Bath Chemistry Control with Different Alumina Compositions

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Abstract

Controlling superheat of electrolysis pots is fundamental to ensure their stability and the right composition of bath for alumina solubility. Alumina from different sources contains different quantities of elements such as sodium, calcium, magnesium, lithium and potassium which influence pot chemistry, impact bath liquidus temperature and therefore the heat balance. In Emirates Global Aluminium (EGA) potlines, we use the FiberLab™ instrument to measure bath temperature, superheat and bath chemistry across different cell technologies. This monitoring allows the control of bath chemistry at optimum level thanks to our AlF_3 additions control logic, leading to the lowest bath composition variability achieved so far and allowing the bath chemistry and temperature to be maintained on targets.

Keywords: Aluminium electrolysis, FiberLab™, Bath chemistry, Superheat, Alumina solubility.

1. Introduction

Emirates Global Aluminium (EGA), a major aluminum producer in the Middle East, and has two sites of operation: Al Taweelah and Jebel Ali. Al Taweelah has 1266 pots and Jebel Ali has 1580 pots for smelting aluminium. Al Taweelah Potlines 1 and 2 have 404 pots each and operate at 439 kA, while potline 3 has 458 pots and runs at 471 kA [1-7]. These pots cumulatively use approximately 5.13 Mt/a of alumina, more than half imported from different alumina refineries around the world. In 2019, EGA commissioned its own alumina refinery in Al Taweelah, which produced 2.48 million tonnes of alumina in 2023, enough to meet 85 % of the demand of the three potlines in Al Taweelah.

This article will discuss how the chemical balance issues were handled when we used the Al Taweelah alumina in Al Taweelah potlines. We will explain how we monitored and adjusted for the different chemical properties. We will also talk about EGA's own AlF_3 feeding program, which is a key achievement for EGA's digital transformation vision.

2. Al Taweelah Alumina and Evolution of Its Properties

Figure 1 shows the Al Taweelah alumina transferred to Al Taweelah smelter per year. The Al Taweelah alumina contribution gradually increased from 30 % in 2019 to 85 % in 2023. The increased quantity of Al Taweelah alumina has also dominated the presence of oxides such as Na_2O, CaO, MgO, and K_2O which have a direct impact on bath composition.

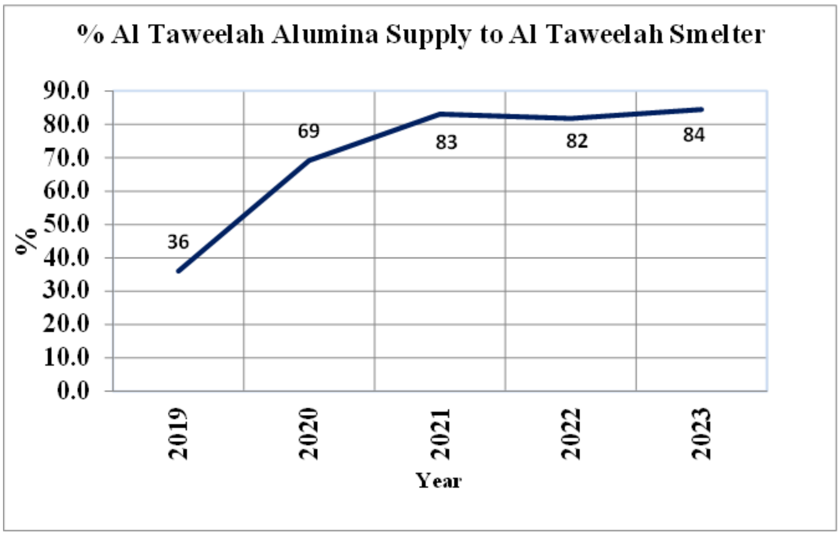

Figure 1. Al Taweelah alumina supply to smelter 2019 to 2023.

Table 1 shows the typical oxide composition for Na_2O, CaO, MgO and K_2O during 2023 and January to July 2024.

Table 1. Major oxide composition in Al Taweelah alumina.

Chemical Property	unit	Analysed (2023-2024)
Sodium Oxide (Na_2O)	wt%	0.28
Calcium Oxide (CaO)	wt%	0.009
Potassium Oxide (K_2O)	wt%	0.0034

Note: MgO is not monitored due to negligible variation in Al Taweelah alumina. However, MgF_2 is monitored in the bath which is discussed in the next section

The alumina from Al Taweelah typically contains around 0.28 % Na_2O. It was observed that the alumina delivered to the smelter, which includes imported alumina, accounted for roughly 0.30 % Na_2O. Figure 2 illustrates the consumption of AlF_3 in kilograms per tonne of aluminium produced.

