Controlling Alumina/Caustic Ratio

BACKGROUND

Aluminum is refined from raw bauxite ore in an energy intensive process that uses substantial amounts of caustic soda (NaOH) as the dissolving agent. Caustic is used because it is readily available and cost effective. The basic refining process has remained unchanged for about 100 years now, and is named after its' inventor, Karl Josef Bayer. Although originally developed in France, the Bayer process is now mostly used in Australia, Jamaica, and the southern United States.

PROCESS

Raw bauxite (mostly $Al_2O_3 \cdot H_2O$) ore can contain up to 50% impurities in the form of iron oxide and silica that must be removed prior to deposition of the aluminum metal. Treatment with caustic dissolves the alumina and allows separation and purification in later steps.

The bauxite ore is ground and fed into a steam-heated digester where it is mixed with the caustic solution at a temperature of 145°C (300°F) and 50 psig pressure. Some variations of the process may use much higher temperatures and pressures. Over a period of 30 minutes to a few hours, the alumina dissolves, but the impurities remain solid in the form of "red mud". These solids tend to scale the process equipment, requiring frequent cleaning.

Following the digester, the product slurry is cooled in heat exchangers and then separated, usually by gravity into a coffee colored liquid and the red mud. Residual solids are then filtered out and the liquid is allowed to cool in a precipitator. Lower temperatures allow aluminum to precipitate out as hydrated alumina ($Al(OH)_3$) after "seed crystals" are added to stimulate the process. The hydrated alumina is then dried in a long kiln at about 1000°C (1832°F) to remove the water and produce commercially pure alumina powder. Aluminum is finally produced by electrolysis of the alumina powder in a reduction pot.

Electrical conductivity is used to control the addition of caustic to the digester to optimize the yield of dissolved alumina in the process. The amount of caustic added in this step is proportional to the concentration of alumina in the stream. Controlling this alumina/caustic (A/C) ratio in the digester is essential to the process. Generally, the process is most efficient when the ratio is higher. An abnormally high ratio, on the other hand, causes early precipitation of alumina on the filters, causing product loss and scaling problems. Conductivity can also be used in recycling spent caustic liquid that is washed off the red mud impurities.

THE MEASUREMENTS

Electrical conductivity is an additive and non-specific property. All acids, bases, and salts will contribute to the total value. In applications where mixtures are present, more information on the process is needed to provide quantitative information.

Conductivity can be correlated to alumina/caustic ratio because the process in the digester consumes caustic and produces hydrated alumina that has much lower conductivity. Establishing a certain minimum operating conductivity (typically in the 300-500 mS/cm range) insures that enough caustic has been added to dissolve the bulk of the alumina. Conductivity measurement of wash water is used to prevent loss of caustic and minimize waste disposal needs.

THE PRODUCTS

Bauxite processing involves some heavy slurries that are highly conductive and very abrasive. To survive contact with the slurries, the conductivity sensor must be rugged and designed to minimize plugging from the process solids. Rosemount Analytical has addressed these concerns by designing a ceramic-lined sensor that can withstand abrasion.

INSTRUMENTATION

The Model 242 electrodeless conductivity sensor uses externally-mounted toroids to measure conductivity in a lined pipe. The lining is available in teflon, PEEK, or alumina — which is especially recommended for this abrasive application. The modular sensor consists of liner, contact ring, and process o-ring. The Model 242 is compatible with all Rosemount Analytical Toroidal Conductivity Analyzers including the Model 5081-T and Xmt-T DC-powered HART® and FOUNDATION® Fieldbus Analyzers, the Model 1056 Analyzer, and the Model 54eC HART Analyzer/Controller. Sensors for line sizes from 1" (25mm) to 4" (100mm) are available.

The Model 5081-T is housed in a robust explosion-proof enclosure and is especially suited to difficult working environments. The transmitter can be accessed locally using an infrared remote or via any HART or FF-compatible host device. The Xmt is designed for panel-mounting, has an integral keypad, and also fully supports HART and FF communication protocols.

