Increase in Metallurgical Recovery of Alumina on Bauxite Beneficiation with Small-Diameter Hydrocyclones

Allan Reis[1], Geraldo Duarte[2], Hudson Couto[3], Otavia Rodrigues[4], Elves Matiolo[5], Luiz Santos[6], Thalia Lopes[7] and Thais Lourenço[8]
1. Technology Consultant
2. R&D Senior Specialist
4. External Consultant
8. Process Engineer
Hydro Bauxite & Alumina, Paragominas, Brazil
3. Chemical Engineer, DSc
5. Mining Engineer, DSc
6, 7. Mining Engineers
CETEM/MCTI, Rio de Janeiro, Brazil
Corresponding author: allan.reis@hydro.com
https://doi.org/10.71659/icsoba2025-bx004

Abstract

Bauxite is the main ore for metallic aluminium production, mainly consisting of aluminium hydroxide, iron oxides, titanium dioxides and kaolinite. Amazonian bauxite beneficiation usually consists in attrition to disaggregate deleterious clay minerals from the aluminous rocky matrix, followed by classification steps to remove fine particles which are discarded to tailings. At Mineração Paragominas, cut size to separate product and tailings is 37 µm, and characterization works have shown that there are mid-size particles in tailings, between 10 and 37 µm that could potentially meet product chemical specifications. Pilot scale tests have been developed using a 40 mm diameter hydrocyclone to process current tailings seeking the recovery of particles between 10 and 37 µm to product and generation of new tailings, finer than 10 µm. Different apex and vortex diameters, operating pressures and a multi-stage circuit were evaluated. The selected circuit had three classification steps, with the primary step fed with current Mineração Paragominas' tailings, the secondary step processing primary step underflow and the tertiary step processing secondary step underflow. The evaluated circuit product is the tertiary step underflow and tailings are the combination of primary, secondary and tertiary steps overflows. As a result, 30 % available alumina recovery was achieved, with 41 % available alumina grade in the product. In addition, the particle size distribution results showed a reduction in material passing through 10 µm (P_{10}) in the first stage feed from 78 % to only 20 % in the third stage underflow.

Keywords: Bauxite beneficiation, Alumina recovery, Hydrocyclone classification.

1. Introduction

In mineral processing, fine particles represent a major challenge, especially in flotation, compromising the separation process. There are negative effects associated to these fine particles (slimes) on the process, as they have a high surface area, which causes high reagent consumption and, in some cases, coating of the surfaces of larger particles, compromising the efficiency of the process, a phenomenon known as slime coating [1, 2]. Specially on Amazonian bauxite processing, slimes have an additional deleterious effect as those particles usually present a low concentration of available alumina, the main mineral, and high concentration of reactive silica, a gangue mineral [3].

An alternative to this issue is the use of hydrocyclones, equipment that has a high volumetric capacity and has numerous applications, being used in closed grinding circuits, in mineral slurries

dewatering and in ores desliming for further flotation [4]. The separation principle of the hydrocyclone is centrifugal sedimentation: the slurry is introduced under pressure through a duct located in the upper part of the cylindrical section, resulting in a descending helical flow in which the larger and higher density particles are directed to the hydrocyclone wall, exiting at the bottom (apex) establishing the underflow, while finer and lower density particles and the majority of the water rise towards the vortex finder forming the overflow. The performance of the hydrocyclone is directly linked to its dimensions (conical and cylindrical section), characteristics of the ore and its operational variables [5]. Operational variables such as feed pressure and the diameter of apex and vortex finder can affect the classification size and hydrocyclone efficiency.

Present work objective was to process a bauxite beneficiation tailings sample that has a high amount of clay, seeking the recovery of mid-size particles to product with minimized contamination with fine particles of clay. Different cyclone geometry and operating pressures were evaluated seeking to reduce the presence of fine particles in the desliming circuit product to less than 20 % finer than 0.010 mm, making it suitable for eventual additional concentration in flotation steps.

2. Materials and Methods

2.1 Mineração Paragominas' Beneficiation Plant

At the existing Mineração Paragominas' beneficiation plant in Brazil three main circuits can be highlighted. The first one is responsible for the disaggregation between rocky, alumina rich, particles and fine clay, where most of the kaolinite is concentrated. The disaggregation is promoted by the attrition between bauxite constituents with water and grinding media, inside semi-autogenous grinding mills. The slurry of bauxite particles and water obtained as the product of the disaggregation step follows to the clay removal circuit, with a series of separation steps carried out on vibrating screens and hydrocyclones, where particles finer than 37 μm are removed to tailings. Coarser particles, with high available alumina and low reactive silica grades follows to the third circuit, with crushers and ball mills, where bauxite particle size is adjusted to meet the specification to be transported to the Alunorte alumina refinery through a 244 km long pipeline.

