Seasonal Protocol – Strategies to Improve Thermal Balance in an Aluminium Potline

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Abstract

Seasonal ambient variation plays a key influence in defining the operational window of an aluminium reduction cell, which is mostly determined by potline thermal balance. Even though gas treatment plants often study these basic features of environmental changes separately, the parameters of the potline are related and must be addressed to have minimal effect. Thermal balance influences the pot current distribution, the dissolution of alumina, and the instability of the pot. Bath superheat is a key indicator of thermal balance in the potlines. The productivity and energy consumption of the system are both ensured by keeping the superheat within a close range. Significant shifts in superheat can bring about unfavourable consequences, inefficient dissolution of alumina, formation of sludge and a decrease in the efficiency of the pot line. Seasonal fluctuations also make cell operations more complex because of the impact of varying heat losses on thermal balance. Higher cell instability and poor thermal control leads to higher metal bath interface instability, which consecutively accounts for higher back reactions.

Sohar Aluminium is a pioneering greenfield aluminium smelter and a market leader in Oman's manufacturing industry. To keep the thermal balance consistent throughout the year, regardless of the weather (summer-winter), this paper presents a predictive control method that adjusts the bath temperature set point, adds thermal resistance, and optimizes the pot forced cooling network (FCN) using real-time data or estimates of different indicators. The paper delves into the seasonal routine and provides an insight into thermal balance management for changes in the context of Sohar Aluminium's experience.

Keywords: Aluminium reduction pots, Seasonal variation, Thermal balance, Forced convection network, Superheat.

1. Introduction

The Sohar Aluminium plant is operating a single potline of 360 cells that is divided into two pot rooms with AP40/42S design and with a potential total metal production of 399 692 tonnes per year. It also has a carbon plant producing baked anodes and a cast house to cast the molten aluminium into final ingots and sows' format. Sohar Aluminium facilities include a smelter that utilizes advanced technology and employs best practices along with a dedicated power plant and port facility.

Sohar Aluminium has helped to establish and supply four downstream partners, of which all are in operation. Sohar Aluminium operates its own state-of-the-art 1000 MW natural gas-fired power plant and dedicated port facility in the Sohar industrial port area.

Modern primary aluminium production utilizes the Hall-Héroult process. Bauxite ore undergoes Bayer processing to yield alumina (Al_2O_3). This alumina is then dissolved in molten cryolite (Na_3AlF_6) within a high-temperature electrolytic cell. Direct current electrolysis breaks down the alumina into its elemental components, aluminium and oxygen. The denser molten aluminium accumulates at the cell bottom, while carbon dioxide (CO_2) evolves at the anode. The aluminium is then siphoned off for further processing**.**

Aluminium smelters face a unique challenge regarding seasonal heat balance. During summer months, the already significant heat generated by the electrolytic process can be exacerbated by rising ambient temperatures. This excess heat can cause inefficiencies in the reduction process and increased energy consumption for the cooling system, or in other words, bringing challenges for efficient operation. Conversely, winter months might necessitate additional heating to maintain optimal operating temperatures, impacting overall energy usage and current efficiency. This seasonal fluctuation in heat balance can affect production output and energy costs. To address these seasonal variations, smelters leverage several strategies. Utilization of heat recovery systems to recover waste energy, heat insulators, water coolers, and heat exchangers in a gas treatment plant. Additionally, some operational practices are adjusted seasonally to optimize efficiency. These engineering solutions play a crucial role in energy conservation and process optimization and ensure optimal cell temperatures, maintaining process efficiency. However, effective process control remains paramount. By proactively adapting cell operating parameters within established windows, smelters can accommodate seasonal changes and prevent significant disruptions to current efficiency and energy consumption. By managing the seasonal heat balance, smelters can strive for consistent performance throughout the year.

Maintaining stable bath temperatures in aluminium reduction cells is becoming harder. Growing demands for higher current and energy savings create conflicting goals. This necessitates precise pot control, including a deeper understanding of heat and mass flow within the cell. Notably, some smelters experience hotter pot side shell temperature and lower efficiency during summer, exceeding predictions based on a constant ambient temperature. This phenomenon is more pronounced in smelters located in regions with hot and humid summers. Places like the Southern U.S.A., parts of the Middle East, and some regions in Asia might see a more significant impact on efficiency during summers. So, in this paper we will explore the potential reasons for this phenomenon. It combines theoretical analysis, targeted tests, and real-world data to identify seasonal variations in key parameters and overall performance. The research shows multiple factors contribute to thermal balance, with varying impact. Importantly, a novel "seasonal protocol system" (SPS) by Sohar Aluminium addresses these challenges. This protocol adapts to extreme seasonal shifts by adjusting thermal setpoints, adding or reducing cell resistance, and optimizing the forced convection network (FCN) crucial for side ledge formation [8].

In this paper we will cover the Sohar Aluminium experience in the implementation of the seasonal protocol system and how the new thermal regulation system improves the cell performance and efficiency. The Sohar Aluminium trial approach was designed to gradually introduce new procedures, hence limiting potline disruption.

Sohar aluminium understands the relationship between ACD and current efficiency (CE), which had been established scientifically before. It suggests that even a small reduction in ACD can influence cell energy balance, particularly if the cell operates near its lower ACD limit. This could lead to a paradoxical situation where a decrease in ACD, which typically reduces heat generation, might actually increase heat generation due to loss of current efficiency.

Further research with additional tests and measurements is planned to explore CE-ACD relationship. This will help to develop even more effective strategies to mitigate the "summer-winter effect" and ensure optimal cell performance throughout the year.

7. References

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