

## Smelter Grade Alumina Properties - The Alumina Refinery Challenge

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### Abstract

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Alumina is the main raw material to produce aluminium. The quality of alumina depends on many factors such as the bauxite, the process design and the process operating conditions. Some quality parameters are more reliant to one or more of the forementioned factors than others. This overview should give a high level overview on the different factors to influence the alumina quality.

**Keywords:** Alumina quality

### 1. Introduction

Alumina quality is mainly impacted by:

- Bauxite source
- Process design
- Refinery operations and operational discipline, process parameters

Ideally the required alumina specification should be known before the bauxite is selected and the refinery is designed. Mostly the bauxite is a given, which already determines some of the quality parameters. A refinery is usually designed for a specific bauxite – but over time this bauxite can change as it is a natural material. Other bauxites could also be introduced.

Adjusting the process to influence alumina quality comes with either a big Capex requirement or a higher Opex and / or production impact as there is often a competition between quality requirement and production /costs. Quality also comes down to working out the business case to achieve certain parameters. Therefore, one should be clear, what is the benefit of achieving these desired parameters.

In alumina refineries there are two different categories of quality parameters: Chemical impurities and physical properties. The main chemical impurities/properties are iron ( $\text{Fe}_2\text{O}_3$ ), silica ( $\text{SiO}_2$ ), calcium ( $\text{CaO}$ ), soda ( $\text{Na}_2\text{O}$ ), Phosphorous ( $\text{P}_2\text{O}_5$ ) and traces of many others e. g. gallium ( $\text{Ga}_2\text{O}_3$ ) or zinc ( $\text{ZnO}$ ), titanium ( $\text{TiO}_2$ ), alpha alumina/ LOI.

The main physical properties are the particle size (<45micron, <20micron), BET (surface area), Attrition Index, flowability, angle of repose etc.

The quality parameters are influenced in different areas of the process. The table below shows a high level summary of, where the main areas are, in which the quality can be affected. This is meant to be a deeply technical table, but provide an indication, what a refinery can do to control the quality. The number of dots indicate how strong the influence is (three strong dots mean a strong influence).

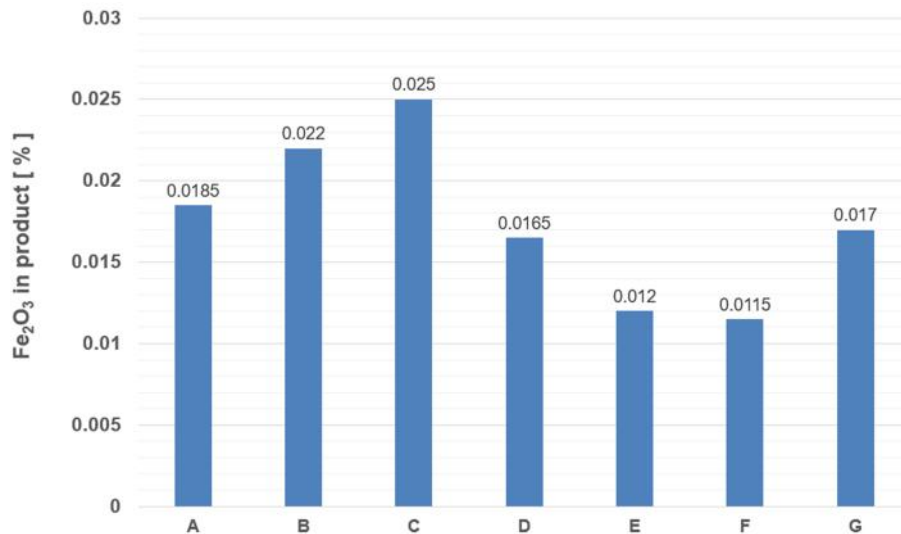
One example of how design and process condition can impact the quality is shown in Figure 1, which displays the  $\text{Fe}_2\text{O}_3$  levels of various aluminas coming from different refineries using the same bauxite source.

**Table 1. Quality parameters and its origin.**

Quality parameter	Mainly influenced by			Where impacted	Process control lever
	Bauxite	Design *	Process		
Fe <sub>2</sub> O <sub>3</sub>	●●●	●●	●	Digestion, security filtration	Lime addition, digestion conditions temperature, free caustic, holding time..
SiO <sub>2</sub>	●	●●	●	Digestion	Pre-desilication
CaO	●	●	●●	Security filtration, liquor chemistry	Operational discipline
Na <sub>2</sub> O	●	●●●	●●	Precipitation/ product filtration	Temperature in precipitation; Product wash
P <sub>2</sub> O <sub>5</sub> , V <sub>2</sub> O <sub>5</sub>	●	●●●	●●	Digestion	Lime addition
Ga <sub>2</sub> O <sub>3</sub>	●●	**	●	Digestion/ Precipitation	Temperature in precipitation
Particle size/ Attrition Index		●●●	●●	Precipitation Calcination	Agglomeration/nucleation/ classification
BET/Alpha/LOI			●●●	Calcination	Furnace temperature / bypass

\*The bauxite determines the design operating digestion temperature, and hence, some impurities such as Fe<sub>2</sub>O<sub>3</sub>.

