

AL39 - Management of Fluoride Emissions during Amperage Increase in Potlines

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Abstract

Management of fluoride emissions has always been a challenge during amperage increase in any smelter. In general fluoride emission increases with increase in potline current. This adds up to challenges posed in terms of ecological balance and carbon footprints which is already a chronic problem for aluminium business around the world. Ma'aden Aluminium increased its amperage from 370 kA to 410 kA over a span of 5 years. During these years, the potline process has evolved over various phases of different parameters changes to align with higher amperage. This paper intends to share our experience on the impact on fluoride emissions at GTCs and scrubbing efficiency of GTCs before and after the amperage increase.

Keywords: Fluoride emissions, Scrubbing efficiency, Gas temperature, Amperage increase, Online analyzers.

1. Introduction

The Ma'aden Aluminium smelter is provided with 4 gas treatment centers (GTCs) supplied by Fives Solios. Each GTC is connected to 180 pots collecting hot gases and supplying reacted alumina to the associated pots. Like all other aluminium smelters around the world, Ma'aden Aluminium operates under strict limits of fluoride emissions that are regulated by the Royal Commission of Saudi Arabia. Ma'aden Aluminium aspired to increase its production capacity by increasing its operating current in both potlines which is a common practice among the aluminium smelters. Over the years the line current in the potlines has been increased gradually from 370 kA to 410 kA, which was achieved in December 2020. In the journey to increase line current, the process has experienced several changes and adopted accordingly to meet the production and efficiency targets.

2. HF Emissions at Different Ambient Conditions

In Figure 1, there is an historical trend of increase in potline current in Maaden Aluminium since January of 2016. With the increase in potline operating current by 40 kA usually there is an increase in gas temperatures as well as an increase in fluoride concentrations at GTC inlet. Figure 2 shows the historical trend of Ambient temperatures and Fume temperatures recorded at the GTC inlet together with HF emissions recorded in the stack by online analyzers. Looking at the data, which is average of four GTCs, there are no significant changes in gas temperatures recorded at the inlet of GTC during or after the increase in line amperage. However, there is observed a very gradual reduction in average HF emissions (in secondary axis) recorded at stack by online analyzers.

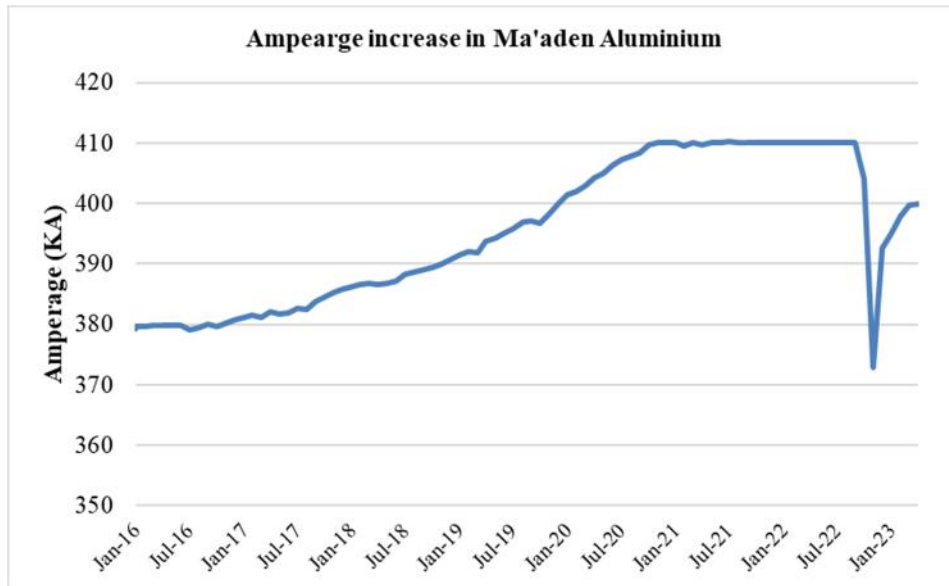


Figure 1. Increase in potline operating current.

