Influence of Sodium Hexametaphosphate as Dispersant on Amazonian Bauxite Flotation

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https://doi.org/10.71659/icsoba2024-bx005

Abstract

The production of alumina is a crucial process in the aluminum industry since primary metallic aluminum is obtained from alumina. Among the various methods for producing alumina, the Bayer process is the most commonly used. Bauxite, the main ore for alumina production, typically contains gibbsite as the main mineral in Amazonian bauxite in Brazil. In general, Amazonian bauxite has iron and titanium oxides, as well as clay minerals like kaolinite (source of reactive silica). The presence of silica is a common and significant problem in the bauxite and alumina industry due to kaolinite, quartz, and other silicates present in various types of bauxite. In the Bayer process, reactive silica reacts with sodium hydroxide (NaOH), forming the sodalite increasing the alumina production costs and waste generation at the refinery. The purpose of this work was to evaluate the influence of sodium hexametaphosphate as a dispersant to enhance flotation selectivity in the reverse flotation of an Amazonian bauxite, aiming to improve its chemical quality. Bench flotation tests were performed at natural pH (~ 7) with a constant collector dose of 200 g/t of Flotinor 16939 and a variable sodium hexametaphosphate dosage as pulp dispersant (0, 250, 500, 750 and 1000 g/t). The presence of 250 g/t of sodium hexametaphosphate reduced the reactive silica content in flotation concentrate approximately 6 percentage points compared to baseline (without dispersant), from 38% to 32%. The best flotation scenario tested (200 g/t of collector and 250 g/t of dispersant) had alumina recovery of 73 % eliminating 68 % of reactive silica content. It has potential to reduce approximately 60 kg of caustic soda consumption per ton of bauxite processed in the Bayer Process. Two adsorption mechanisms can explain the research results. At a dosage of 250 g/t of dispersant (best effect of silica reduction), greater dispersion of the flotation pulp may have occurred, increasing the selectivity of flotation (better adsorption of the collector on the kaolinite surface). At dosages higher than 250 g/t, there was a decrease in the potential for reducing the reactive silica content. This may be related to the depressive effect of sodium hexametaphosphate on kaolinite, reducing its flotation. Sodium hexametaphosphate can improve the selectivity of bauxite flotation.

Keywords: Bauxite, Flotation, Reactive Silica, Sodium Hexametaphosphate, Dispersant.

1. Introduction

The production of alumina is a crucial process in the aluminum industry since primary metallic aluminum is obtained from alumina. Among the various methods for producing alumina, the Bayer process is the most commonly used. Bauxite, the main ore for alumina production, typically contains gibbsite as the main mineral in Amazonian bauxite in Brazil. In general, Amazonian bauxite contains iron and titanium oxides, as well as clay minerals such as kaolinite [1,2].

A common and significant problem in the bauxite and alumina industry is the presence of silica minerals including kaolinite, quartz, and other silicates in various types of bauxite. In the Bayer process, kaolinite reacts with sodium hydroxide (NaOH), forming sodalite, increasing the alumina production costs and waste generation at the refinery [3, 4].

Flotation is a mineral beneficiation technique that exploit the differences of minerals surface properties to promote the separation between minerals phases present into the pulp. The flotation route can be direct (floating the main mineral) or reverse (floating the gangue minerals) [5, 6,].

Lot et al. (2019) evaluated a cationic collector (Flotinor 5530) to promote a Brazilian low-grade bauxite beneficiation at bench-scale. Tests were performed at pH 10 in the presence of 800 g/t of starch as gibbsite depressant varying the collector dosage between 100 and 200 g/t. In the presence of 800 g/t of starch and 200 g/t of Flotinor 5530 it was possible to reduce the reactive silica content in 20 % with 93 % of metallurgical recovery. The bauxite had high slime content around 25 %.

Duarte et al. (2023) evaluated an amide-amine (Flotinor 16939) as kaolinite collector to promote an Amazonian bauxite beneficiation at bench-scale. The highest re. silica reduction was under 400 g/t of collector dosage with av. alumina recovery of 73.5 %, eliminating 47 % of re. silica content. The time of flotation was 2 minutes.

The purpose of this work was to evaluate the influence of sodium hexametaphosphate as a dispersant to enhance flotation selectivity in the reverse flotation of an Amazonian bauxite, aiming to improve its chemical quality.

2. Materials and Methods

2.1 Ore

To perform the bench flotation tests, a sample of bauxite from Hydro Paragominas was used. The sample was similar to the sample used by Duarte et. al. (2023).

2.2 Reagents

Flotinor 16939 (amide-amine) was used as kaolinite collector and sodium hexametaphosphate as dispersant.

2.3 Methodology

The sampling process yielded a global sample of approximately 15 liters, containing around 61 % solids by weight. This global sample underwent filtration, followed by drying in an oven at 105 °C, homogenization, dry disaggregation, and quartering. Twenty aliquots each weighing approximately 1 kg were then generated from this processed sample for ore characterization and flotation tests.

2.3.1 Particle-size distribution

The Particle-size distribution was made by wet sieving (> 400#) and laser diffraction (< 400#).

