Accurate Bath Height Control in 500 kA Pots

Dailiang Wu[1], Qinglei Wei[2] and Jiantao Mo[3]
1. Technical Assistant of Potroom 1, Assistant Engineer
2. Operating Assistant of Potroom 1, Assistant Engineer
3. Superintendent of Group D, Potroom 1, Assistant Engineer
Guangxi Hualei New Materials, Baise, Guangxi
Corresponding author: 2064504301@qq.com
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Abstract

In the production process of high amperage pre-baked pots, the accurate control of bath height is one of the core factors to ensure efficient and stable operations of the pots. With all-graphite 500 kA pots as the object of study, this paper systematically discusses the influence mechanism of bath height on the thermal balance, alumina dissolution, current efficiency and pot life by combining theoretical analysis with production practices. The study shows that an insufficient bath height will lead to increased heat loss in the pots, abnormal ledge development, and aggravated abnormal fluctuations in the molecular ratio; If the bath height is too high, it may cause the frequent occurrence of anode effect, reduce the current efficiency, accelerate the erosion of the pot lining, and easily give rise to stub washing by bath, greatly affecting the quality of primary aluminium. By establishing a dynamic correlation model between bath height and process parameters, an optimization strategy is proposed to control the bath height within a range of 15–18 cm. Combined with industrial production tests, it has been verified that this strategy can significantly improve pot stability, reduce the DC power consumption by about 100 kWh/t Al, extend pot life by more than 10 %, and ensure high quality of primary aluminium. The study gives guidelines for energy consumption reduction and refined control of large high amperage pots.

Keywords: 500 kA aluminium reduction pots, Bath height, Process optimization, Energy saving.

1. Introduction

During aluminium electrolysis, the electrolyte (bath) is the reaction medium that dissolves alumina and electrolytically reduces alumina to aluminium. It is in contact with anode carbon blocks and the cathode, Electrochemical and chemical reactions take place in the bath, making it indispensable for the production of aluminium.

The electrolyte composition determines the temperature of the electrolysis process and is responsible for smooth operation. It greatly affects the energy consumption, product quality and pot life. Variations of process parameters caused by fluctuations of bath height are particularly sensitive in relined pots. This paper discusses the impacts and control of bath height in a 500 kA potline.

2. Impact of Bath Height Changes on the Pots

This paper discusses the influence of bath height on thermal balance, alumina dissolution, current efficiency and pot life at constant metal height. Variations of bath height may greatly affect the thermal balance and material balance, electrolyte temperature, anode effect frequency and current efficiency. The variations of bath height give rise to poor pot operation and increase labour intensity, and reduce the pot life. This was recognized already a long time ago [1].

2.1 Impact of Excessively High Bath Height

(1) Thermal imbalance and increased energy consumption

Excessive heat capacity: If the bath is too high, it is difficult to maintain the thermal balance of the heat input (Joule heat) in the pots.

Increased voltage demand: High bath may lead to higher anode-to-cathode distance (ACD) and pot voltage, which increases DC energy consumption by about 50–100 kWh/t Al.

(2) Increase of anode effect (AE) frequency

Before 2022, the average anode effect frequency of each work area in our plant was about 0.15–0.23 AE/pot-day. After the standardized adjustment of bath height since 2023, the anode effect frequency was reduced to less than 0.02 AE/pot-day, and the pots with high bath level are rarely seen. The cases where the anode effect occurs due to high bath levels are relatively rare, accounting for less than 3 % of all effects.

Low alumina concentration: With high bath, the bath volume is high, and the alumina (Al_2O_3) concentration tends to be low, near the critical value (< 1.5 %) for anode effects.

Difficulty in discharging bubbles: As the anode immersion depth increases, CO_2 bubbles accumulate at the bottom of the anode, forming continuous gas film, which may increase the occurrence of anode effects.

(3) Molecular ratio imbalance and degradation of electrolyte properties

Increased aluminium fluoride (AlF_3) volatilization: High bath level increases bath surface area and increases AlF_3 volatilization, decreases molar ratio (NaF/AlF_3), decreases bath liquidus temperature, and increases bath the viscosity.

Reduced alumina solubility: Lower bath temperature (due to reduced molecular ratio) will inhibit the dissolution of alumina, generate sludge and make alumina concentration distribution less uniform.

(4) Ledge degradation and pot lining erosion

Melting of side ledge: The excessively high bath level increases the side heat flux and melts the ledge, so that the side wall blocks are directly exposed to bath, which accelerates the sidewall erosion.

Shortened pot life: The lining erosion may lead to the cathode collector bar attack, pot shell deformation and other problems, significantly shortening the pot life (approximately by 20–30 %). Table 1 shows the pot life of 500 kA potline with long-term excessively high bath level, long-term excessively low bath level and stable bath level.

The metal height in the above selected test pots was 22–25 cm for a long time (the smelter target is 23–26 cm). The metal height in the pot 0010 is greater for protective maintenance after the pot was damaged.

As can be seen from Table 1, the pot life may be shortened due to the excessively high or low bath. Excluding the individual cases of pots 0005 and 0010, pots 0001–0003 in group I (extremely high bath level) had an average pot life of about 1428 days. Pots 0004, 0006 and 0007 in group II

4. References

1. Zhenglin Zhang, How to maintain bath height in electrolytic aluminium production, *Proceedings of the 2005 Annual Meeting and Academic Exchange Conference of the Fifth Aluminium Electrolysis Professional Committee*. 2005: 145–149 (in Chinese).