Upgrading and Application of Cathode Energy-Saving Technology for 500 kA Aluminium Reduction Pots

Tang Wei[1], Xi Cao[2], Mengqi Yang[3], Longjin Yu[4], Dejiang Ni[5], Dezan Li[6], Wei Liu[7], Yafeng Liu[8] and Zhibin Zhao[9]

1. Director of Production Technology Department
2. Technical Executive of Aluminum Reduction Branch
3. Director of Aluminum Reduction Workshop 2
4. Vice Director of Production Technology Department

Guangxi Hualei New Materials, Baise, China

6. Director of Research and Innovation Center
7. Senior Engineer of Research and Innovation Center
8. Chief Engineer of Research and Innovation Center

Shenyang Aluminium and Magnesium Engineering & Research Institute (SAMI), Shenyang, China

9. Master's Degree Candidate

Northeastern University, Shenyang, China

Corresponding author: zhb_zhao@chinalco.com.cn

https://doi.org/10.71659/icsoba2025-al011

Abstract

The story of upgrading and application of cathode energy-saving technology in Guangxi Hualei New Materials Co., Ltd. was started from 2020. In the numerical simulation part, it showed the cathode energy-saving structure could significantly reduce the horizontal current in the metal pad and its resulting disturbances. The distribution of cathode current could be homogenized, and the cathode voltage drop (CVD) could be reduced as well. In the production management part, low metal level and seven stages method were adopted in the smelting process. Based on three months' KPIs in normal production, an energy saving of 300 kWh/t Al was obtained with the application of this technology. The paper may provide some experience and reference for domestic smelters in the work towards carbon peaking and carbon neutrality.

Keywords: 500 kA aluminium reduction pot, Cathode energy-saving technology, Horizontal currents, Cathode current distribution, Low metal level operation.

1. Introduction

With the Chinese Government "dual carbon policy" of carbon emissions peaking before 2030 and carbon neutrality before 2060, aluminium smelters are facing mounting pressure both in energy consumption and energy intensity [1, 2]. In order to support national policies, Chinese aluminium smelters are keeping on upgrading their technologies in energy saving, green and environmental friendliness. Some mature domestic energy-saving technologies are popular ones, e. g., new cathode collector bars [3–6], variable cross-sectional area collector bars [7], graphitized cathodes [8–9], etc. In new established greenfield lines, large capacity and ultra-large-capacity technology were widely applied due to its advantage in energy efficiency. The potential energy saving has been obtained by the increased magnetohydrodynamic (MHD) stability, which could be optimized both from the direction of magnetic field (B) in busbar design and current density (J) in lining structure design [10].

The new technologies used in greenfield lines also have the ability and potential for industry promotion of brownfield potlines. Particularly the cathode energy-saving technology was developed for the applications on different types of aluminium reduction pots. In order to try to

reduce the energy consumption for existing pots (in short form of G1 pots) in Guangxi Hualei New Materials Co., Ltd., the cathode and lining were redesigned by Shenyang Aluminium & Magnesium Engineering & Research Institute (SAMI). Some new operation parameters and methods were also applied for overhauled pots (in short form of G2 pots). We hope this paper could offer some reference for domestic smelters in the background of carbon peaking and carbon neutrality.

2. Basic Information on G1 Pots

The potline in Hualei was designed with a current capacity of 500 kA and installed with 300 pots. It was put into production in September 2017. The production of G1 pots was always accompanied by some persistent problems, as the following:

1) High pot voltage, and there was a considerable possibility for the optimization of KPIs.
2) Short service life resulted in high labour intensity for operators and loss in economy.
3) It is extremely difficult to control the tap-out risks in lots of pots, and operators were restless and prone to leaving.

In light of the above reasons, the technical upgrading was carried out for G1 pots in September 2020.

3. Technical Upgrade Strategy

Since the aluminium reduction pots are complex systems integrating multiple physical fields such as thermal field, electric field, magnetic field, flow field and stress field. These physical fields are mutually restrictive and influence each other. The ideal economic and technical indicators can only be obtained when a fragile balance is achieved. Slight deviations in the design of these physical fields would seriously affect the safety and KPIs of running pots. The design of MHD stability and thermal balance is particularly important in these physical fields.

Therefore, the strategy of the upgrading was first to evaluate the above-mentioned conditions by numerical method. And to identify problems was the second step. Then implementation of the most reasonable and effective upgrading plan in combination with the actual on-site conditions was the final part.

4. Evaluation of G1 Pots

4.1 MHD Stability

Through numerical simulation of original G1 pots, the MHD stability had the following characteristics:

1) The current out from side A (upstream) accounted for 50.3 % of the pot current, and the current on the side B (downstream) was about 49.7 %. The current on side A was slightly 0.3 % higher than the theoretical value, as shown in Figure 1.
2) The maximum value of the horizontal current in the aluminium pad was 5095 A/m^2, and the cathode voltage drop (CVD) was 287 mV (shown in Figure 2). Compared with the similar pots (SY500 pots) started up in China during the same period, there was a clear space on the optimization both in horizontal current and CVD.
3) The average values of the vertical magnetic field (Bz) in the four quadrants of the melt zone were 5.97, 4.64, 5.92 and 5.03 G, respectively. Its distribution is shown in Figure 3. The average value of the four quadrants was 5.38 G. In contrast, the average value of Bz in domestically operated SY500 pots was only 2.94 G. Higher Bz has a significant disadvantage impact on the MHD stability in G1 pots.

2) Through dual upgrading in design and process management, the upgraded pots achieved exceptional performance: the average pot voltage stabilized at 3.912 V, and the DC power consumption dropped 300 kWh/t Al. The problems in production were eliminated with significant improvements in production and economic directions.
3) In the background of China's "Dual Carbon Policy", reducing energy consumption through low-carbon optimization and upgrading is an important technical route to support national policies. This paper could offer some reference for domestic smelters.

9. References

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