MODEL 5081-T

MODEL XMT

MODEL 242

MODEL 1056

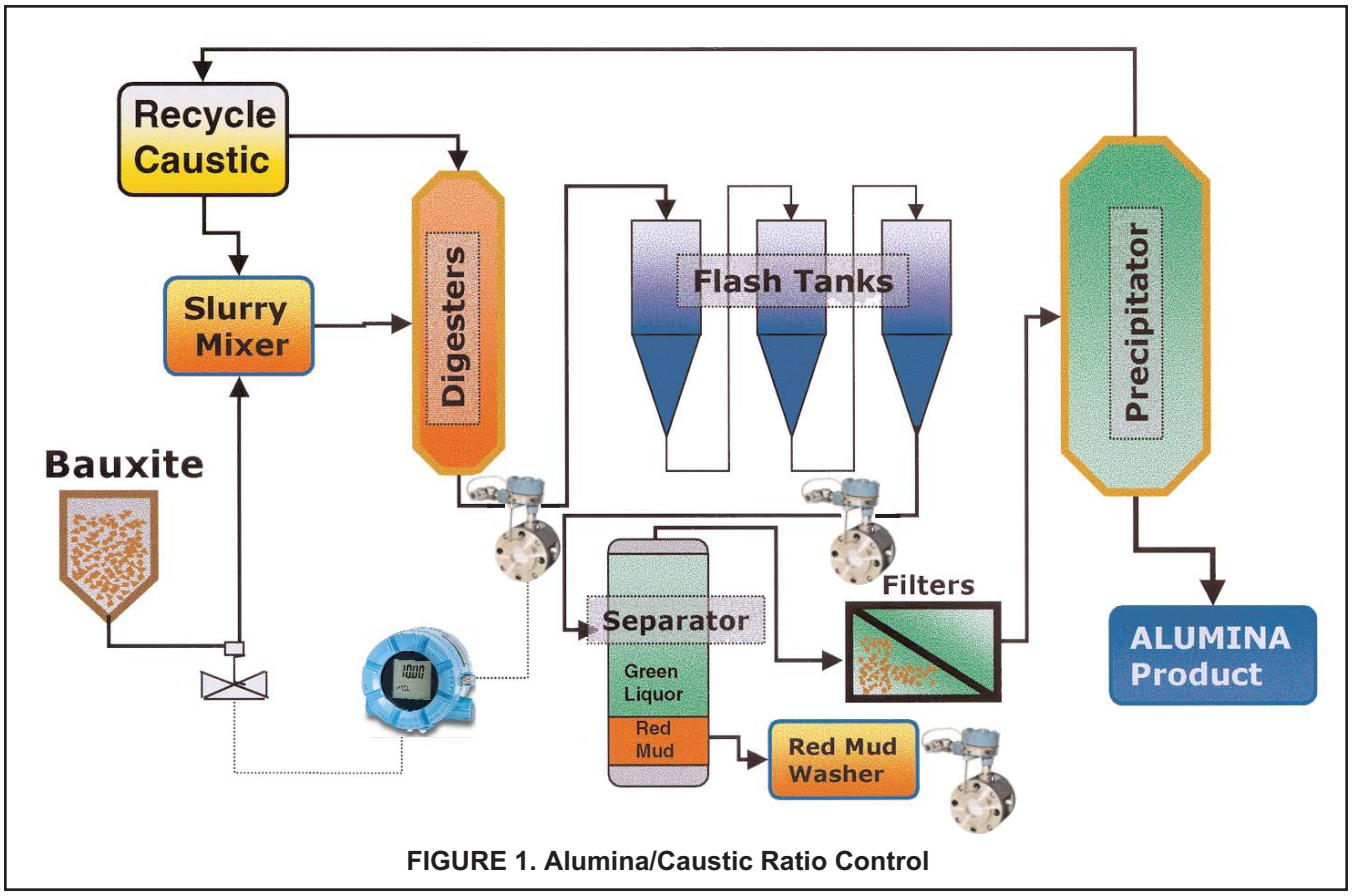

FIGURE 1. Alumina/Caustic Ratio Control

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