Light Metal Research Centre (LMRC) – Alumina

Integrated Alumina Research

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

Alumina Production

In the Hall-Heroult process the main uses of Smelter grade Alumina (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 entire production chain and 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 scrubbing 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 studyed the source of HF generation by using analytical tools as X-ray diffraction with Rietveld refinement, thermal analysis, and in-situ monitoring of HF emissions from industrial and laboratory electrolysis cells. We examined the alumina composition changes from the boat through all stages to the electrolytic pot. Our research revealed that residual hydroxyls, which are a part of the transition alumina structure, are the main source of HF generation in the electrolyte, and local humidity has a far more pronounced effect than previously expected in HF generation.

A dedicated lab was built with in-house designed rig for simulation of HF scrubbing. A methodology was developed to explore the effect of different parameters on the scrubbing process. These investigations into dry scrubber efficiency indicate that effective utilisation of alumina in dry scrubbers is not only related to the surface area available for the reactions, but also the accessibility to this surface (figure 1).

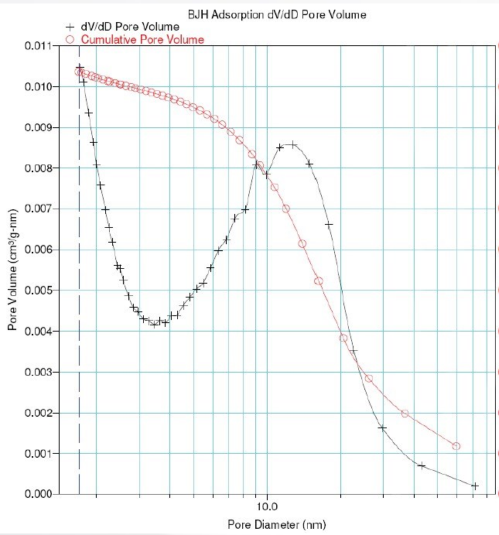

Figure 1: Alumina pore size distribution and cumulative pore volume plot for an alumina with under- and over-calcined components

The understanding of surface area and other important properties that changing during the calcination process offer our researchers ways to fine-tune the calciners, and improve the alumina quality as well as optimise dry-scrubber performance (figure 2).

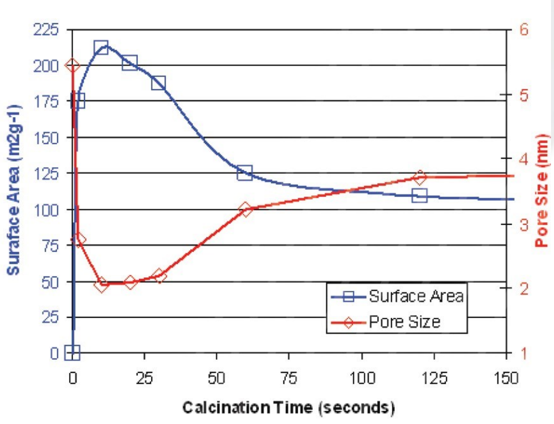

Figure 2: Development of porosity during the early stages of the gibbsite dehydroxylation reactions .

Another key problem in aluminium smelting is generation of fines, which affect the reduction process in negative ways. A new research in LMRC is focused on alumina strength as it the root cause of fines generation. LMRC are trying to fill the gaps in the fundamental knowledge on alumina strength and how strength evolves during calcination.

Special analytical tools as ESEM, ToF-SIMS are used In order to investigate the composition of fines and gibbsite growth rings (Figure 3) as well as impurity distribution.

Our research indicates that the distribution of impurities is tied to the co-precipitation of certain species (as alpha alumina) which also influences the particle morphology as well as cracking and attrition. The formation of a predominantly alpha alumina crystals observed in many rapid calcinations processes, have performance consequences for scrubbing and dissolution behaviour when alpha-rich alumina is used.

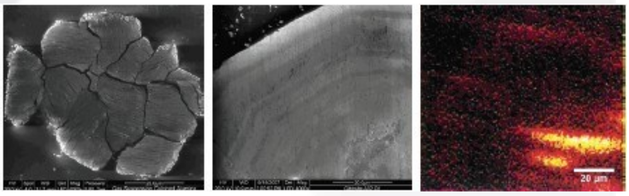

Figure 3: Alpha alumina observed around the edge of a cross sectioned alumina particle (left) and gibbsite growth rings (middle) as revealed by Environmental SEM and corresponding Na distribution (right) obtained using a ToF-SIMS instrument.

Integrated approach to alumina quality

LMRC advocate 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 without compromising the quality (and properties) of the alumina. 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.

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