

Digestion of Boehmitic Bauxites: Problems, Challenges and Opportunities

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Abstract



This paper reviews selected aspects of high temperature bauxite digestion (HT > 250 °C). HT digestion is usually carried out owing to the presence of significant amounts of boehmite or diaspore (> 5 % Al₂O₃). Gibbsite is almost completely dissolved during digestion, and HT Digestion further removes the majority of the boehmite, with ultrafine natural boehmite particles (< 2 micron) dissolving first. If not removed these fine particles will act as seed surface area and promote auto-precipitation. Hot, high ratio (A/C) liquor in digesters, flash tanks and in thickeners can create the perfect conditions for boehmite seeding and growth. Coarse natural boehmite particles (> 10 microns) will constitute a lower exposed surface area and are unlikely to act as seed. Incomplete removal of boehmite will lead to an increase in g/L solids, and in-turn will increase the solids load to thickeners and washers. Over charging the bauxite to digestion would have a similar impact. Auto-precipitation will lead to a reduced extraction, and higher A/C targets (> 0.70) will become more difficult to achieve with boehmite precipitation occurring faster than boehmite dissolution. For some bauxites a higher activity in the mud fraction may impact on the performance of security filtration. To minimise alumina losses the target liquor ratios may need to be lowered to prevent: auto-precipitation, reduced filter performance, and white side scale losses. In the treatment of boehmitic bauxites to achieve high target ratios, ideally requires: 1) fine milled bauxite, 2) optimal bauxite charge, 3) short residence times in digestion, 4) rapid settling in thickeners and washers, and 5) addition of liquor stabilizers to minimise any security filtration related issues. Alternatively, the sweetening process can be implemented and is guaranteed to raise the A/C ratio of the final liquor. High alumina extractions are achieved during the primary digestion event. The second stage injection of bauxite raises the A/C ratio and lowers the “free” caustic concentration and the iron-content of the liquor.

Keywords: Boehmite, Sweetening, Digestion, Auto-precipitation, Scale.

1. Introduction

Gibbsite dissolves rapidly at low temperatures. However, when bauxites contain boehmite or diaspore the digestion behavior is thermodynamically and kinetically very different, and requires elevated digestion temperatures (>250°C) and caustic concentrations to deliver an appropriate A/C ratio. Incomplete digestion, with boehmite losses to the residue of > 5 mass% Al₂O₃, would be significant, unless bauxite costs are exceptionally low. The extra costs associated with mining, transportation, milling, digestion, clarification and mud disposal often justify the extra Al₂O₃ recovery.

The feed to the Ma'aden refinery contains > 25 % boehmitic alumina and has HT extractable alumina concentrations ranging from 40 to 55 %. The boehmite is generally coarse grained,

whereas other bauxites such as in Weipa and Guinea are very different in that they are likely to contain considerable amounts of ultrafine boehmite within a gibbsitic matrix [1].

2. Bauxite Particle Size

The simple shrinking core particle model [2] infers that the particle size of bauxite is important for rapidly achieving a higher A/C ratio. This is important when considering kinetic and thermodynamic aspects of boehmite and diaspore digestion. The gibbsite and boehmite solubility curves (Table 1) suggest that if alumina particles are infinitely small (< 1 micron) and in equilibrium with the liquor, the solubility trajectory will follow the solubility curve with increasing digestion temperatures. However, as the A/C ratio increases the kinetics of particle dissolution will decrease owing to a lowering in Free Caustic (FC) and the start of boehmite precipitation. For coarser particles (> 10 microns) at increased A/C ratio there will be slower dissolution, also boehmite dissolution will start competing with boehmite precipitation at the higher A/C ratios. The boehmite solubility curve at higher ratios and at high temperatures (> 270 °C) begins to plateau and becomes more uncertain mainly because the boehmite cannot equilibrate fast enough with the liquor phase. Longer holding times may promote a higher rate of boehmite growth, and remove increased alumina concentrations from the liquor.

Tube digesters are designed for high digestion temperatures and short residence times. One of the advantages of a tube reactor is that the slurry undergoes turbulent “plug-flow” as the slurry moves through the tube circuit. In a unit slurry volume, the coarse and fine particles will both have the same residence time. This overcomes some of the issues related to differences in particle residence times as experienced in agitated tank digesters. Such a short residence time and plug flow may also prevent boehmite nucleation and growth. The liquor volumes, as they flow in the pipes, are kept separate and there is no chance of mixing with older liquor slurry volumes which may be enriched in boehmite seed.

Improved comminution practice is recommended to reduce the average particle size of bauxite. Sand size particles (> 150 µm) are most likely to be the slowest to dissolve and most likely to be the cause of any boehmite losses. The treatment of a finer sized bauxite should dissolve more completely and help reduce bauxite usage and help achieve an appropriate A/C ratio.

3. Liquor Stability

High liquor A/C ratios can lead to gibbsite or boehmite scale formation and promote auto-precipitation. Seeds of growing boehmite in hot saturated slurry or liquor contribute towards the removal of alumina from the liquor phase. This growth is most apparent during flashing of hot slurries. The resulting alumina then reports to the mud, which is then lost. High g/L solids in the slurry will promote boehmite growth and prevent achieving theoretical target ratios. Goethite in the mud has a significantly lower activity than boehmite, however it can be present in bauxite in higher concentrations and promote auto-precipitation and lead to increased alumina losses and bauxite usage. Even trace quantities of ultrafine boehmite can dramatically enhance boehmite growth and remove alumina from liquor and increase the mud load. Lime addition to digestion may help stabilize the liquor and prevent boehmite growth during flashing. Likewise the addition of lime slurry to the thickener is often practiced to reduce liquor instability and prevent auto-precipitation.

The amount of boehmite precipitation is governed by the amount of seed and the residence time (=holding time) of the slurry at temperature. It is likely that it is the number of nuclei or the boehmite surface area that is more important than the actual boehmite content. For this reason, coarse boehmite particles (> 10µm) are likely to have a lesser impact on slurry stability. Bauxite samples from different geographic regions of a deposit can have highly variable behavior in digestion and this may be explained by changes in boehmite particle size and content.

If higher target ratios are not delivered this is a lost opportunity and will lead to a reduced overall plant performance. Helping deliver the optimal target requires 1/ Finer bauxite particle sizes, 2/ Shorter digestion times, 3/ Rapid settling, and 4/ Potential use of reagents for process control. Alternatively, sweetening can be used to deliver increased A/C ratios, with increases of up to 0.03 to 0.06 units, this would also reduce the FC and guarantee a significantly reduction in the Iron in product simultaneously.

9. References

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