Upgrade Experiment on MHD Stability of 350 kA Pot

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Abstract

During the process of reducing energy consumption in the SY350 potline of State Power Investment Corporation (SPIC), challenges arose in terms of insufficient magnetohydrodynamic stability. Specifically, a noticeable decline in current efficiency was observed after reducing the anode-cathode distance (ACD). To address this issue without affecting the overall production capacity of the potline, test pots were selected for an upgrade experiment on magnetohydrodynamics (MHD) stability by SAMI. The experimental plan involved the redesign of the busbar around the pot using the most advanced magnetic field calculation platform, coupled with the application of "Self-Balancing Busbar Network" Technology to enhance the anti-interference capability between adjacent pots. After the technological upgrade, the vertical component of magnetic field (B_z) of the test pots was significantly reduced, with a decrease exceeding 70 % in the 1st quadrant and over 40 % in the 2nd and 4th quadrants. Additionally, the distribution of the magnetic field is much more uniform. Both the liquid metal velocity and the bath velocity decreased, with a more regular two-pool circulation pattern. The interface deformation below the anode projection was reduced from approximately 4.3 cm to around 3.6 cm. The improvement of the above indicators has significantly increased the performance of the pot, and the MHD stability is no longer a technical bottleneck. The net voltage of the test pots is reduced from about 4.02 V to about 3.90 V and the current efficiency is no longer affected when the ACD is reduced by 3 mm, and the average DC power consumption is < 12 400 kWh/t Al.

Keywords: Magnetohydrodynamic stability, Busbar design, Self-Balancing Busbar Network (SBBN) technology, ACD, Energy saving and consumption reduction.

1. Introduction

A total of 276 pots in a SPIC's (State Power Investment Corporation, a large aluminum production enterprise in China) potline are in production using SAMI's 350 kA aluminum pot technology. After the potline was put into operation at the end of 2007, most of the pots have been in operation for more than 2 relining cycles so far. The technology route of this potline aimed at achieving high efficiency with high voltage. Its design voltage is about 4.15V. The design of magnetohydrodynamic (MHD) stability was limited by the accuracy of the simulation model at that time, which had significant technology gaps compared to the current standards. Nowadays, with the strict control of energy consumption and carbon emissions in China, the potline has to reduce anode-cathode distance (ACD) to reduce energy consumption.

However, in the daily production of this potline, if the ACD is reduced, the operation will be unstable and the noise will increase significantly. At the same time, there are also the following phenomena: when a single pot is disturbed, such as anode effect, abnormal bath-metal pad interface oscillation (pot noise), anode change, it can also lead to a decrease in the stability of adjacent upstream and downstream pots, and even anode effect and liquid metal instability may

occur in adjacent pots. And during the maintenance and shutdown process of the pot, the upstream and downstream pots are also unstable, manifested by significant voltage fluctuations, which do not decrease after increasing the voltage [1–2].

To effectively solve the above problems, 5 adjacent pots were selected for technological upgrading industrial tests in this potline, with the goal of minimizing energy consumption without reducing current efficiency. For this purpose, the following innovations were implemented on the test pots: Optimized pot-to-pot busbar design with self-balancing busbar network technology [3]; lining upgrade technology; optimized design of gas collection system, etc. In this paper, we focus on exploring the optimization of MHD stability and magnetic field distribution in the pots.

2. Selection of 5 Test Pots

Five adjacent pots were selected for testing in the south potroom of the 350 kA potline (Figure 1). Three of these 5 reduction pots have come to the end of relining cycle.

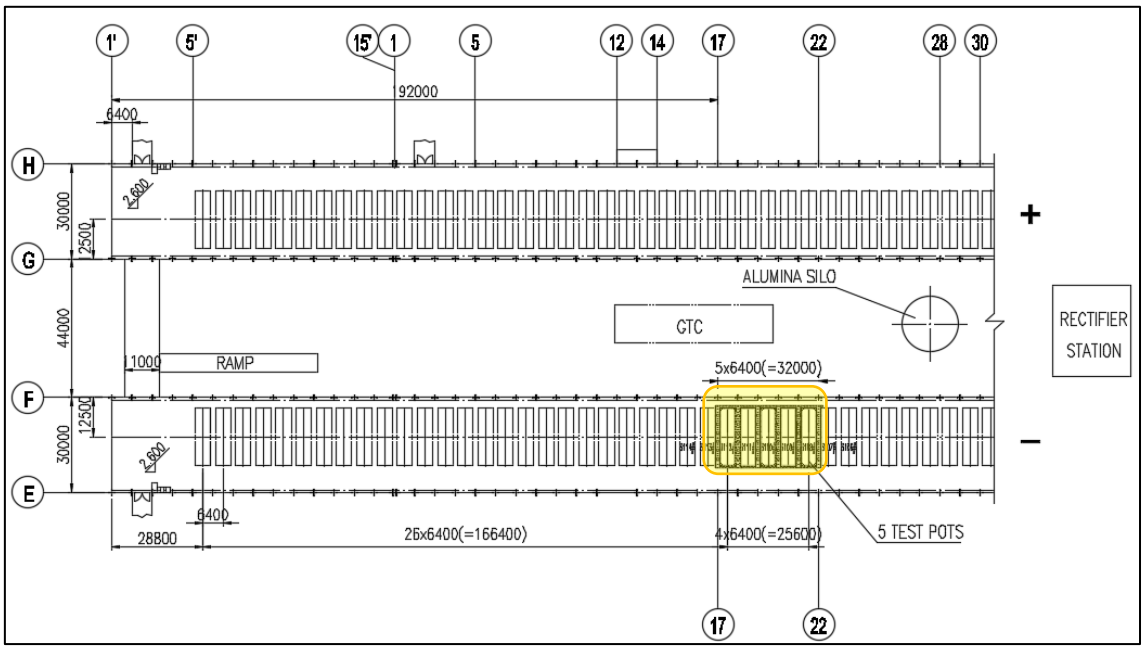

Figure 1. Location diagram of test pots (in yellow frame).

3. Establishment and Simulation of Electromagnetic Field Model for Test Pots

The establishment of magnetic and electric field models requires consideration of all components through which current flows, including anodic and cathodic busbars, anodes, bath and metal, cathode carbon blocks and collector bars, bimetallic (or trimetallic) transition joints, etc. [4–7].

The magnetic field and electric balance model of the test pots is shown in Figures 2 and 3.

consumption per tonne of aluminum in 5 test pots is 12 398 kWh/t Al, which is in a leading position in energy conservation in Chinese primary aluminum production.

8. Conclusions

Through the optimization of the pot-to-pot busbar design, combining the application of SBB technology and lining upgrade technology, the 5 test pots have shown better performance.

1) Compared to the original design, the test pots have significantly reduced B_z, with a more uniform gradient. Specifically, the z-direction magnetic field in the test pots has decreased by over 70 % in the 1st quadrant and more than 40 % in the 2nd and the 4th quadrants.
2) The electrical balance in both, the original and the test pots is relatively uniform, with the current in each collector within 4 % of the average.
3) The optimized busbar design of the test pots, has had a marked impact on MHD stability and metal-bath interface deformation. The flow rate of the metal pad has decreased and the circulation pattern are symmetric. The metal heave beneath the anode projection has significantly decreased from 4.3 cm to 3.6 cm.
4) After normal operation of five test pots, the average DC power consumption was recorded at 12 398 kWh/t Al, whereas the original design had an average DC power consumption of 13 060 kWh/t Al. This significant reduction in DC power consumption per tonne of aluminum in the test pots places them in an advanced class among Chinese aluminum potlines.

9. References

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