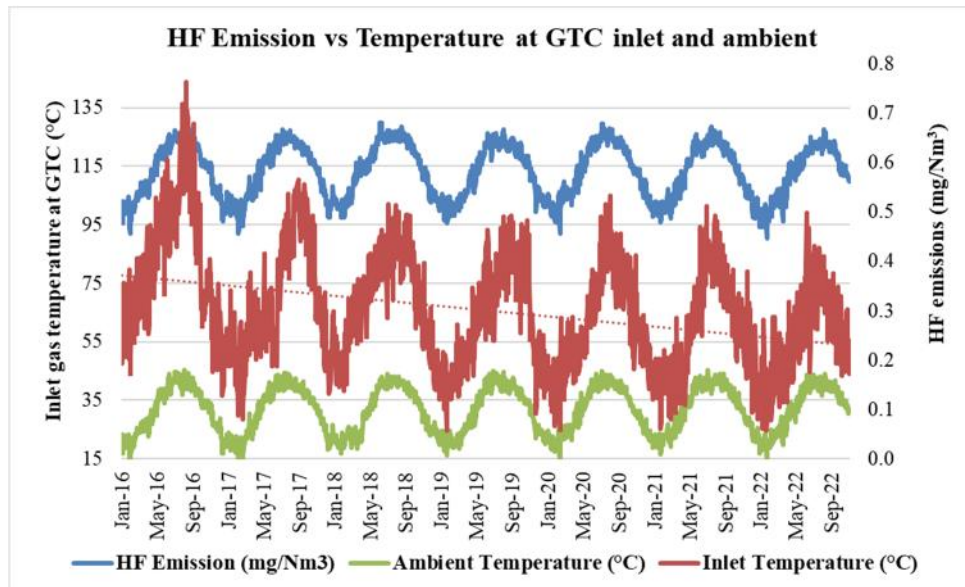


Figure 2. The scrubbing efficiency of GTC with temperature.

Going forward we will discuss the behavior of GTC scrubbing efficiency at different gas temperatures at the GTC inlet and will analyze the behavior separately under different weather conditions as well.

The relation between fluoride emissions and gas temperatures was established long back and published in various journals earlier. Here we intend to interpolate our own data to complement those findings with reference to Figure 3 [1]. Figure 4 shows the variation of HF emissions with respect to gas temperatures at GTC inlet across the year where the gas temperature varies from 90 to 130 °C while the HF emission varies from 0.1 to 0.6 mg/Nm³ throughout the year. Further, the data was split in two different ambient temperature zones of the year when the weather is hot during April to September and when the weather is cold from October to March which is more relevant to identical weather conditions shared by middle eastern countries like Saudi Arabia, Oman, Bahrain, Qatar, UAE etc.

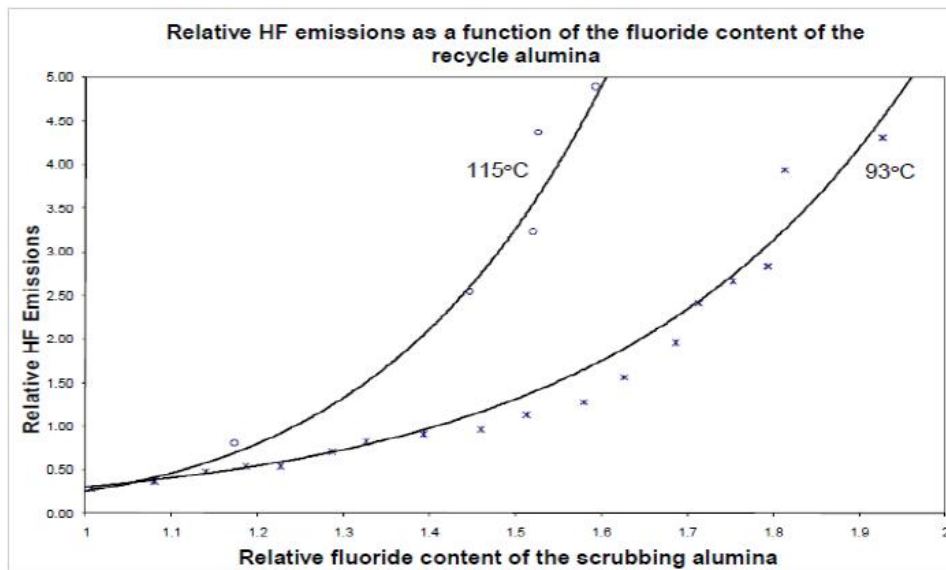


Figure 3. Relationship between HF emission and gas temperature [1].

