Reduction of Specific AlF_3 Consumption in Hindalco Hirakud Smelter

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Abstract

Hirakud Smelter (HKD), a unit of Hindalco Industries Limited is a part of Aditya Birla Group (ABG). Hirakud Aluminium is an integrated aluminium smelting complex which uses GAMI Technology and is one of the oldest smelters in India, established in 1959. The potlines, converted from Søderberg to prebake in 2009, have inherent challenges in terms of technology and retrofitting the old pots to prebakes.

Aluminium production is a continuous process. Addition of aluminium fluoride is today a well-established practice in the operation of industrial aluminium electrolysis cells. The main purpose with this additive is the lowering of the melting point and its beneficial effect with respect to reducing the solubility of metallic aluminium in the electrolyte. The composition of the electrolyte changes continuously during electrolysis. In addition to alumina, which is consumed in the process, the concentration of excess AlF_3 also varies due to several reasons, the main one being reaction with soda (Na_2O) and moisture that enters the electrolyte:

$$3\ Na_2O + 4\ AlF_3 = 2\ Na_3AlF_6 + Al_2O_3 \quad (1)$$

$$2\ Na_3AlF_3 + 3\ H_2O = 6HF + Al_2O_3 + 6NaF \quad (2)$$

AlF_3 being very costly raw material, the smelters are trying to reduce specific AlF_3 consumptions to reduce the emissions and the cost of the metal. Hindalco Hirakud smelter being oldest smelters, many initiatives taken in last one year to reduce the specific AlF_3 consumptions. This paper describes the action taken by the smelter team to reduce the AlF3 consumptions.

Keywords: Aluminium reduction cell, AlF_3, Fume Treatment Plant (FTP).

1. Introduction

The aluminium smelting process at Hirakud Smelter involves the use of AlF_3 as a crucial additive to reduce liquidus temperature for the reduction of alumina to aluminium. Aluminium fluoride for commercial use in Aluminium smelters is typically manufactured by two processes. The “dry” process uses fluorspar as the source of fluoride. The “wet” process uses fluorosilicic acid as the fluoride source. Aluminium fluoride is used as a bath additive, to maintain a desired excess fluoride target in the bath [1-3]. The main purpose of this additive is the lowering of the liquidus temperature and its beneficial effect for reducing the solubility of metallic aluminium in the electrolyte. The composition of the electrolyte changes continuously during electrolysis. In addition to alumina, which is consumed in the process, the concentration of excess AlF_3 will also vary due to several reasons, the main reason being the reaction with soda and moisture that enter the bath with alumina, according to the Equations (1) and (2).

Evaporation of $NaAlF_4$ is another factor that affects the AlF_3 balance of the cells. The water in alumina reacts with the fluoride in the bath to form HF according to the Equation (3):

$$3H_2O + 2AlF_3 \rightarrow 6HF + Al_2O_3 \quad (3)$$

To compensate these losses and to maintain desired excess AlF_3 in pot bath, charging of aluminium fluoride is essential in pots. However, the high consumption of AlF_3 not only translates to increased operational costs but also has environmental implications. Being the oldest smelter and having technological constraints in Hirakud, this paper aims to explore and propose strategies for reducing the specific AlF_3 consumption in the smelting process at Hirakud Smelter while maintaining operational efficiency and productivity. To compete in the global market in terms of sustainability and higher productivity with quality, each smelter must work strongly on the probable factors which might have appeared as major setbacks in the future. Most modern smelters are adopting innovative approaches to have minimum losses in the potline and have a stable operation. Similarly, Hirakud Smelter also had to find ways to minimize losses, to improve efficiencies of fume treatment plants as well as potlines, to optimize process parameters and thereby reduction in aluminium fluoride consumption in the potline.

2. Brief Description of FTP

The function of FTP in a potline, is to extract fumes from the pots, extract and recycle HF, and release clean air into the atmosphere. Major components of the fumes are:

a. Fluoride (gaseous and particulate)
b. Particulate matter (alumina)
c. CO, CO_2 and SO_2.

As a part of the FTP design, before releasing into atmosphere, the fumes are scrubbed with alumina.

FTP consists of the following main subsystems:

a. Ducting network – To collect fumes for individual pot and taking them to the FTP baghouse.
b. Baghouse – To collect particulate matter across filter media. At this part, alumina interacts with fumes to get maximum adsorption and HF is trapped. Cleaning of filter media is done at regular frequency.
c. Induced draught (ID) fan system – to create negative suction in the entire system.

At Hirakud, there are five pot lines. Lines 1-4 are operated at 85 kA, and Line 5 at 235 kA. In 85 kA, there are three FTP's – FTP 1, 2 and 3 and in 235 kA potline – FTP 4. All the FTPs are catering the requirement of 12 potrooms.

3. Challenges Faced in FTP

FTP-1 system collects fume Line-1 and PR-8 pots. Ideal location of FTP should be between two adjacent pot rooms of a line, but in case of FTP-1 it is located after Room 4 of Line-1 as the Line-1 pots are converted from Søderberg to prebake. Total ducting length of FTP-1 is approximately 1 km with many bends. So, we were not able to collect all the fumes from pots due to large pressure drop across the double layered ducting system with numerous bends and damaged ducts in the ducting system; this was impacting FTP performance and less enrichment of FTP secondary

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10. References

1. Peter M. Entner, Control of AlF_3 concentration, *Light Metals* 1992, 369-374.
2. Peter M. Entner, Further development of the AlF_3- model, *Light Metals* 1993, 265-268.
3. K. R. Kloetstra, S. Benninghoff, M. A. Stam and B. W. Toebes, Optimisation of Aluminium Fluoride Control at Aluminium Delfzijl, *Proceedings of the 7th Australasian Aluminium Smelting Workshop*, 11-16 November 2001, 506-514.