Potlife and Pot Design Evolution at Alcoa Deschambault

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Abstract

Alcoa Aluminerie de Deschambault started its operation in 1992, 264 cells using AP-30 technology, with an initial nominal amperage of approximately 300 kA. Since then, more than 1600 cells have been started as part of regular operation. Through capital investments, people dedication, pot design optimization, improved process control and optimized operating procedures, the smelter increased amperage in many steps and is on its way towards 405 kA. Managing different pot designs at the same time, without compromising potlife, is of prime importance to optimize the smelter economics during amperage creep periods and during steady-state operation. This paper presents the results of potlife management and optimization methods, since the initial start-up, accounting for different new pot designs and the challenges that come with them and from the almost continuous amperage creep.

Keywords: Cathode design, Potlife, Process optimization, Amperage creep, Aluminium reduction.

1. Introduction

Aluminum is industrially produced using the Hall-Héroult process, based on carbon anodes [1]. A few other processes have been developed [2], although a limited subset such as inert anodes [3, 4], carbothermic reduction [5] or the Alcoa chloride process [6] were tried at different pilot scale stages over time and have yet to be deployed for industrial mass production.

The Hall-Héroult process [1] occurs within metallurgical reactors, called pots or cells, at about 950 °C, where a continuous current (100 to 600 kA) dissociates alumina (Al_2O_3) into aluminum (Al) and oxygen (O), as shown in Equation (1). Oxygen reacts with the carbon (C) anodes to produce carbon dioxide (CO_2) and the molten aluminum deposits at the bottom of the cell. This reaction happens within a molten fluoride salt bath containing the dissolved alumina.

$$2Al_2O_3 + 3C = 4Al + 3CO_2 \tag{1}$$

The pot sidewalls are lined with materials such as silicon carbide or graphite plates, which need to be protected from the molten bath by a frozen layer of bath. The bottom part of the cell is made of carbon-based cathode blocks, connected to electrical connectors to close the electrical circuit, and different layers of refractory and insulating materials. The pots are designed to dissipate sufficient heat in a way to keep a given layer thickness of frozen bath, called ledge, on its inner sides. In practice, the pots are designed to operate at a given current and electrical resistance with a specific molten bath chemistry. Deviations from those targets, or operating ranges, result in operation instabilities affecting the cell productivity (metal production rate), the electrical energy consumption, the metal quality, or the pot life duration.

In practice, excluding early failures [7], the pots need to be stopped and replaced either 1) preventively to manage the pot relining rate, 2) due to poor operation performance or 3) following a bottom or side failure. A bottom failure could happen locally if the cathode erosion reaches one of the steel collector bars. Such an event eventually dissolves part of the steel bar, thus leading to a molten aluminium leak. On the other hand, a side failure could happen locally on the side of the pot shell when the frozen ledge protection disappears, thus exposing the side-lining material to the molten bath. The bath eventually dissolves the material, reaches the steel shell, and eventually leaks out of the pot. Depending on leak location, bath and some molten aluminium may leak from the pot. In both cases, the pot needs to be stopped and replaced with a new one. As this replacement takes place, busbar and concrete floor damages from leakages may need to be repaired, therefore delaying the new pot start-up. Hence, managing potlife is a matter of maximizing potlife while minimizing the occurrence of side and bottom failures.

To maximize economic benefits from an operating smelter, aluminum producers are heavily relying on amperage increase to produce more aluminum with the same assets [8, 9, 10] without undertaking major pot technology modifications. One such example is the Alcoa Deschambault smelter, which started its operation in 1992, based on 264 pots using the AP-30 technology, with an initial nominal amperage of approximately 300 kA. Through capital investments, people dedication, pot design optimization, improved process control and optimized operating procedures, amperage was increased in many steps, as shown in Figure 1, and is on its way towards 405 kA.

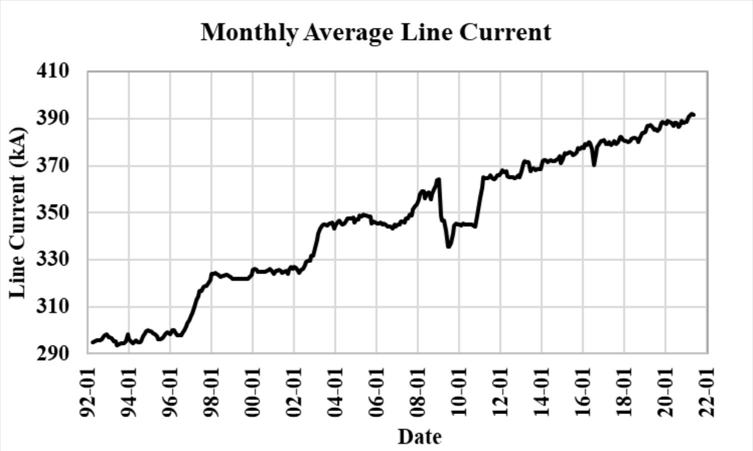

Figure 1. Monthly average line current at Alcoa Deschambault smelter.

However, increasing amperage generally requires converting to a different pot design, aimed to provide optimal and robust performance at the new amperage operating target. Due to the long cycle time to design and deploy a new pot design, in sufficient number to enable the amperage increase, smelters must generally operate different pot designs at the same time.

Simultaneously managing those different designs, without compromising potlife, is of prime importance to optimize the smelter economics during both amperage creep periods and steady-state operation.

This paper presents results from the Alcoa Deschambault smelter potlife management and optimization methods, since the initial plant start-up, accounting for different new pot designs and the challenges that come with them and from the almost continuous amperage increase.

6. Conclusions

Managing potlife within an aluminium smelter is of prime importance to optimize financial benefits. Many factors have an impact on potlife; pot technology, pot design, materials, lining procedures, start-up, early operation, operational targets and day-to-day activities. Each aspect needs to be optimized to deliver high and consistent potlife.

However, amperage increase can jeopardize potlife in many ways as it typically comes with a new pot design, requiring to be operated in different ways than previous designs. Since its start-up in 1992, the Alcoa Deschambault managed to maintain good potlife while also performing significant amperage increase. To achieve such results, the Alcoa Deschambault team deployed many countermeasures.

- Development and deployment of new pot design,
- Operating many pot designs at the same time,
- Improved day-to day operation and process control,
- Rapid and efficient interventions on sick pots,
- Efficient ways to patch cathodes and cure hot shells.

Managing potlife and amperage increase is a continuous effort and requires everyone and every sub-system to operate efficiently.

Aiming to further increase its performance, Alcoa Deschambault is on its way to 405 kA and continues to work on solutions to increase potlife.

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