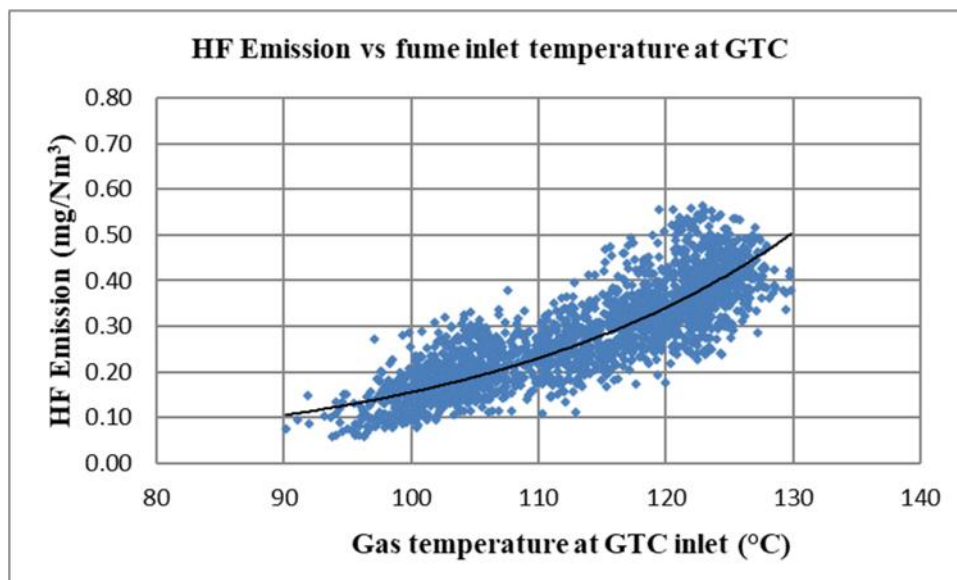


Figure 4. Relationship between HF emission and gas temperature observed in the Ma'aden GTCs.

Figure 5 shows the variation of HF emissions during colder ambient temperatures where the ventilation gas temperature varies from 90 to 120°C while the HF emission varies from 0.1 to 0.45 mg/Nm³. Figure 6 shows the variation of HF emissions during hot ambient temperatures when the ventilation gas temperature varies from 105 to 130 °C while the HF emission varies from 0.3 to 0.65 mg/Nm³. The data used to plot the chart is an average from 4 GTCs collectively over a period of 6 years.

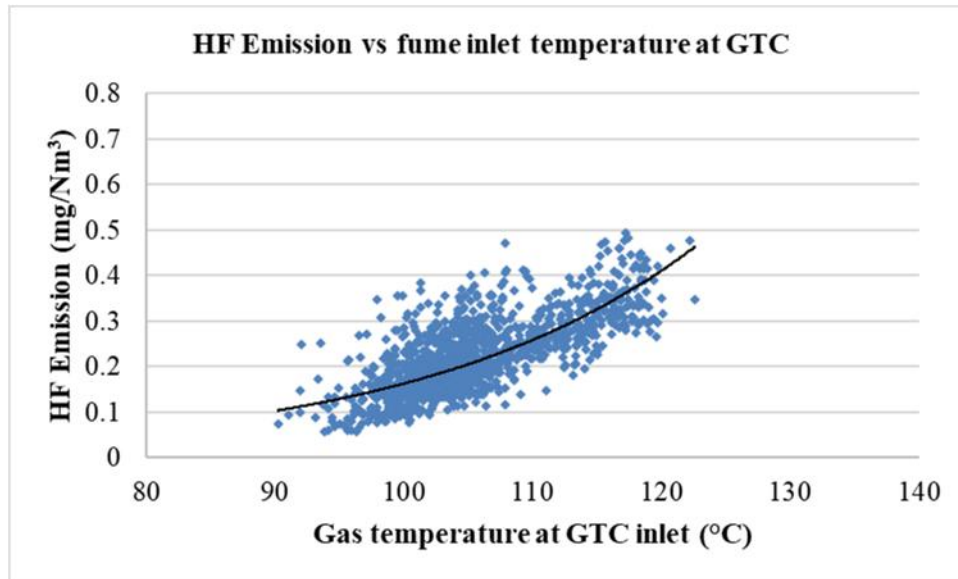


Figure 5. Relationship between HF emission and gas temperature observed in winter season. (October to March).

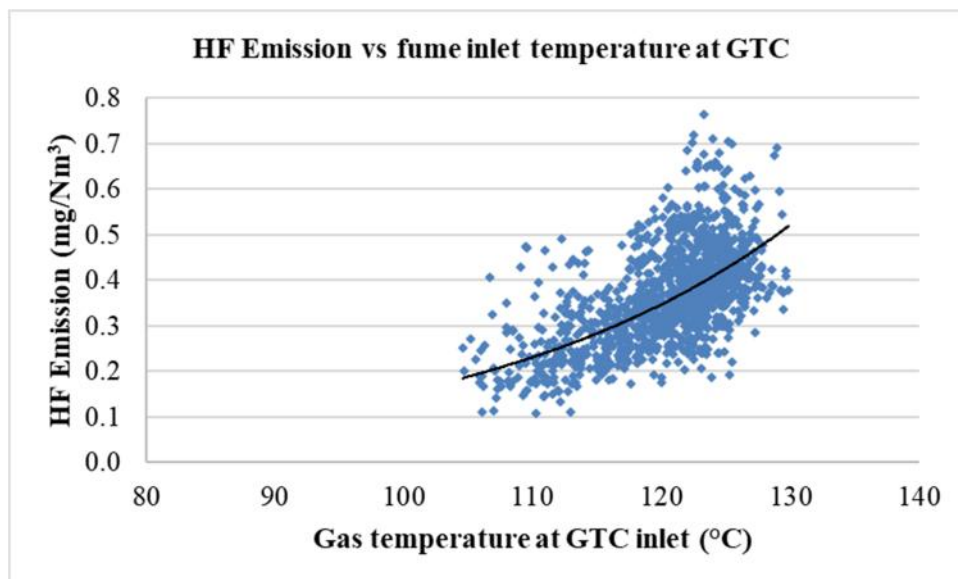


Figure 6. Relationship between HF emission and gas temperature observed in summer season (April to September).

