Impact of Lithium Fluoride on Fluoride Evolution from Aluminium Electrolytic Cells in Maaden

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Abstract

The impact of lithium modified baths in electrolytic cells has been widely studied in the past, which provides a lot of guidance on the impact and extent in the electrolytic process. However, there is very limited information available from smelters operating with lithium fluoride in the bath at an amperage as high as 410 kA. Maaden is an integrated aluminium complex completely depending upon the alumina produced from its own bauxite supplied by mines located at Al-Baitha, Kingdom of Saudi Arabia. Bauxite in Maaden contains traces of lithium, which finds its way to the bath in the smelter through smelter grade alumina (SGA). The tendency of lithium to accumulate in the bath has been clearly witnessed with an increase in lithium fluoride content in the bath in the smelter. This paper is summarizing all the information available so far about the behavior of lithium modified baths on bath properties and fluoride emissions and describes our actual experience over ten years of gradual increase in LiF concentration and its impact on fluoride evolution from electrolytic cells and from Gas Treatment Centre (GTC) stacks as well.

Keywords: Aluminium electrolytic cells, Lithium fluoride (LiF), Fluoride evolution, Electrolyte.

1. Introduction

Maaden, The Saudi Arabian Mining Company is the largest fully integrated aluminium complex in Ras Al-Khair, Kingdom of Saudi Arabia, and consists of bauxite mines, an alumina refinery, an aluminium smelter and a rolling mill. The aluminium smelter commenced operation on 12 December 2012 with 720 AP37 technology reduction pots in two lines, operating at 370 kA. The potlines were upgraded with Alcoa center of excellence (ACE) 410 kA package from 2019 to increase amperage to 410 kA and gradually increasing the production to 805 kt Al/y.

Maaden Aluminum smelter was fully commissioned, and all 720 pots were in operation by July 2014 at an amperage of 370 kA, sourcing smelter grade alumina (SGA) from different locations worldwide, while the Maaden alumina refinery was still under commissioning phase. The production in the refinery started in January 2015 with calciner-1 and brought to full production by November 2016. The aluminum smelter was slowly transitioning from imported to Maaden alumina and from December 2016 Maaden became self-dependent for alumina requirement and thereby eliminating the imports.

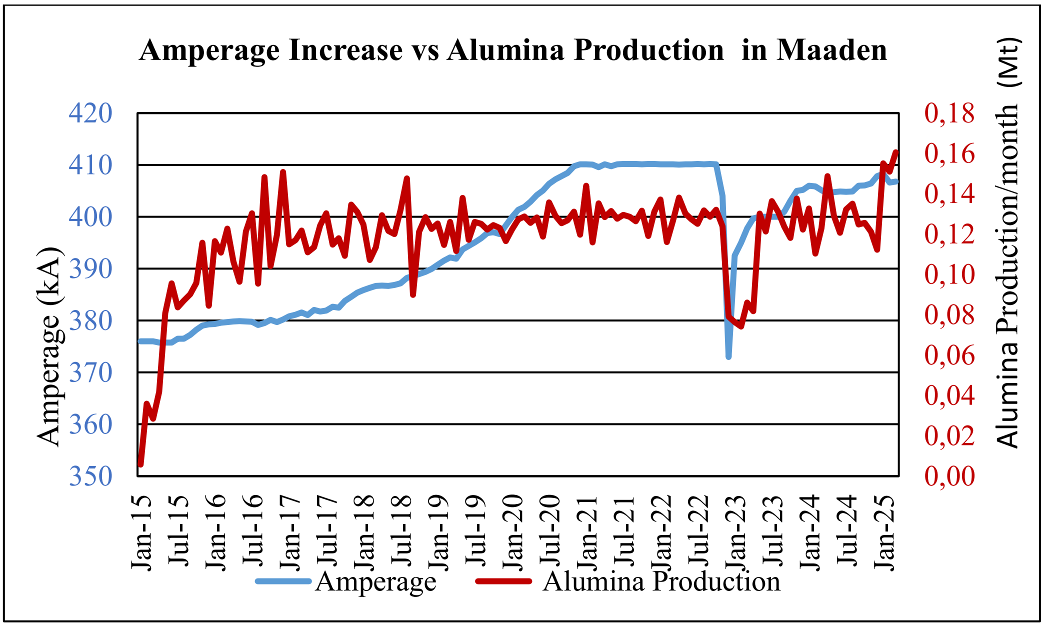

Figure 1. Increase in potline operating amperage and monthly alumina production.

