Filtration Efficiency of Tricalcium Aluminate Filter Aid Synthesized with Batch and Continuous Stirred Reactors

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Abstract

The filtration rate specific cake resistance (α) of tricalcium aluminate (TCA) aided filtration of dilute bauxite residue slurry were measured and calculated. TCA was firstly crystallized from synthetic and industrial Bayer liquor in both batch and continuous reactors. From the particle size distribution, when synthesized in continuous operation, the majority of the particles were smaller than 5 μm while a decrease in the amount of fine particles and a relatively narrow particle size distribution was observed in batch synthesis. Shorter filtration times and lower solids content in the filtrate were observed with the TCA prepared in batch mode. Filter aid quality is an important factor in determining the performance the Bayer liquor filtration unit operation.

Keywords: Filter aid, Tricalcium aluminate, Cake resistance.

1. Introduction

In alumina refineries, fine particles in the post-digestion thickener overflow are removed from the pregnant leach liquor by filtration. These fine particles have a tendency to flow through or block the filter cloth pores compromising alumina product quality and resulting in undesirable process downtime and costs associated with cleaning and replacing the filters [1]. To aid the filtration process, the filter cloth is coated with tricalcium aluminate filter aid which provides a porous network permitting solution flow while trapping the fine particles and delaying the onset of cloth blinding [2, 3].

It has been shown that filter aid particle size distribution has a profound effect on filtration performance. In a study by Kinnarinen et al. [4], the effect of particle size of wet ground calcium carbonate slurries was investigated. It was found that, the finer particles slow down filtration due to blinding the filter cloth. In another system, the influence of crystal morphology and particle size distribution on porosity, cake resistance for l-glutamic acid and an aromatic amine derivative was studied. It was found that spherulites resulted in higher cake resistance values than needle shaped particles. Comparably high cake resistance for the spherulites particles are accounted for by lower mean particle size as compared to needle-like particles [5]. It has been stated that "*If the particle properties could be specified for filtration, the target properties would be for the particles to have a higher mean size, be as near to spherical as possible, and have a monosize distribution*" [3].

Many studies have been carried out to investigate the effect of reaction conditions used for the preparation of TCA on the composition, particle size and particle morphology [6, 7, 8, 9]. Other work linking TCA properties to filtration performance consider filtration pressure, TCA concentration, flocculants, slaking conditions, and TCA synthesis reaction conditions [6, 1, 10]. The effect of batch and continuous TCA particle formation was recently studied [11]. TCA particle characteristics were found to be relatively sensitive to operating parameters such as agitation intensity and residence time. The fine particle concentration was considerably higher for the continuous reactor compared with the batch test which was ran for a time equivalent to the mean residence time. Also, the continuous reactor yielded dense agglomerates with minimal void space which are not desirable features for filter aid. In this study, a quantitative method was used to determine the effect of TCA produced by batch and continuous on filtration performance.

2. Methods and Materials

2.1. Bayer Liquor

Synthetic Bayer liquor was prepared from Gibbsite (C-31 grade, 99.4 % $Al(OH)_3$ by weight), sodium hydroxide (2.2 % Na_2CO_3 by weight), anhydrous sodium carbonate (99.9 wt %) and deionized water. The mixture was heated to 95 ºC to form an optically clear solution. An industrial Bayer liquor solution was also used to synthesize the "Plant" TCA. The composition of the Bayer liquors used to synthesize the TCA samples are shown in Table 1.

Table 1. Bayer liquor compositions.

Bayer Liquor	A g/L as Al_2O_3	C g/L as Na_2CO_3	A/C	Carbonate g/L as Na_2CO_3	S Total Soda g/L as Na_2CO_3	C/S
Plant	137	243	0.56	20.5	263.5	0.92
Synthetic	172	214	0.80	42	256	0.83

2.2. Lime Slaking

Hydrated lime slurry was prepared by mixing 10 g of pure CaO (> 96 % pure) with 100 mL deionized water. The density of slurry was 1.06 g/mL at 90 ºC. It was confirmed by XRD that $Ca(OH)_2$ was the only crystalline phase present in the slaked lime. Approximately 95% of the slaked lime particles were below 2 µm in diameter according to Accusizer particle counting. The size was confirmed by SEM analysis and the shape of the slaked lime particles appeared to be irregular.

