Pilot Tests with Tertiary Cyclone for Reactive Silica Removal from Amazonian Bauxite

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Abstract

Bauxite is the main ore for metallic aluminum production, consisting of aluminum, iron oxides and kaolinite, a clay mineral commonly found in Amazonian bauxites, as the main carrier of reactive silica. In the process, due to the small particle size, kaolinite is usually removed by attrition and washing of coarse material followed by desliming using hydrocyclones. In the Bayer process, kaolinite reacts with sodium hydroxide, increasing reagent consumption in the process. Beneficiation process at Hydro Paragominas is based on the separation of coarser fractions with higher gibbsite content from the clay minerals, where kaolinite is more concentrated. The separation takes place in two-stage hydrocyclone circuits, equipment that inherently presents a bypass of fine particles to the underflow, consequently, contaminating the concentrate with kaolinite, and increasing the operating cost in the Bayer process. A Tertiary stage of cyclones was tested in a pilot plant using 254 mm diameter cyclone seeking a reduction on fine particles bypass and consequently, bauxite product with lower kaolinite levels. Average removal of fine particles below 10 µm, where clay minerals are concentrated, ranged between 80.8 % and 89.1 % on pilot tests. Consequently, available alumina grade increased from 43.3 % to 48.1 % and reactive silica reduced from 6.0 % to 3.3 %. The classification process was selective, with 89.3 % metallurgical recovery of alumina and 45.9 % recovery of silica to product.

Keywords: Bauxite beneficiation, Clay removal, Silica reduction, Hydrocyclones.

1. Introduction

Bauxite is the main ore for production of metallic aluminum. Production is generally carried out by the Bayer process to form alumina, followed by the Hall-Héroult process to carry out the reduction of alumina into metallic aluminum. Some factors that interfere in this process are available alumina and reactive silica contents in bauxite [1].

Bauxite is a rock composed of aluminum oxides. Bauxites can be "lateritic" or "karst" types. Lateritic bauxites are formed in equatorial regions and are mostly composed of gibbsite as the main mineral and gangue composed of kaolinite, iron oxides, titanium oxides and quartz. The Amazonian bauxite is of the lateritic type and is mostly located in Paragominas, Juruti, Trombetas and Almerim [2,3].

Kaolinite is a clay mineral commonly found in Amazonian bauxite and Brazilian iron ores. Due to its particle size, kaolinite is usually removed from the process in desliming steps using hydrocyclones. Kaolinite is the source mineral for reactive silica. In the Bayer process, kaolinite reacts with sodium hydroxide, increasing the consumption of the reagent in the process and forming desilication product [4, 5].

The hydrocyclone is a well-known mechanical classifier used for separations of particles of different sizes. Hydrocyclone performance characteristics such as coarse particle recovery to underflow, cut size and bypass reduction are related to operating parameters: pressure, solids percentage, apex diameter, vortex diameter and cone angle [6, 7].

Process simulations and pilot tests developed for coal classification have shown the potential of multi-stage circuits to reduce the hydraulic bypass of fine particles into the coarse product by reclassifying the cyclone underflow stream multiple times. Coal reclassification was able to reduce fine particles bypass from 14 % to 6 % [8].

Hydro Paragominas processes lateritic Amazon bauxite. To remove kaolinite, the beneficiation plant has two cyclone stages in two different circuits (fines and super-fines). Seeking to reduce the content of reactive silica in bauxite a pilot plant was installed in the super-fines circuit, with 254 mm diameter hydrocyclone, allowing the performance evaluation of tertiary cyclones.

2. Materials and Methods

2.1 Hydro Paragominas' Beneficiation Plant

Hydro Paragominas' bauxite processing circuit includes three main classification steps to separate the coarser fraction, with higher gibbsite content, from the finer fraction, where most of the kaolinite is concentrated. The first step is also responsible for separating fine particles from pebbles, which is followed by the re-crushing process, and is carried out on vibrating screens. The second step, called fines classification circuit, is carried out in 660 mm diameter hydrocyclones and separates clay and finer bauxite particles, from mid-size particles, that feeds the ball mill. The third step, called superfines classification circuit, is carried out in 254 mm diameter hydrocyclones and is the final step for separation of clay, beneficiation process tailings, to fine bauxite particles, that forms the product. A simplified flowchart of the processing plant is presented in Figure 1.