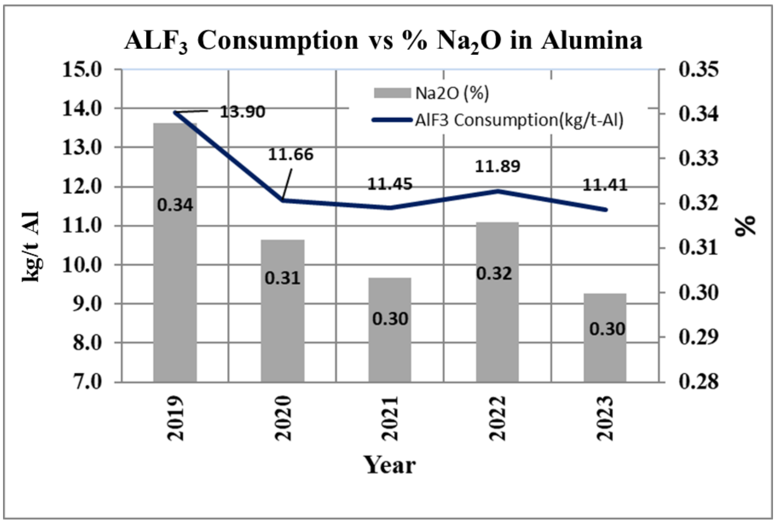

Figure 2. AlF_3 consumption (kg/t Al) vs % Na_2O in alumina, 2019 to 2023.

Figures 3 and 4 show the monthly average bath analysis of MgF_2 and KF. These cone from MgO and K_2O in alumina which transform to corresponding fluorides in the bath.

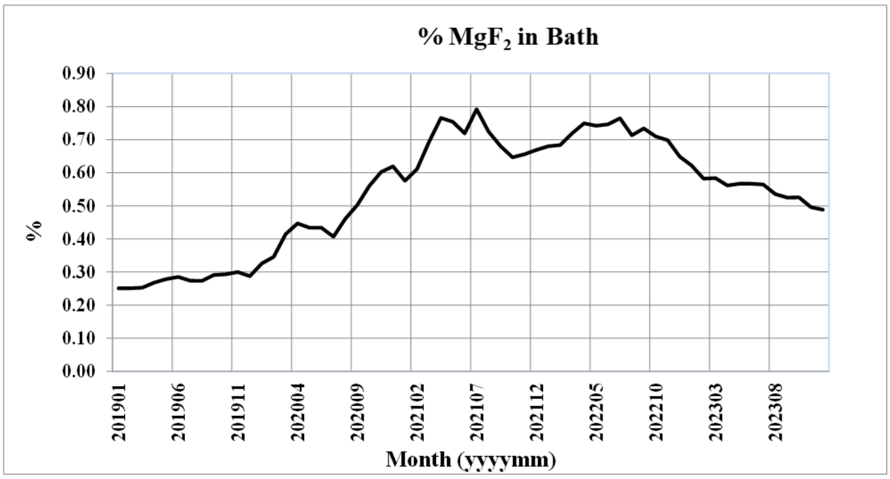

Figure 3. % MgF_2 in average monthly bath composition.

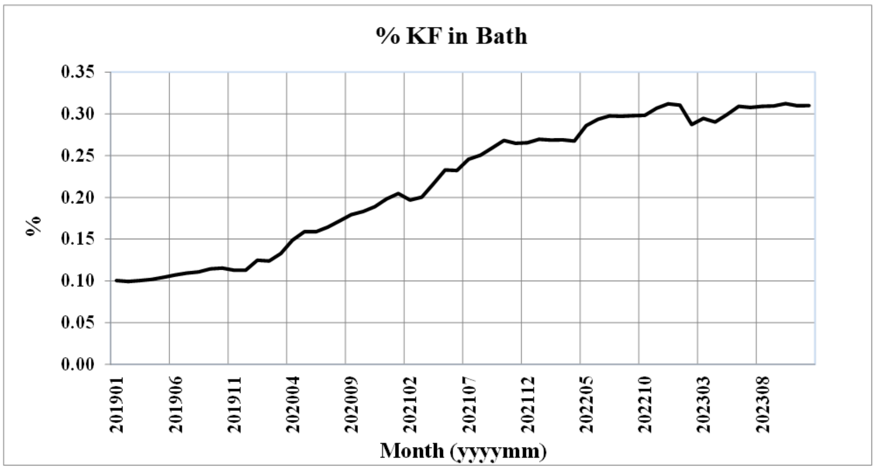

Figure 4. % KF in average monthly bath composition.