\*\* Unless Gallium plant.



**Figure 1. Fe<sub>2</sub>O<sub>3</sub> from various refineries using the same bauxite source.**

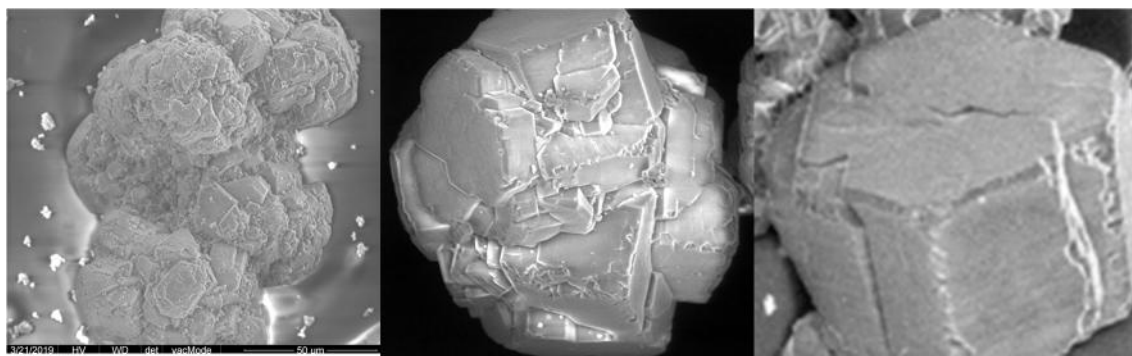
The difference can be quite large. The spread is up to 100 %. Refineries with high temperature digestion, sweetening and high yield produce alumina with low Fe<sub>2</sub>O<sub>3</sub> content. Scalping and lime addition support Fe<sub>2</sub>O<sub>3</sub> reduction as well. However, these features need to be designed into the plant from the very beginning.

## 2. Bauxite

Bauxite is a natural raw material and therefore tends to vary over time. The business case of a refinery is usually done by using a representative sample, but this does not reflect the dynamic behaviour over time of the refinery life, when the bauxite is delivered and thus on alumina quality.

This leads to the question, whether the attrition index is a good metric to predict the impact on the smelter in the potroom. Because also the morphology of a particle, that has “survived” the mechanical stress in a calciner, can lead to different forms of debris once it leaves the gas treatment centres of the smelter. A particle that consists of many small particles (very mosaic) and has a low attrition index can demonstrate a different (and maybe worse) behaviour in the materials handling system and the subsequent pots of the smelter after it has been smashed up in the gas treatment than a blocky particle with a higher attrition index.

Figure 2 shows different morphologies of particles. The particles stem from different refineries and demonstrate how variable the internal structure of hydrate and alumina can be depending on the precipitation circuit design and its operation.



**Figure 2. Different morphologies of particles.**

The equipment and total percentage of classified material in the circuit as well as the agglomeration set up and interstage cooling is quite determining on how the particle structure can be formed. The presence of oxalate and organics play another role in precipitation levers as they impact on precipitation temperatures and thus yield and supersaturation. This leads to different mechanisms of how a particle can crystallize which result in different particle strength and impurity incorporation such as soda.

Physical properties are managed in the refinery. BET, LOI in the calciner by different furnace temperature. As stated above the bauxite source can play a role here, too, as organics can make the life quite difficult in the precipitation circuit. This is true specifically as particle size is in direct competition with yield/productivity and hence, production.

However, even though it is not possible to undertake big step changes in the quality parameters without major Capex or Opex requirement, the refinery has one good lever to contribute to quality – keep the process and its parameters as constant as possible in order to provide the alumina of as consistent quality as possible.

## 5. Conclusion

Once the bauxite source is selected and the refinery is designed the alumina quality is fixed. The alumina refinery can adjust alumina quality only in certain boundaries, but this will always come at a cost (either Capex or Opex or both) or loss of productivity. Therefore, a holistic approach should be applied across the entire value chain from bauxite via refinery and smelter to sales and marketing to work out the business case of modifying a quality parameter.