Alumina Quality and Yield Improvements at Alunorte

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Abstract

The control of alumina quality is one of the key challenges in the Bayer process. The objective of this paper is to demonstrate how application of a new particle size control philosophy, rooted in fundamentals of precipitation kinetics has allowed for marked improvement in the overall quality of Alunorte's alumina. Specifically, it will be shown how this new control philosophy, combined with improved performance of hydrate seed filters and cyclones has reduced the number of alumina shipments out of specification for #100 mesh and Attrition Index, while simultaneously reducing total soda in alumina and maximizing process productivity, valued at 82,000 tons per annum.

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Keywords: Alumina quality, Yield, Seed filter, Hydrocyclones.

1. Introduction

Located on Highway PA 482 km 12 in the district of Murucupi, Barcarena city, state of Pará, Hydro Alunorte is currently the largest alumina refinery in the world in industrial production capacity. Currently, the refinery operates seven production lines. The sixth and seventh production lines were built in expansion 3, starting in 2008, raising production capacity to 6,261 Mtpy.

The Hydro Alunorte precipitation circuit has seven lines with distinctive characteristic between them (see Figure 1). Lines 1, 2 and 3 have gravimetric classifiers with coarse seed filtration. Lines 4 and 5 do not have seed filtration and its classification system is based on hydrocyclones. The last precipitation lines, lines 6 and 7, have a classification system similar lines 1, 2 and 3, but with coarse and fine seed filtration. These particularities bring differences in yield and quality.

Figure 1. Alunorte precipitation circuit. Seven Precipitation lines.

In 2016, the alumina quality produced by Hydro Alunorte showed deviation in some of the quality parameters. There were 38 certificates of analysis out of specification (CoA) due to +100#. These deviations led to a concentration of efforts to understand and propose solutions for quality improvements.

2. Particle Size Distribution Control Theory

Crystallization phenomena are not simple and the relationships between operating conditions and product specification are complicated. The driving force of crystallization is supersaturation in a non-equilibrium process. So, the operation strategy for setting supersaturation is important in order to keep high quality in parameters such as size distribution and crystal morphology [1].

Nucleation, growth and agglomeration are the three main phenomena driving precipitation of aluminum hydroxide from Bayer liquor. New fine particles produced in nucleation, gradually grow in size. Agglomeration – joining and bonding of two or more particles together – is the main phenomenon responsible for particle size enlargement in aluminum hydroxide precipitation. Added seed crystals in combination with newly born fine crystals, come together due to available shear stress and/or inter-particle weak forces [2].

Then in a second step, the particle undergoes bonding, whereby the precipitation of aluminum hydroxide in pores and corners of contact points resulting in crystal bridges that consolidate the particle [2]. As described by Zhanwei Liu et al [3], agglomeration and crystal growth are the main mechanisms for producing coarse aluminum hydroxide, so it is highly important to study the agglomeration process for producing sandy alumina.

2.1. Supersaturation Effect.

The supersaturation of sodium aluminate solution (liquor) is a prerequisite for agglomeration and the key factors that determine supersaturation of liquor are caustic sodium concentration (C) and molecular ratio of Al_2O_3 to Na_2CO_3 to (A/C). So, it is necessary to understand the effects A/C on the agglomeration process of seeded precipitation [3].

Zhanwei Liu et al [3] have shown that agglomeration efficiencies of fine particles in seed reduce and the average particle size of agglomerates decrease with decreasing (A/C). In their experiments the average particle size of agglomerates is less than that of seed when (A/C) is low, indicating that the agglomeration is not a dominant mechanism. The content of > 45 μm in agglomerates is less than that of seed when (A/C) is low in certain values, indicating that agglomeration cannot happen at this time.

2.2. Temperature Effect

M. Bahrami [2] demonstrated in his research that the temperature has the most significant effect on agglomeration. Sung Oh Lee et al. [4] have shown the effect of increasing the precipitation temperature on the average size of the final product. At the higher temperature, coarser seeds were formed as a result of more crystal growth or agglomeration, whereas at the lower temperature, fine crystals were formed due to the predominance of nucleation.

2.3. Initial Seed Mass Effect

Sung Oh Lee [4] also found the effect of the amount seed addition used during the precipitation of aluminum hydroxide product. With increasing seed addition, fine powders, were obtained. The increase of seed mass at constant temperature and agitation rate has a double facet effect on agglomeration rate. Increasing the seed mass, results in higher collision among particles and also higher surface available for precipitation. The higher available surface leads to lower precipitation of matter per unit area at a fixed supersaturation. As it is well known, the bonding of two particles together is the second step of agglomeration. Increasing the precipitation amount per unit area, results in more bonds between particles in contact. The opposite effects of seed mass increase resulted in a maximum point of agglomeration [2].

5. Conclusion

Increasing the concentration of solids in precipitation favors the generation of fines in the circuit. High concentration of solids with fine particle size results in better condition for the precipitation productivity. The principal benefits of the new control philosophy included reducing the number of shipments out of specification and increases in yield (by increasing the solids concentration in precipitation chain). Based on the success of this application, the Critical Group concept has now been fully implemented to other parts of the plant, with action plans periodically revised. The challenge and key learning of this work was to resolve differences in performance in each line, development of troubleshooting for solids concentration control and finding new ways to operate the existing equipment.

6. References

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