2.3. TCA Synthesis

"Batch" TCA was synthesized in a batch stirred baffled reactor and "Continuous" TCA was synthesized in a continuous stirred tank reactor as described in a previous paper [12]. The batch synthesis time and continuous reactor mean residence times were both 120 minutes. For the continuous reactor, feed solutions were supplied from two separate heated stirred tanks to the reactor using Masterflex peristaltic pump. The flowrate of the 10 % (w/w) $Ca(OH)_2$ slurry was 2 mL/min and the flowrate of the Bayer liquors was at 4 mL/min. The TCA was freshly synthesized ahead of each filtration test. The resultant TCA slurry densities were similar at 1220 and 1244 g/L for batch and continuous TCA respectively. Filtration tests were also conducted on a TCA sample from an alumina refinery termed "Industrial" TCA.

2.4. Tricalcium Aluminate Characterization

The particle size distribution of tricalcium aluminate was determined by an Accusizer; (The Accusizer instrument consists of five parts: autodiluter, optical sensor, pulse-height analyzer, computer processor and software controller). To ensure that the particles were not dissolving upon dilution, the dilution solution consisted of a saturated solution of tricalcium aluminate. A separate beaker of this saturated solution (100 mL), with baffles and a stirrer to ensure homogenous slurry distribution. Then, a small amount of slurry from the experiment (1 mL)

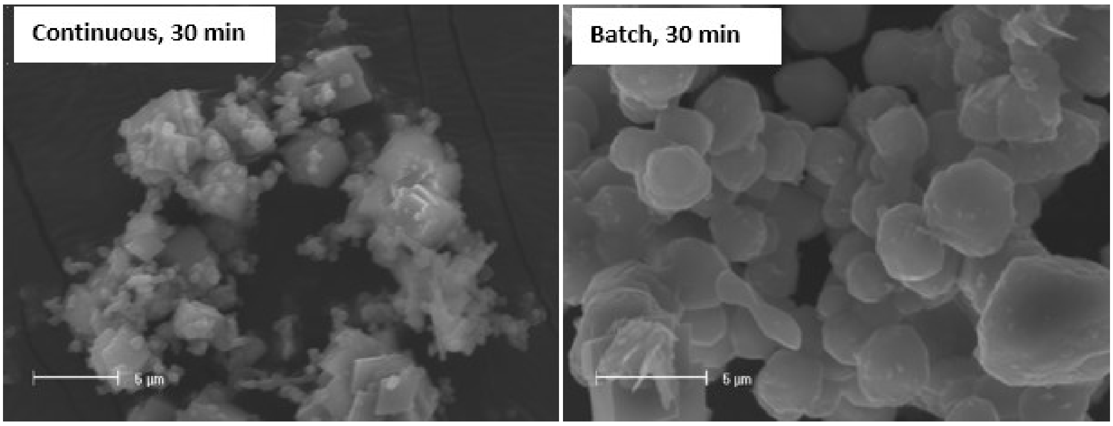

Figure 6. Morphology of TCA sampled with a mean residence time of 30 minutes for the continuous reactor and at 30 minutes for the batch reactor.

4. Conclusions

The filtration performance was measured considering filtration rate, carry-over solids concentration in the filtrate and the specific cake resistance. was calculated The filtration performance was found to be influenced by the amount and particle size distribution of the TCA. The filtration time was shorter and the filtrate clarity was improved when using TCA synthesized in a batch reactor compared to a continuous reactor.

It was shown that the batch synthesized TCA contained less fines than the continuous synthesized TCA. Fine TCA particles can pass through the filter cloth and also get stuck inside the cloth decreasing performance. The reason for the fines from the continuous reactor can be explained by short circuiting of some lime resulting in insufficient time to develop well-formed TCA.

The cake resistances were estimated, however, a different experimental approach is required to deconvolute the effects of the bauxite residue and the TCA.

5. References

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