Methods of Measurement and Improvement of Rheological Properties of Bauxite Residue

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Abstract

The concentration and transportation of bauxite residue and bauxite slurry are two common challenges alumina refineries face today. Alumina refineries are seeing lower available alumina and increased gangue-minerals that make handling of bauxite residue more difficult. Difficulties in handling of bauxite residue can lead to a shorting of an alumina plant's working life due to the filling of bauxite residue waste lakes, or there can be difficulty in filtration of bauxite residue at the end of a counter current deceanting circuit. While synthetic polymers are necessary to achieve faster liquid-solid separation rates, polymers can impart negative rheological characteristics to slurries of bauxite residue or bauxite slurry. This paper will discuss the increasing rheological properties caused in part or total by the mineralogical components within bauxite residue, operational philosophies, unit-operation's design and equipment, and the addition of chemical additives. In addition, this paper will cover methodologies for measurements of rheological properties of bauxite residue and bauxite slurry.

Keywords: Rheology, Alumina, Bauxite Residue, Yield Stress, Slurry

1. Introduction

In alumina refineries and other mining processes, challenges exist in the dewatering and transport of slurries. Substrate characteristics and solution salt concentrations, as well as other factors, such as chemical treatment, affect liquid-solid separations and subsequent pumping of aqueous dispersions also known as mining slurries. Also, alumina refineries are processing bauxite (ore) that contain a higher content of gangue minerals that require higher polymer dosages. Polymers are necessary to achieve fast rates of liquid solid separation and maintain suitably high plant flows for economic viability, but these polymers impart negative rheological characteristics to the concentrated aqueous dispersions (bauxite residue in the Bayer process) that make transport and washing more difficult. Aqueous dispersions that have lower threshold energy (yield stress) and uninhibited flow (lower viscosity) result in consistently faster flow rates through mining processes, including alumina refineries. New rheology modification technology; when combined with any number of synthetic polymers, has been successful in bench-top, pilot, plant trials, and commercialized sites, yielding improved rheological characteristics of concentrated aqueous dispersions. Benefits to the preparation plants include:

- Higher levels of throughput
- Improved efficiency and productivity
- Lower energy costs
- Consistency of unit operations
- Avoidance of additional CAPEX

In this article, the author will provide results from bench-top experiments to full plant trials to show the efficacy of the combination rheology modifier and a synthetic polymer to provide value in achieving the mill or plants operational objectives.

2. Background

Rheology modifiers effectively treat process slurries, tailings and concentrates. Other benefits over treatment with flocculant alone, include increased settling rate, less scaling, and improved filtrate clarity.

Trials of the rheology modifiers focused on applications characterized by difficult to process aqueous dispersions due to ore quality, process material quality, nature of aqueous solution, under-designed unit operations. Multiple studies of aqueous dispersions have identified and characterized properties that have negative impacts on liquid-solid separation and transport. For example, Klein et al [1] outline factors that impact of the rheological properties of slurries;

- Solids concentration
- Particle morphology
- Particle size distribution
- pH
- Ionic strength of aqueous phase
- Chemical additive

Examples of unit operations that are affected by the aforementioned factors are:

- Pumping
- Transport
- Grinding
- Gravity concentration
- Flotation
- Mixing
- Leaching
- Thickening
- Tailings disposal

Chemical additives, such as flocculants, coagulants, and dispersants, create particle to particle aggregation, networks. Another study depicts an increase in slurry viscosity as these structures develop [2]. As with other authors, the author of this paper propose that the morphology of networks resulting from chemical treatment without the use of rheology modifiers can negatively affect the rheological properties of these aqueous dispersions [3]. Rheology is the study of deformation of flow and matter, which included both viscosity, yield stress, etc. Viscosity is the internal friction of a fluid that gives the tendency to resist flow; that is defined as the ratio of the shear stress to the shear rate. Since mining slurries are non-Newtonian fluids, flow does not begin until the slurry's yield stress is exceeded. Yield stress is the critical shear stress that must be exceeded before irreversible deformation and flow may occur. In measuring yield stress, it is important that the yield stress be measured at the same point in the compaction regime. That is, measurements of yield stress should be taken at or near terminal compaction (point closest to maximum compaction attainable due to repulsive forces of polymer and other repulsive forces). Otherwise, there would be a variation in the results obtained in the rheological measurements; that is, workers have shown that with a variation of time, the magnitude of the rheological measurement changes. Yield stress is conveniently determined by a vane technique. The authors utilized the yield measurement to characterize treated and untreated slurry's rheological properties very similar to that used by Liddell and Boger for their work with yield stress measurements in concentrated suspensions [4,5]. Typically, rheologist test a combination of rheology modifiers with a range of synthetic flocculants, whereby the right flocculant and rheology modifier were chosen for a particular substrate that results in a network morphology that is conducive for flow,

5. Summary

Return on investment calculations were part of each investigation by the authors to demonstrate the value of using the new rheology modifier technology. Return on investment due to use of the rheology modifier for alumina refineries, preparation plants, mills, or refineries were estimated in some cases to be greater than $20 million per annum due to energy savings, reduced maintenance costs, washing efficiencies, scale prevention, life span of tailings repositories, optimized chemical spend, and increased production. The return on investment also benefited from reduced capital expenditure by eliminating the additional thickeners, bauxite residue lakes, and pumping equipment. Capex in some of the case studies were as high as $100 Million.

6. References

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