Study of Gibbsite Effect on HF Emission in Aluminium Reduction Cells

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Abstract

In addition to moisture, structural water, or more accurately structural hydroxyl (Gibbsite) that is available in smelter grade alumina (SGA) and aluminum fluoride contribute to HF generation in the electrolysis cell. The hydroxyl group dissolves in molten cryolitic electrolytes and produces HF by electrochemistry. About 70-75 % of the total F emissions from aluminum reduction cells are gaseous. Even if HF and fluoride particles that emerged from the cell are effectively caught in the dry scrubber, the portion not captured will be the main source of fluoride emission out of the potrooms. Fluctuation in HF evolution from a cell can alter cell bath chemistry and increase demand of aluminum fluoride, as well as contribute to fugitive emissions of fluoride.

At Sohar Aluminium, a method to analyze gibbsite content in the alumina was developed and validated. In this paper, the impact of gibbsite in typical SGA and aluminum fluoride was quantified and potential correlations with actual results verified. This study tries to explore and isolate the impact of % gibbsite in the process parameters like fluoride adsorbed in GTC (Gas Treatment Center) and eliminate % gibbsite contribution from aluminium fluoride as part of a full study of sources of HF emissions in cells.

Keywords: Aluminium reduction cells, Fluoride emissions, structural hydroxyl, Gibbsite in smelter grade alumina, Gas treatment center.

1. Introduction

The Sohar Aluminium (SA) plant is operating AP40 cells around 400 kA with a metal production of 395 000 tons per year, a carbon plant producing baked anodes and a cast house to cast the molten aluminium into ingots and sows. Some of the molten metal is delivered to downstream customers. In addition, SA has its own 1 000 MW power plant and a port terminal.

In the aluminium industry today, smelters must rely on more than one alumina supplier. The various alumina refineries have their own technology and unique processes to produce alumina. Refineries also use different bauxites and raw materials from sources around the world. This creates certain variations in the quality of smelter grade alumina (SGA) from the suppliers. It is not uncommon that smelters experience changes in the cells process conditions when there are changes in the alumina source or in the quality [1].

The Sunndal smelter of Norsk Hydro has reported on the problems they experienced with a different alumina quality. They experienced a loss in aluminium fluoride from the bath whereby bath chemistry changed and the cryolite ratio was affected.

It is generally assumed that HF is produced by the reaction of AlF_3 in the electrolyte or as a vapor with a source of H, as shown in Figure 1, as described by Equations 1 and 2.

$$2AlF_3\text{ (g or diss)} + 3H_2O(g) \leftrightarrow 6HF(g) + Al_2O_3\text{(s or diss)} \quad (1)$$

$$3NaAlF_4(g) + 3H_2O(g) \leftrightarrow 6HF(g) + Al_2O_3(s) + Na_3AlF_6(s) \quad (2)$$

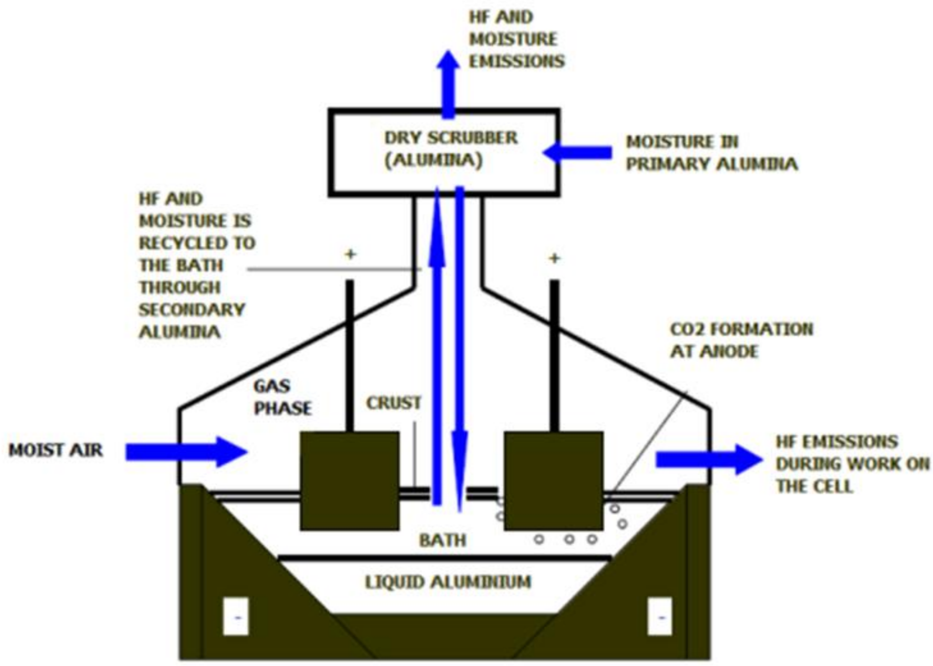

Figure 1. A principle drawing of the HF formation inside an electrolysis cell [8].

The source of H may be:
- Residual H in the anode
- Moisture in the air
- Water and hydroxyls in smelter grade alumina.

Quantification of duct HF levels in smelter studies showed that smelter grade alumina represents the largest single source of H for HF generation, Figure 2. Alumina has a strong affinity for water due to its polar surface. Moisture adsorbs on alumina in different ways [3]:
- Physisorbed water/physical adsorption of water
- Chemisorbed water
- Incorporated structural hydroxyl water in the crystal lattice.

The definition of physically adsorbed water is water that adsorbs to a surface due to relatively weak Lifschitz-van der Waals forces. This means that the water adsorbs on the surface of the molecule due to attractive interaction forces that arise from permanent and/or induced dipoles. These forces are relatively weak [4], and this type of water will mainly evaporate upon heating to 110 °C.

4. Discussion

According to this study, the average gaseous HF emissions from aluminum reduction cells constitute 72 % of the overall fluoride % in reacted GTC alumina over the course of nine-month period average. The actual influence of the gibbsite present in SGA to the HF emission is higher than the theoretical HF generation and this discovery provides a chance to study additional hydrogen entry to the melt by the chemisorption process between gibbsite and water molecules. The correlation between gibbsite % and AlF_3 kg/t of Al demand in cryolite melt with rate variation confirms that there is a contribution from the gibbsite concentration available in both SGA and aluminum fluoride. Revealed gibbsite% in aluminium fluoride allows to narrow down the product specification to one with the least amount of gibbsite concentration.

5. Conclusions

Gibbsite present in SGA and aluminium fluoride can have direct influence in the aluminum reduction process and emissions. The quantification of gibbsite in the materials should be considered in the procurement process and should be discussed for quality purposes. Highlighted here that the quantification process is relevant. This paper increases confidence in the measuring system and the desire to have outcomes for process data interpretation.

Monitoring the gibbsite phase in aluminium fluoride material assists in notifying the supplier to improve the calcination performance to prevent feeding extra hydrogen to the cell, which will play partial role to the HF emission from the melt and influence the AlF_3 demand variation.

6. References

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