2. Evolution of Bath Chemistry with Transition into Maaden SGA

The journey of increase in amperage and transition from imported to indigenous alumina were followed simultaneously. Figure 1 represents the increase in amperage in the smelter and increase in alumina production in the refinery together. Figure 2 represents the gradual change in ratio of Maaden alumina blended with imported aluminas as the production in the refinery was gradually increased.

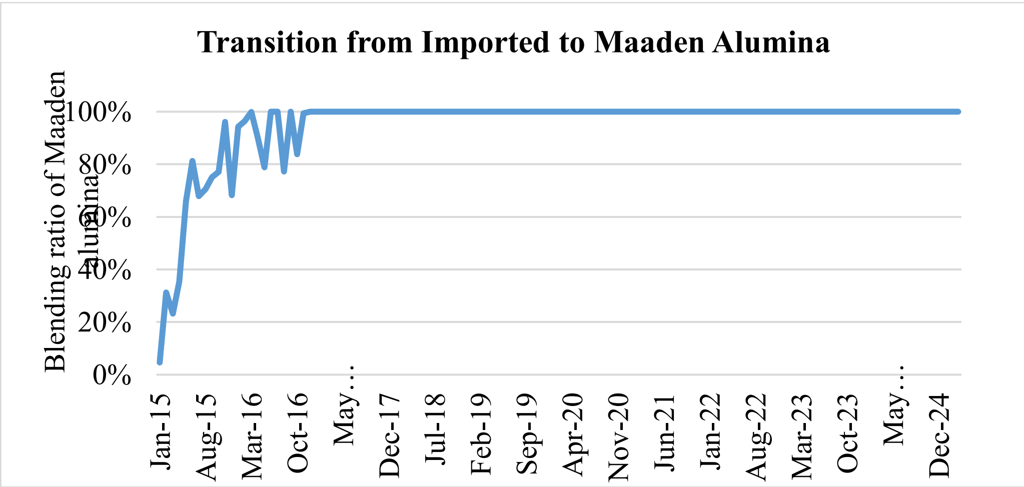

Figure 2. Transition from imported to Maaden alumina.

The bauxite for alumina refinery is sourced from Maaden Al-Baitha mines, which also contain traces of lithium in the form of lithium oxide (Li_2O). Lithium, as it enters the bath through calcined alumina, tends to accumulate in the bath unlike most other impurities, which get dissolved rapidly and ends up alloyed with the metal. Figure 3 shows the gradual increase of LiF concentration in the bath over the years since 2016. It increased to 3 % by April 2022 while the Li impurity in the metal gradually increased from 3 ppm in 2016 to 18 ppm in 2022. After that both values have decreased. The Li content in the metal shows good correlation with the content of LiF in the bath.

Figure 17. Corroded anode stubs before and after cleaning oxidized layer.

- The hardness of anode crusts increased with LiF concentration in the bath. The hard crusts are difficult to break through by hammers installed in primary bath removal system (PBRS) and increase the breakdown of hammer tool in the rodding shop.
- With the increase in bath density, AE frequency might increase above 2.8 % LiF concentration in the bath if target bath heights are not well maintained. However, with AE frequency ~0.12 per pot/day Maaden is still the second benchmark among all AP plants operating above 400 kA with better alumina feed management and liquid level controls in place.
- Since Li is an integral component of Maaden bauxite, and the smelter is fully reliant on Maaden Alumina, diluting LiF using imported alumina is a tedious exercise for the smelter. Low Na_2O content in alumina is another bottle neck to dilute the LiF.

6. Conclusion

Over a period of ten years, with the decrease in Na_2O content in alumina from ~4000 ppm to ~1800 ppm, decrease in pot operating temperatures from 963.5 °C to 960 °C, and gradual increase in LiF concentration in the bath to 2.1 %, Maaden experienced a reduction in fluoride evolution from the cells by 25 % (calculated value), reduction in fluoride concentration at GTC inlet by 35 % (measured value) and reduction in HF emission from GTCs by 50 % (measured value by online analyzers). As per the experience and with reference to the data presented here, it is recommended that the optimum LiF concentration in the bath should not exceed 2.0-2.5 % to ensure its benefits without compromising key operating indicators such as anode effect frequency, cathode resistance and specific energy consumption. The issue of increased lithium (Li) impurity in the metal has been effectively addressed by processing all crucibles through the TAC station, successfully maintaining Li levels in the metal below 7 ppm.

7. References

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