About 85 % of the alumina supplied to the potlines comes from the EGA's Al Taweelah alumina refinery. Since the use of Al Taweelah alumina began, there has been a significant rise of % KF and % MgF_2 in the bath. Table 1 shows the average increase in % KF and % MgF_2, along with the corresponding changes in calculated superheat, using the Solheim equation [8]. After a thorough analysis of the overall mass balance of these fluorides, the excess AlF_3 % was decreased by 1.0 % which not only compensated for the change in liquidus temperature due to higher KF and MgF_2 but increased the liquidus temperature by 2 °C. This adjustment aimed to achieve a slightly higher target bath temperature and lower superheat [7].

Table 2. Changes of liquidus temperature due to increased % of KF and MF_2 in bath [7].

Compound	Without Al Taweelah alumina	With Al Taweelah alumina	Change %	Corresponding change in liquidus temperature, °C	Corresponding change in liquidus temperature, °C
% KF	0.11	0.22	0.11	0.4	**1.4**
% MgF_2	0.55	0.80	0.25	1.0	

3. Monitoring and Control

Al Taweelah smelter imports the rest of its smelter grade alumina, which was 16 % in 2023, that arrives at irregular intervals according to EGA's raw material strategy. The imported alumina has different chemical and physical properties than Al Taweelah alumina. To deal with the variability, monitoring and control actions are applied, such as more frequent alumina analysis and using the in-house developed AlF_3 control program.

The analysis of the primary alumina was changed from every 3 days to every day and the analysis results have been automatically input into the control program since 2021 to prevent any delay in AlF_3 feeding response. Earlier, the control program did not have automatic alumina analysis input and was adjusted manually which caused delays and bigger variations in the % excess AlF_3.

Figures 5 and 6 show the trend on the standard deviations of % excess AlF_3 and bath temperature (ºC), respectively for AT DX potlines. Since the actions related to the control program and raw material analysis monitoring, the key thermal indicators improving improved.

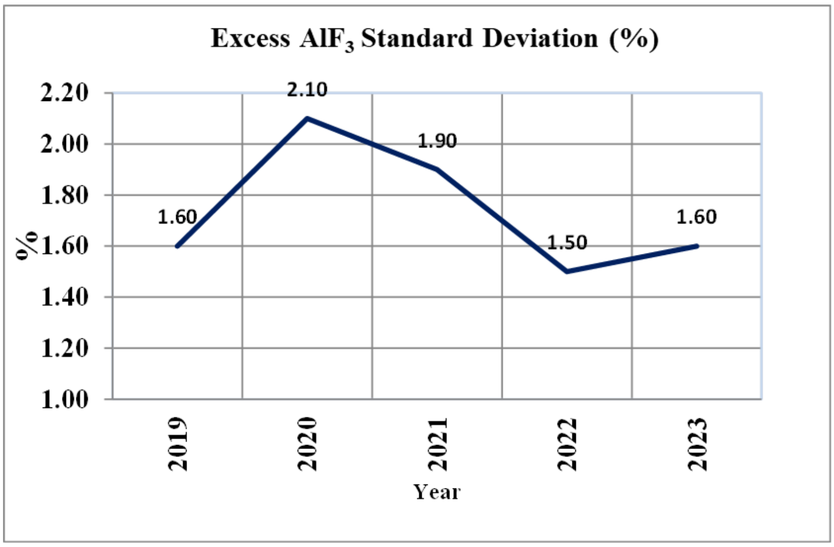

Figure 5. Standard deviation of % excess AlF_3.

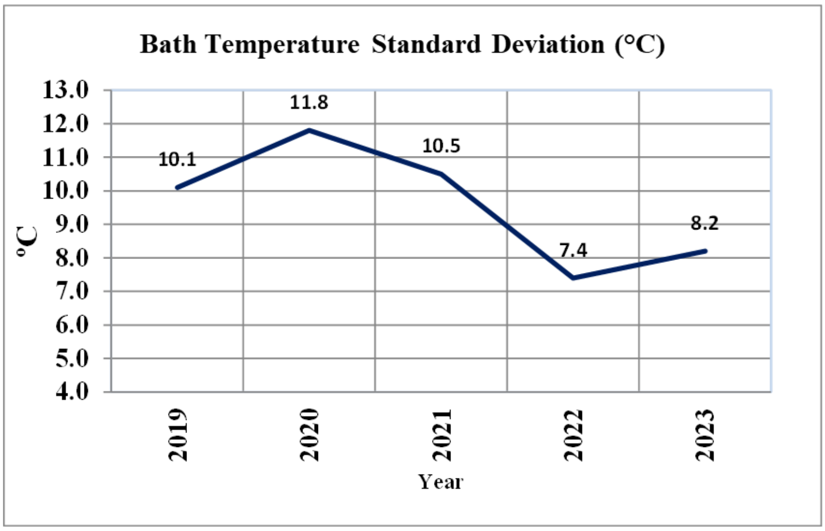

Figure 6. Bath temperature standard deviation (ºC).