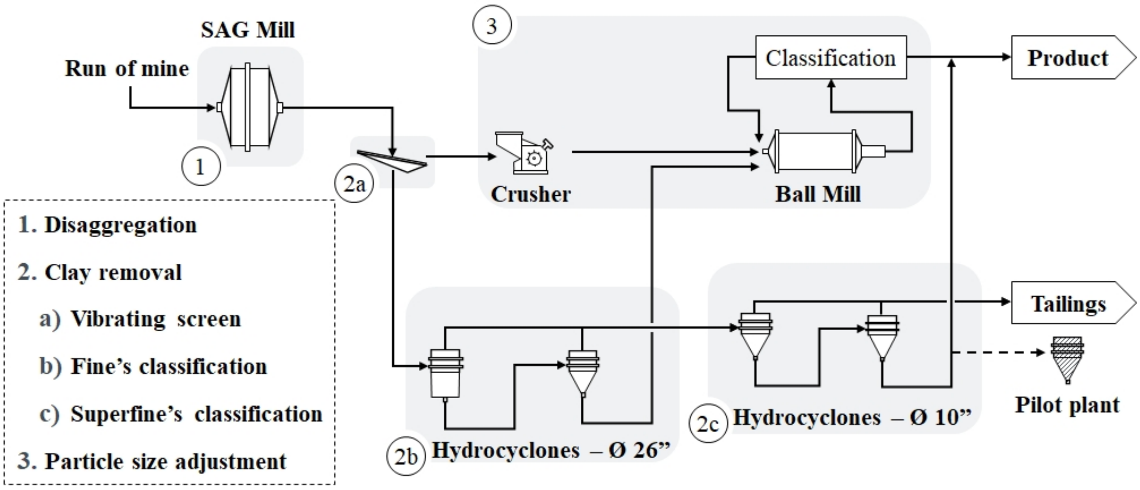

Figure 1. Hydro Paragominas' beneficiation plant simplified flowchart.

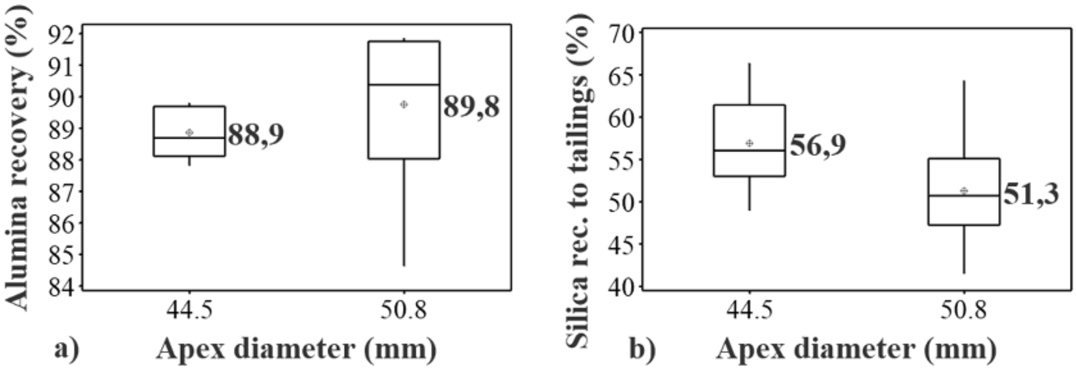

Figure 8. Available alumina recovery to product (a) and reactive silica recovery to tailings (b) on pilot tests.

In terms of main elements on the product, available alumina grades increased from pilot tests feed to product, while reactive silica grades decreased, as shown in Figure 9. Average available alumina upgrades were 1.106 and 1.083 with 44.5 mm and 50.8 mm diameter apex respectively. Average reactive silica downgrades were 0.536 and 0.587, with 44.5 mm and 50.8 mm diameter apex respectively.

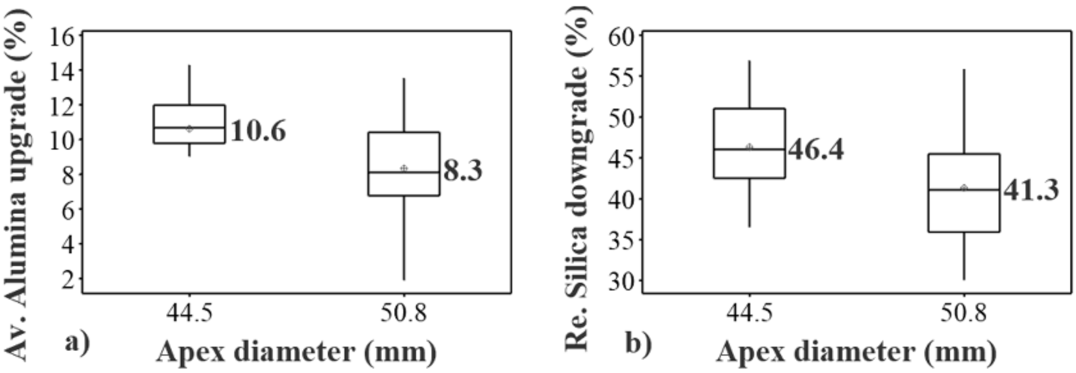

Figure 9. Available alumina upgrade (a) and reactive silica downgrade (b) to product.

4. Conclusion

Pilot tests have shown that tertiary cyclones can be a technical solution to increase available alumina and decrease reactive silica grades on bauxite beneficiation, keeping high levels of metallurgical recovery of alumina.

On the different apex diameter evaluated, average available alumina upgrade ranged between 1.083 and 1.106, while for reactive silica downgrade range was between 0.536 and 0.587.

Average metallurgical recovery of alumina ranged between 88.9 % and 89.8 % and reactive silica recovery to tailings ranged between 51.3 % and 56.9 %.

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