an industrial environment. Using the methodology here presented it was possible to segregate some of these impacts and build some sensitivity curves. The preliminary laboratory trials were a crucial factor in defining the process strategy.

Given the additional operational costs associated with blending process and the penalties associated with increased alumina losses in digestion and clarification compared to the performance when operating with the current Amazonian bauxite, it was found that the business case for the use of the new bauxite was not attractive at high blend ratios. The scope of the trial did not allow a detailed analysis of the root causes of these penalties. However, the trial indicated that the new bauxite could be processed at levels up to 15% with minimal operational disruption.

5. References

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