4. Introduction of AlF_3 Control Program

The control program was developed by the EGA Technology Development and Transfer department and deployed in EGA potlines and in ALBA Potline 6. This program helps to achieve smaller variation in the potline key thermal indicators as shown in the previous section.

Figure 7 illustrates how the program has reduced manual interventions, which shows that human interference has decreased considerably since it was implemented. This was a major factor that influenced the variation of indicators based on subjective manual interventions.

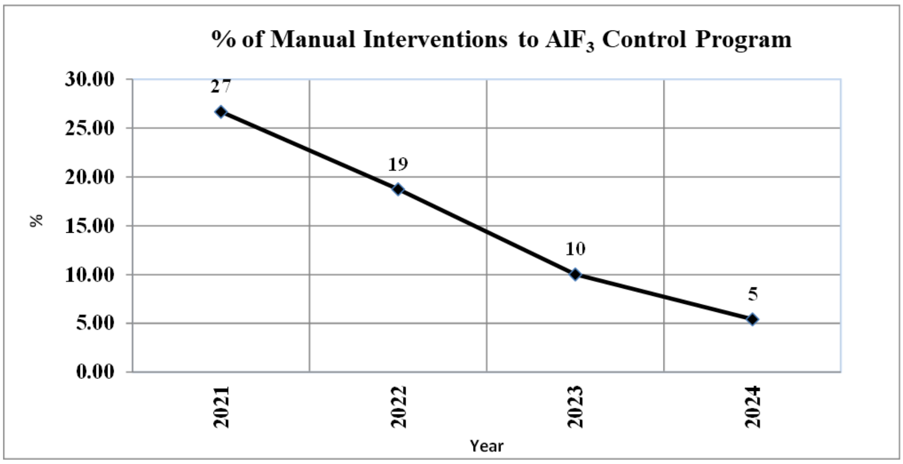

Figure 7. Manual interventions in control program in Al Taweelah potlines.

5. Conclusions and Way Forward

The modification in bath composition targets, implementation of rigorous regular raw material analysis, and monitoring strategy with the new control program in Al Taweelah potlines have demonstrated significant improvements in the quality and consistency of the aluminium production process. By minimizing the manual interventions and relying on the automated system, the program has reduced the variation of key performance indicators such as metal purity, current efficiency, and anode effect frequency. The program has also enhanced the safety and environmental performance of the potlines by reducing the risk of human errors and environment emissions. The program is a successful example of how digitalization and automation can optimise the aluminium smelting process and increase its profitability and sustainability.

In line with the EGA's vision of digital transformation and adopting Industry 4.0 solutions, the work is in progress in various fields such as transferring the key process measurement and analysis in real-time to control programs and logic to take actions and reduce the time lag and human interference.

6. References

1. Ali Al Zarouni et al., The successful implementation of DUBAL DX Technology at EMAL, *Light Metals* 2012, 715-720.
2. Michel Reverdy et al., Successful implementation of amperage increase to 380 kA in DX cells at DUBAL and EMAL, *Proceedings of 31st International ICSOBA Conference* and *19th Conference, Aluminium Siberia*, Krasnoyarsk, Russia, 4-6 September 2013, *TRAVAUX* 43, 542-545.

3. Vinod J. Nair, Vishal Ahmad, Shaikha Al Shehhi, Amperage Increase from 340 kA to 425 kA and beyond in EGA DX cell technology, *Proceedings of 36th International ICSOBA Conference*, 2018, Paper Al07, *TRAVAUX* 47, 663-674.
4. Vijayakumar Pillai, Amperage increase in DX potlines at EMAL, *Proceedings of 33rd International ICSOBA Conference*, Dubai, 29 November to 1 December 2015, *TRAVAUX* 44, 511-521.
5. Rawa Ba Raheem, Arvind Kumar, Sergey Akhmetov, DX cell technology at 400 kA and beyond, Proceedings of 33rd International ICSOBA Conference, Dubai, 29 November to 1 December 2015, *TRAVAUX* 44, 505-510.
6. Abdallah Abdelrahman Rahbar et al., Potlines extension project in EGA Al Taweelah smelter, *Proceedings of 40th International ICSOBA Conference*, Athens, Greece, 10-14 October 2022, Paper AL03, *TRAVAUX* 51, 1029-138.
7. Ishaq Alkharusi and Vishal Ahmad, Amperage Increase in EGA Al Taweelah DX Technology Potlines, *Proceedings of 41st International ICSOBA Conference,* Dubai, United Arab Emirates, 5 – 9 November, 2023, *Travaux* 52, 1209-1219.
8. Asbjorn Solheim et al., Liquidus temperature and alumina solubility in the system Na_3AlF_6-AlF_3-LiF-CaF_2-MgF_2, *Light Metals* 1995, 451-460.