A simplified Mineração Paragominas' beneficiation plant flowsheet with the representation of process flow submitted to pilot tests is presented in Figure 1.

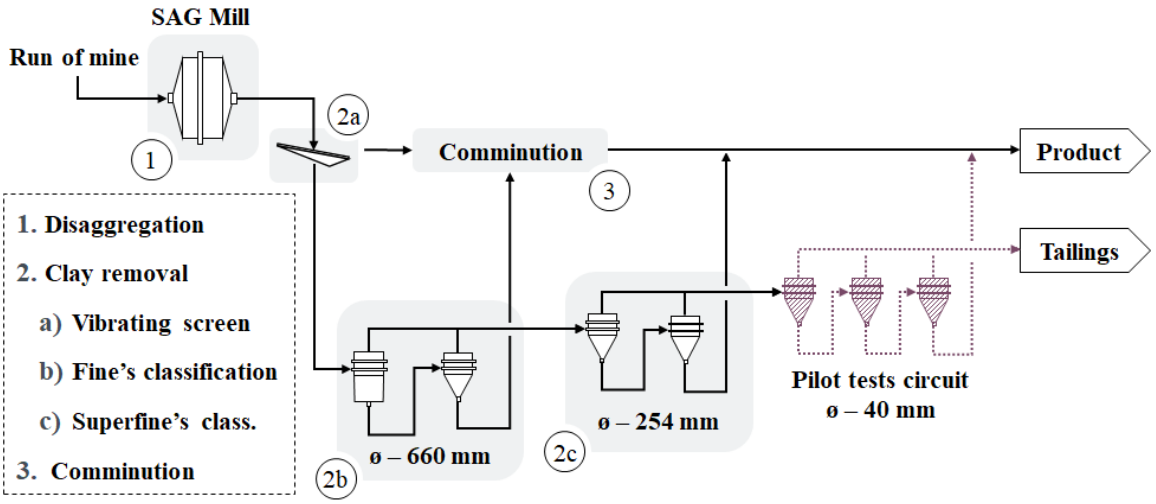

Figure 1. Mineração Paragominas' beneficiation flowsheet, indicating pilot test's location.

5. References

1. Leonardo Queiroz, Emprego da atrição na deslamagem: efeitos na flotação reversa de minérios itabiríticos, Dissertação de Mestrado, Escola de Engenharia da Universidade Federal de Minas Gerais, Belo Horizonte, Brasil, 2003, (in Portuguese). https://ppgem.eng.ufmg.br/defesas/362M.PDF?src=5139
2. Adriano Raimundo Totou and Carlos Alberto Pereira, Efeito da dispersão na deslamagem e flotação de polpas de minérios hematíticos itabiríticos, Dissertação de Mestrado, Departamento de Engenharia de Minas da Universidade Federal de Ouro Preto, Ouro Preto, Brasil, 2010, (in Portuguese). https://www.repositorio.ufop.br/items/6f73a183-df20-476e-a3ed-84b11e5abc86
3. Allan Reis et al., Pilot tests with tertiary cyclone for reactive silica reduction from amazonian bauxite, *Proceedings of the 41st International ICSOBA Conference, Dubai*, UAE, 2023, Paper BX01, *TRAVAUX* 52, 293–302.
4. João Alves Sampaio, Gerson Pereira Oliveira, and Antonio Odilon da Silva, Ensaios de classificação em hidrociclone, *Tratamento de minérios Práticas laboratoriais*, Rio de Janeiro, CETEM/MCTI, 2007, (in Portuguese). http://mineralis.cetem.gov.br/handle/cetem/1035
5. Julio Cesar Guedes Correia, *Classificação e Peneiramento. In: Tratamento de Minérios* (A. B. Luz, J. A. Sampaio, S. C. A. França), CETEM/MCTI, 5. Ed., Rio de Janeiro, Brasil, 2010, (in Portuguese). http://mineralis.cetem.gov.br/handle/cetem/734
6. Timothy J. Napier-Munn et al., *Mineral comminution circuits: their operation and optimization,* Indooroopilly, Queensland, Julius Kruttschnitt Mineral Research Center, 1996, 413 pages.
7. B. A. Wills and T.J. Napier-Munn, *Mineral processing technology - An Introduction to the practical aspects of ore treatment and mineral recovery*, Queensland, Julius Kruttschnitt Mineral Research Center, Butterworth-Heinemann, 2006, 444 pages.