Also, we analyzed the rate of HF emissions over a period of 24 hours during planned stoppages in fresh alumina feed to GTC in both ambient conditions.

Figure 7 shows the HF emissions during colder ambient temperatures when there is a stoppage of fresh alumina feed rate to GTC during descaling activity on airlift pipes. The peak emission of 2.2 mg/Nm³ was recorded during stoppage of 385 min in the month of December.

Figure 8 shows the HF emissions during colder ambient temperatures when there is a stoppage of fresh alumina feed rate to GTC during descaling activity on airlift pipes. The peak emissions of 8.5 mg/Nm³ was recorded during stoppage of 400 min in the month of August. In summer, the rate of increase in fluoride emissions is considerably higher than in winter season.

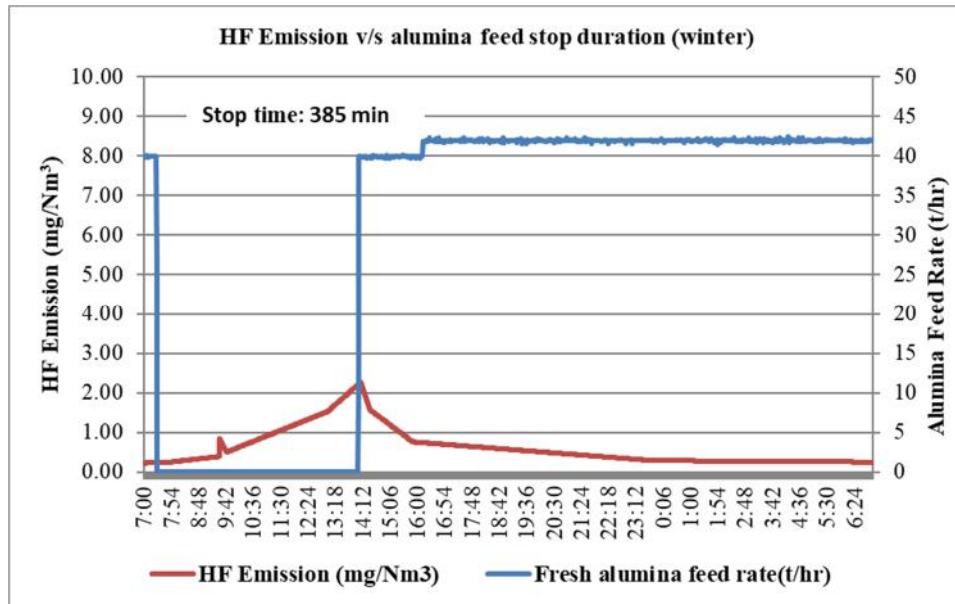


Figure 7. Rate of increase in HF in winter season.

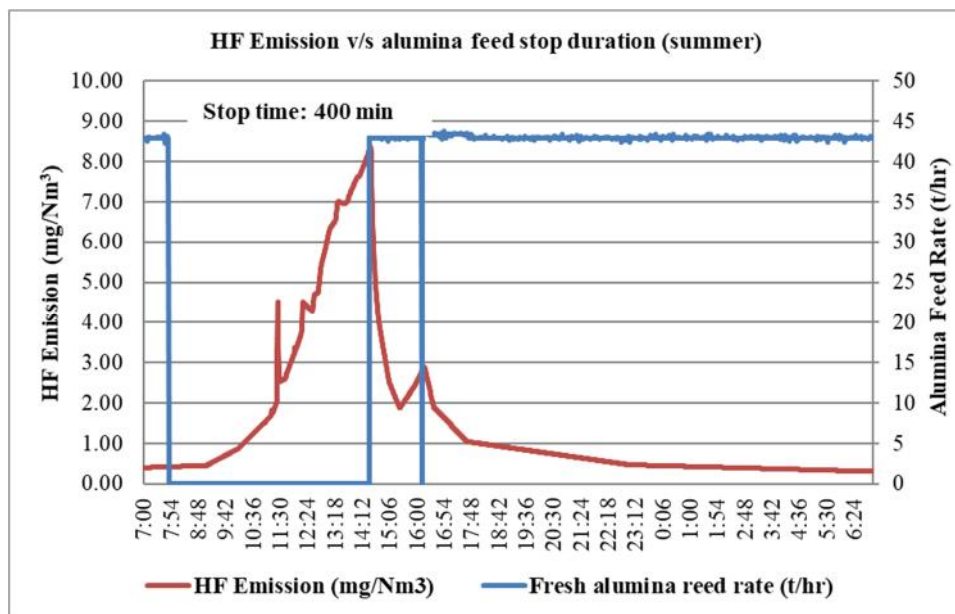


Figure 8. Rate of increase in HF in summer season.

