Light Metals Research Centre (LMRC) - Alumina

Integrated Alumina Research

In 2009 more than forty million metric tons of aluminium metal was produced using the Hall-Heroult process. This requires almost 80MT of smelter grade alumina (SGA), most of which is produced by the Bayer process.

Alumina Production

In the Hall-Heroult process the main uses of SGA are summarised as follows:

- Primary feedstock
- Anode and cell cover material
- Scrubbing medium for the cleaning of HF from cell gases

The multiple roles of alumina in the smelter all require specific material properties. These properties are critical for an efficient smelter operation and a safe and desirable workplace. Maintaining product quality while increasing production volume has become a major challenge; this is fuelled by increasing demand and ever rising energy costs, which are felt by both aluminium and alumina producers. It is necessary to have a detailed understanding of the production chain from bauxite mining and dissolution, through to the settling, precipitation and calcination steps. It is also imperative to understand the connection between alumina properties and smelter performance, as well as identifying areas where direct energy savings, production gains, and product quality improvements can be achieved.

Alumina properties and performance

Aluminium smelters must meet stringent HF emission targets and environmental compliance. In many cases these targets are increasingly difficult to meet due to constraints in raw materials, production increases and technological limitations. Therefore, the key to improving smelter environmental performance is to understand HF generation and capture mechanisms to achieve best operational practice.

LMRC's research (using X-ray diffraction with Rietveld refinement, thermal analysis and in-situ monitoring of HF emissions from industrial and laboratory electrolysis cells) has revealed that residual hydroxyls, which are a part of the transition alumina structure, are the main source of HF generation in the electrolyte. The primary capture mechanism for HF emissions in an aluminium smelter is the dry scrubber, which uses alumina to capture volatile fluorides. Recent investigations indicate that effective utilisation of alumina in this process is not only related to the surface area available for the reactions, but also the accessibility to this surface (figure 1). Understanding how the surface area and other important properties develop during the calcination process can be used to fine-tune the calciners, and improve the alumina quality as well as optimise dry-scrubber performance (figure 2).

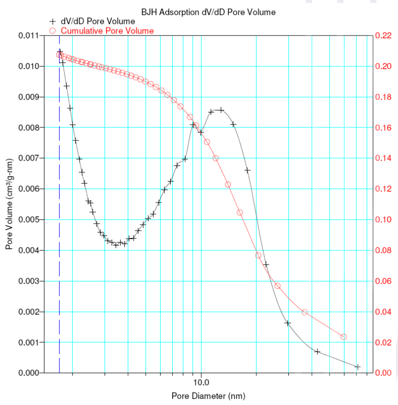

Figure 1. Alumina pore size distribution and cumulative pore volume plot for an alumina with under- and over-calcined components.

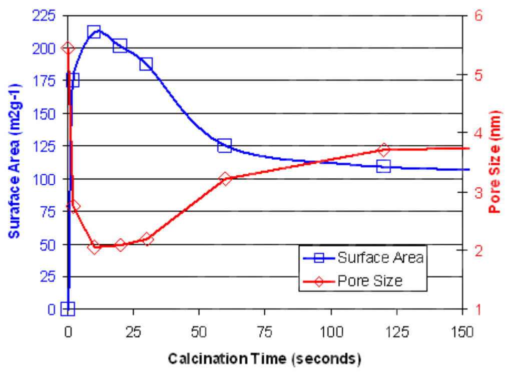

Figure 2 Development of porosity during the early stages of the gibbsite dehydroxylation reactions

Alumina fines is a widely recognised problem in aluminium smelting. However, few studies examine the link between the nature of the fines and the specific operational problems encountered. Similarly, in the alumina refinery, considerable effort goes into understanding the generation but not always the composition of the fines. Examining the fines separately requires little investment and has the potential to better predict the behaviour of a specific SGA and its associated operational response (figure 4).

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LMRC is leading advanced characterisation of alumina and its impact on smelter operations

Advanced characterisation techniques (figure 3, ESEM, XPS and ToF-SIMS) have been used to investigate gibbsite growth rings as well as alpha alumina and impurity distribution. The research indicates that the distribution of impurities is tied to the co-precipitation of certain species which also influences the particle morphology as well as cracking and attrition. The formation of a predominantly alpha alumina shell, observed in many rapid calcinations processes, may have performance consequences for scrubbing and dissolution behaviour when the alumina is used.

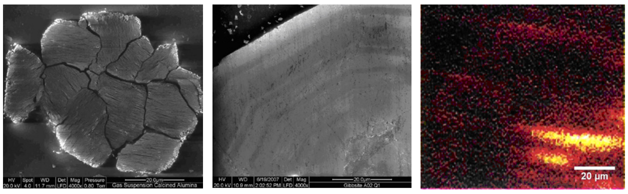

Figure 3 Alpha alumina observed around the edge of a cross sectioned alumina particle (left) and gibbsite growth rings (middle) as revealed by Environmental SEM and corresponding Na distribution (right) obtained using a ToF-SIMS instrument.

LMRC advocates a more integrated approach to alumina quality, which follows from an understanding of what is needed in the smelter and how the key properties are influenced by the refinery operations. A critical performance criterion for alumina is rapid dissolution in the molten cryolite based electrolyte. To achieve this, sufficient dissolution power (or superheat) is needed, but the quality (and properties) of the alumina are also important. In particular, the operational stability and feed strategy rely on a consistent alumina quality. Unfortunately, variations between, and even within alumina shipments are often observed. We are advancing the combined model approach, whereby the major relevant factors are included in a dissolution modelling equation. These models can be used for advanced control algorithms to monitor the feeding and dissolution performance in the pots. This will enable the specific diagnosis of feed related problems, and incorporate corrective / preventive actions before large scale sludge formation occurs.

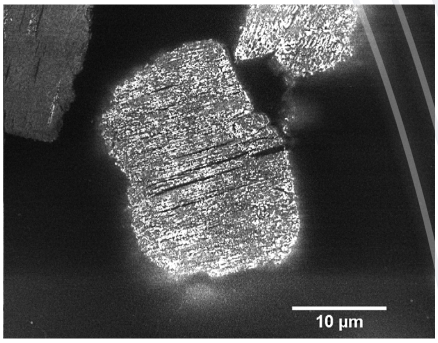

Figure 4 over calcined fines (enriched in poorly dissolvable alpha alumina) revealed by charge contrast differences in the Environmental SEM

LMRC focuses on environmental performance

Understanding how the alumina properties arise and what is required for optimum performance in the smelter, can be used either directly to improve the control of the dry-scrubbers and ensure effective removal of HF from the raw gas streams, or to optimise dissolution. This can be directly linked to seeding, precipitation and calcination strategies in the refinery.

About LMRC

LMRC delivers world-leading expertise in aluminium and magnesium smelting, light metal alloys and their applications, alumina refining and major smelter upgrades. It focuses on solving technical issues and developing new technologies and training that will deliver benefits directly to the bottom line. The team of more than 30 professional and doctoral researchers is led by Professor Mark Taylor, Associate Professor Margaret Hyland, Professor John Chen and Professor Jim Metson and is supported by a dozen contributing academics from The University of Auckland and other universities globally. LMRC is currently engaged in research projects for clients in Australia, China, Germany, Japan, Malaysia, Netherlands, Norway, North America, The Gulf States and New Zealand.

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