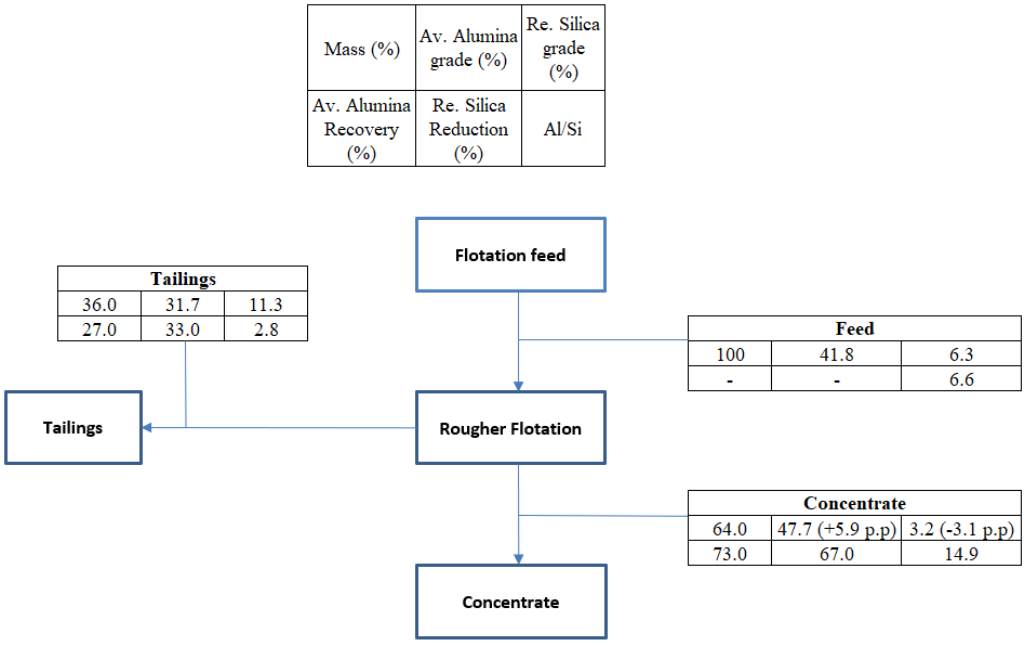

Figure 5. Metallurgical balance of the test with higher re. silica content reduction under 200 g/t of Flotinor 16939 and 250 g/t of sodium hexametaphosphate.

4. Conclusion

The presence of sodium hexametaphosphate reduced the mass recovery compared to the baseline by approximately 4 percentage points, from 68 % to 64 %.

The presence of sodium hexametaphosphate reduced the metallurgical recovery of usable alumina by 3.5 percentage points, from 76.5 % to 73 %.

The presence of 250 g/t of sodium hexametaphosphate increased the reactive silica reduction approximately 6 percentage points, from 61 % to 67 %.

The highest reactive silica reduction was with 200 g/t of Flotinor 16939 and 250 g/t of sodium hexametaphosphate with alumina recovery of 73 %, eliminating 67 % of reactive silica content. This resulted in an enhancement of the available alumina grade from 41.8 % to 47.7 % and a reduction in the reactive silica grade from 6.3 % to 3.2 %.

In all tested conditions the alumina/silica relation in flotation concentrate was greater than 10. The best flotation scenario under 200 g/t of collector and 250 g/t of dispersant has potential to reduce 60 kg on caustic consumption per alumina tonne produced in the refinery.

5. References

1. Sampaio, et. al. Comunicação Técnica – Centro de Tecnologia Mineral (CETEM) – BAUXITA, Rio de Janeiro, December 2008
2. Andrew Ruys, Refining of alumina: the Bayer process. *Alumina Ceramics*, [S.L.], 49-70, 2019. Elsevier.
3. Smith, P. “Economic Processing of High Silica Bauxites – Existing and Potential Processes”, *CSIRO Light Metal Flagship*, 2009.

4. WU, et. al., Reaction behavior of quartz in gibbsite-boehmite bauxite in Bayer digestion and its effect on caustic consumption and alumina recovery. *Ceramics International*, [S.L.], v. 48, n. 13, p. 18676-18686, Jul. 2022. Elsevier BV
5. Bulatovic, S. M., *Handbook of flotation reagents* – Chemistry, theory and practice: flotation of sulfide ores". 1. ed. Amsterdam: Elsevier, 2007. 446p
6. Leja, J., Flotation Surfactants. In: Surface Chemistry of Froth Flotation". 2nd Printing. New York and London: Plenum Press, 1983. Chapter 5, p. 279-294.
7. Lot, et. al., Redução do teor de sílica reativa de bauxita por flotação. XXVIII Encontro Nacional de Tratamento de Minérios e Metalurgia Extrativa. Belo Horizonte, Brasil – November/2019.
8. Duarte et. al., Reactive Silica Reduction on Bauxite by Flotation. *TRAVAUX* 52, *Proceedings of the 41st International ICSOBA Conference*, Dubai, 5 - 9 November 2023.
9. Chen, et. al., Effects of sodium hexametaphosphate on flotation separation of diaspore and kaolinite. *Journal of Central South University Technology*, Changsha, China, volume 12, nº 4, p. 420-424, Agosto, 2005.
10. Rodrigues, O. M. S., Flotação de caulinita em minérios de ferro e bauxítico. 2012. 171 f. Tese (Doutorado) - Curso de Pós-graduação em Engenharia Metalúrgica e de Minas, Escola de Engenharia, Universidade Federal de Minas Gerais, Belo Horizonte, 2012.
11. Mccormick, et. al. Mechanochemical treatment of high silica bauxite with lime. *Minerals Engineering*, [S.L.], v. 15, n. 4, p. 211-214, abr. 2002. Elsevier BV.