3. Scrubbing Efficiency in GTC

It is very clear from Figure 2 that despite amperage increasing by 40 kA there was no significant increase in HF emissions on the contrary there is gradual decrease in HF emissions. Overall fluoride emission is in decreasing trend consistently. But at the same time, we experienced a gradual drop in percentage of fluoride captured in reacted alumina from the GTC which is rather unexpected. In Figure 9, the percentage of fluoride captured in reacted alumina is plotted against the HF emissions over a period of 7 years. Both the values are the average from all four GTCs and all of them share the identical trend. Also, as shown in Figure 10, there was no increase in specific consumption of aluminium fluoride, which eliminates any doubts on fluoride losses caused by deteriorated suction efficiency or scrubbing efficiency of GTC or poor hooding practices in potline. The specific consumption of aluminium fluoride dropped gradually from appx. 12 kg/t Al to 8 kg/t Al from 2016 to 2022 and then stabilized there.

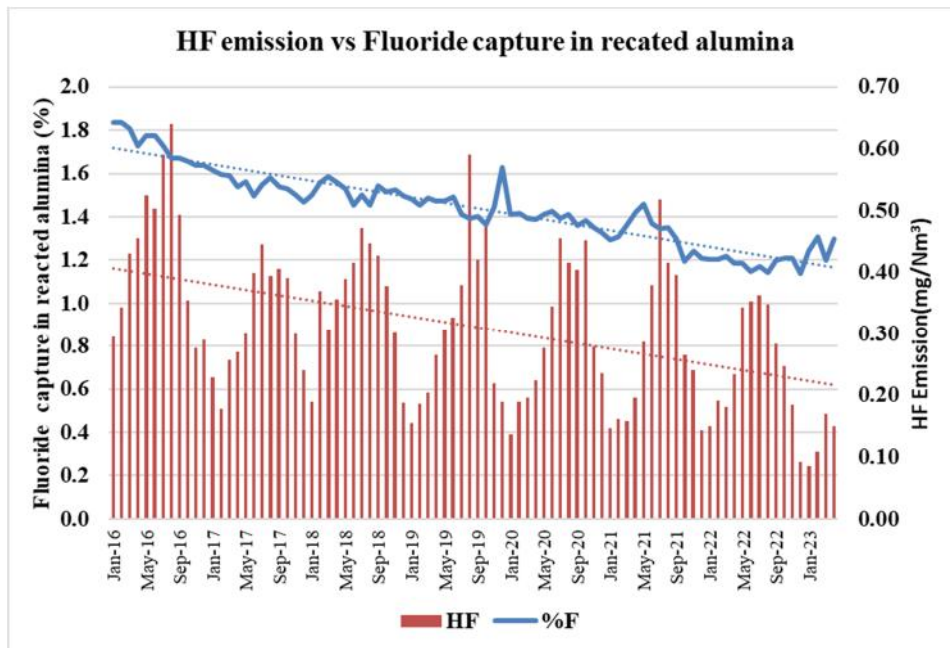


Figure 9. Fluoride emission at GTC stacks with respect to fluoride capture in reacted alumina.

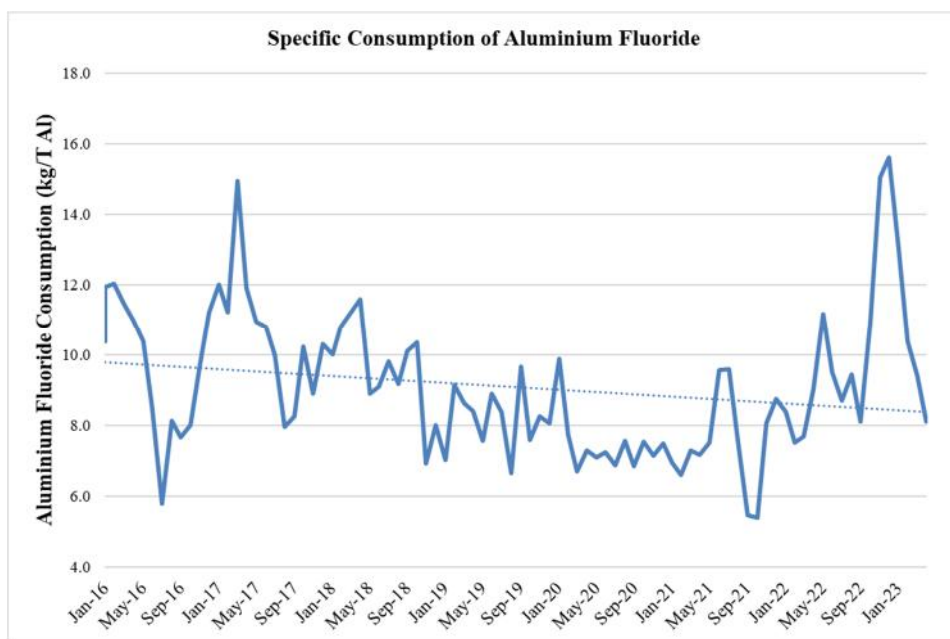


Figure 10. Reduction in the specific consumption of aluminium fluoride.

Figure 11 shows the trend of metal height and bath height set points corresponding to amperage increase over a period of 7 years. While the metal height target was increased from 16.5 cm to 21.5 cm, Bath height target was reduced from 18 cm to 16 cm. Overall 3 cm of total liquid level was increased inside the pots with amperage increase. In Figure-12, the trend of Bath temperature (primary axis) is plotted against the % F captured in reacted alumina (secondary axis). Both go hand in hand in the same downward trend steadily.

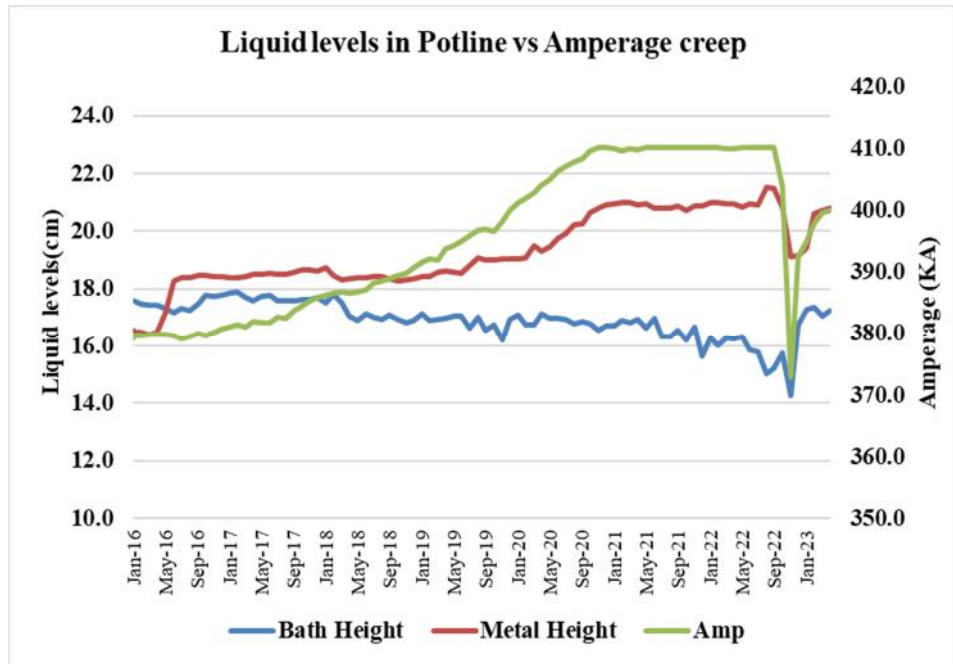


Figure 11. Adjustments in liquid levels in potline corresponding to amperage increase.

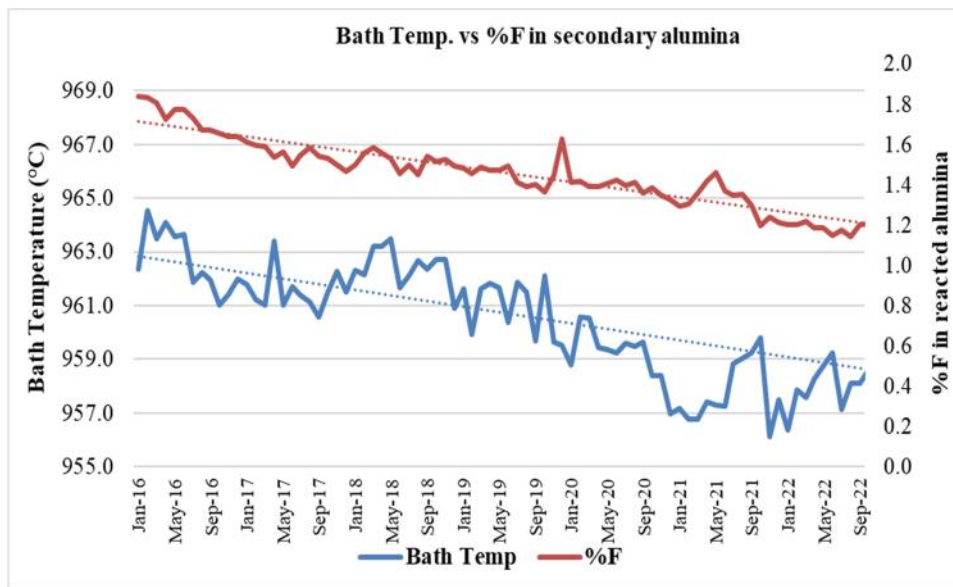


Figure 12. Bath Temp vs % F capture in reacted alumina.

4. Improvement in Fluoride Emissions in GTC

The GTC in Ma’aden Aluminium consist of 18 filters and each filter is provided with an individual online HF analyzer, gas flow transmitter and differential pressure transmitter which altogether provides timely feedback to control room operators to take immediate action in case of any deviation from normal operating parameters. These features have been of great help to bring the stack emissions drastically down year on year basis. Though summer seasons have still been challenging for obvious reasons which were mentioned in the beginning of the paper.

Figure 13 is the HMI view of filters in GTC. Starting from top to bottom, the parameters available online for each filter are gas flow rate, filter outlet damper opening, differential pressure across the filter and HF emission. The online availability of these key parameters keeps the operation

team on their toes to address any abnormality flashed on filter parameters to take corrective actions.



Figure 13. An HMI view of filter parameter in GTC.

Aside from the available tools, it is imperative to mention several improvements made in operational practices which have helped us to bring down the fluoride emissions.

- ✓ Increasing the frequency of hydro jet descaling of airlift pipes and advance cleaning in summer season has eliminated unplanned shutdowns caused by high pressure in airlift pipes.
- ✓ Scheduled cleaning of the alumina distribution box in a GTC. This prevents any foreign material from passing through the air slides and create blockages. This significantly helped to bring down the unplanned shutdowns of fresh alumina feed in GTC.
- ✓ Cleaning siphon pots reacted to alumina discharge from filters to eliminate scale buildup and obstruct flow.

All the above activities are very basic operational practices in GTC but sometimes doing the basics right is what makes the big difference.

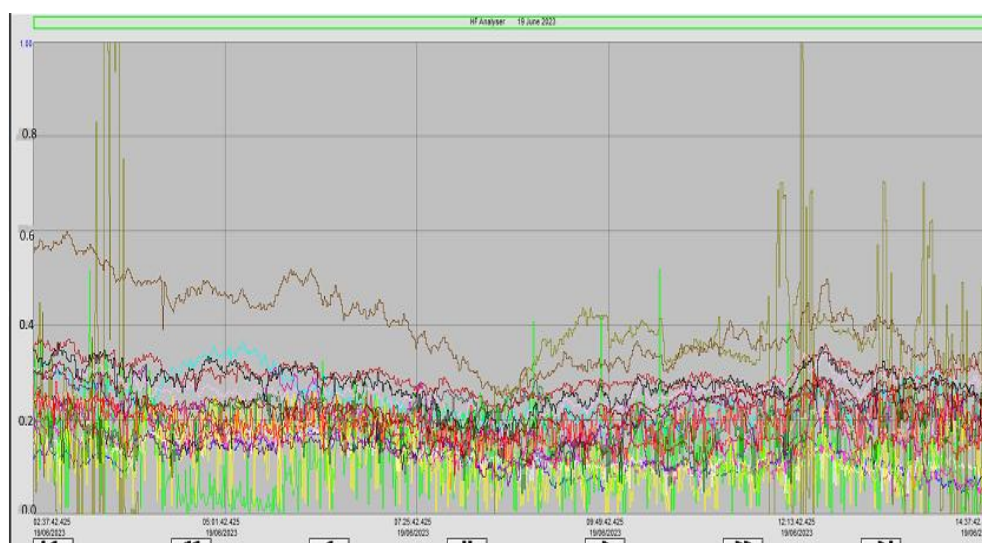


Figure 14. An HMI view HF emissions trend for 18 filters.

5. Roof Emissions Monitoring in Potline

The subject will remain incomplete if we close without analyzing roof emissions. In Ma'aden Aluminium, one online gaseous fluoride analyzer is installed in each half of a potline covering 90 pots and eight analyzers installed in total. The online analyzers have been a great help to gather data and understand the intensity of roof emissions during different activities in potroom. The data collected from roof analyzers in Potroom C over a period of 32 hours are shared in Figure 15. As expected, the highest roof emissions of approximately 1.0 mg/Nm³ are recorded during an anode change. Even higher emissions up to 2.0 mg/Nm³ are recorded in the areas where pots are located that are in startup mode.

In Figure 16, the data from all eight roof analyzers are collected over a period of six months to determine the contribution of each operational activity on roof gaseous fluoride emissions. As expected, the contribution of anode change has been the highest ranging 45-47 % of total roof emissions followed by tapping from 25-32 % and miscellaneous (measurement + anode redressing) from 21-30 %.

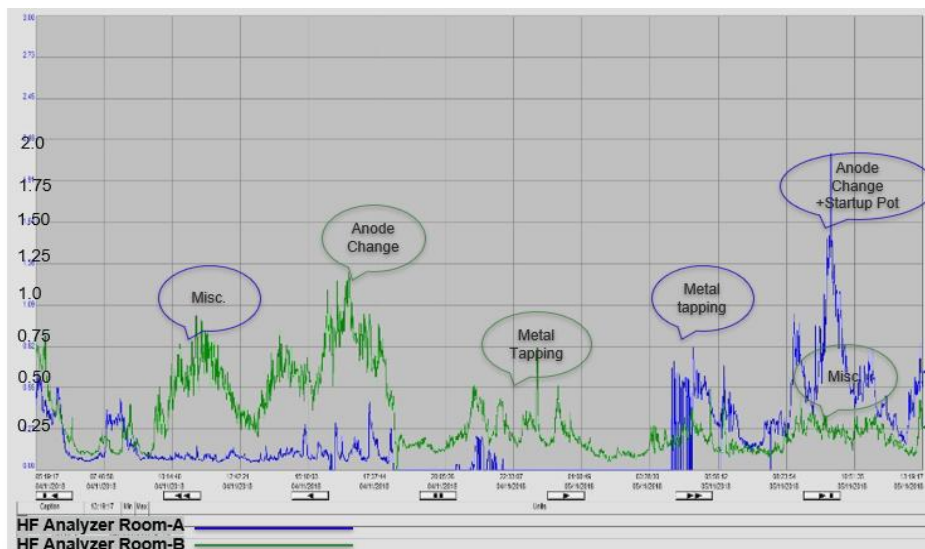


Figure 15. Roof emissions pattern through online HF analyzer.

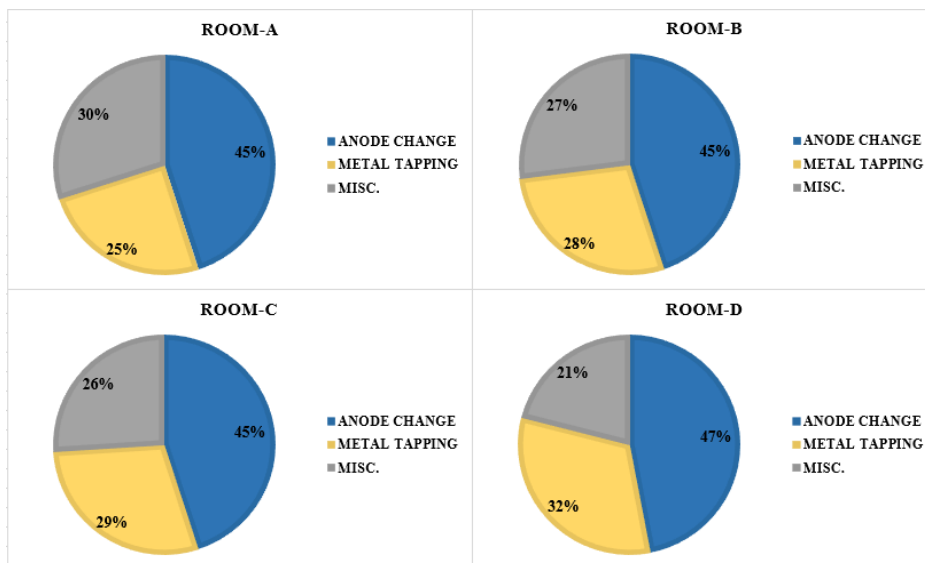


Figure 16. Contributions of different activities in potline to roof emission.

6. Conclusion

The journey of amperage increase along with all the challenges has brought us immense learnings. Though the concept is not new, every journey is unique and brings around loads of experience. Though we have managed to maintain and reduce our stack emissions, the roof emissions remain a challenge and there is a long way to go to meet the benchmark. Going forth we strive to meet our goals aligned to commitments made on the way to net-zero and make a healthier and better environment together.

7. References

1. Hugues Vendette et al., Alumina dry-scrubbing technology: development of a cascade feeding system for improved capture efficiencies, *Light Metals* 2007, 187-191.