500 kA Cell Coke Preheating Optimization

Yongquan Huang[1]
1. Support Engineer
Guangxi Hualei New Materials, Baise, China
Corresponding author: 541781533@qq.com
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Abstract

Electrical preheating using coke bed [1, 2] is the primary preheating method to start aluminium reduction cells. Preheating quality significantly impacts the start-up, normalization and future operation of the cells. During this study, coke grain sizes, coke bed preparation and the installation of anode flexible connections before the start-up of a 500 kA cells were optimized to increase the uniformity of anode current distribution during preheating. Simultaneously, the cell preparation method was improved by covering the anode surface to reduce material drop on the cell cathode and sealing the central channel between anodes to increase cavity tightness. This ensures that the high-temperature flue gas generated during preheating stays longer inside the cell cavity. Additionally, the optimized method of removing shunting plates extends the current shunting time. These measures collectively promote uniform heating throughout the cell cavity, reduce the cell voltage during preheating and lower energy consumption.

Keywords: 500 kA aluminium reduction cell, Coke preheating, Current shunting, Flue gas waste heat, Preheating voltage.

1. Introduction

Cell preheating quality directly impacts cell stability during start-up and early operation, thereby influencing the formation of the ledge during this phase. Poor preheating and start-up performances can lead to unstable operation during the normal operation, to significant variations in energy consumption and to increased workload to manage abnormal situations and even affect the cell life. The 500 kA potline at a smelter comprises 300 cells, all using electrical preheating before start-up. In recent years, the smelter has improved the uniformity of anode current distribution during preheating and increased preheating effectiveness. The coke/graphite ratio in the material used to prepare the bed on which the anode lies during preheating was optimized and the coke bed thickness reduced. However, some cells still exhibit issues like excessive noise, poor stability, and difficulty in voltage reduction after start-up, during early operation. These cells fail to operate stably during normal production. For instance, under identical current efficiency, cell A requires 40 mV higher set voltage than cell B, resulting in higher energy consumption. As the smelter has ambitious production and energy consumption targets, it is imperative to further optimize cell preheating to lay a solid foundation for stable cell operation.

2. Main Operational Steps of Cell Preheating

The main operational steps of cell preheating are cell preparation and energization.

2.1 Cell Preparation

When a cell is shut down and undergoes maintenance, a new lining is installed and inspected. Then cell preparation can start. First, dust on the cathode surface is blown away. Then the coke bed on which the anode will rest during preheating is installed on the cathode surface. The anodes are lowered on the coke bed using a multi-functional crane, ensuring their bottom surfaces make full contact with the coke particles. Flexes are manually installed to link the aluminium anode stem with the anode beam. These steps are repeated until all 48 anodes are installed in the cell. Next, the anodes are covered with crushed bath, cryolite, and soda ash that are evenly spread over the top the anode surface.

2.2 Power-on

After preparation, six sets of shunting plates (two shunting plates per set) are mounted on the cell's downstream anode beam and connected to the six anode risers of the downstream cell. Then, using a non-power-cut cell start-up device on the cell upstream, the cell is energised. The non-power-cut cell start-up device is removed, completing the power-on process. At this stage, the cell has started its preheating. During this phase, the coke bed acts as a resistive heating element, simultaneously heating the anode and cathode carbon blocks [3]. After 96 hours of preheating, the anode and all the elements forming the cell cathode lining reach their target temperature, meeting the conditions for the next start-up phase.

3. Preheating Optimization

In response to issues such as excessive noise, significant voltage deviation, and poor stability observed in newly started cells during their early operation, repeated analysis and discussions were conducted. It was decided to optimize preheating using Cell X as the reference cell and Cell Y as the test cell.

3.1 Coke Bed Optimization

The coke used in this smelter to make the coke bed had a particle size range of 2–6 mm. The relatively large particle size resulted in incomplete contact between the anode carbon block bottom and the coke particles during anode setting, reducing the effective conductive area after power-on. Additionally, uneven particle size distribution affected the uniformity of anode current distribution during preheating, badly impacting anode thermal expansion and lining temperature distribution. To address this issue, the smelter adopted a pre-treatment method involving coke mechanical crushing to refine the particles. Simultaneously, new sieving screens were made to precisely maintain coke particles within a 2–4 mm range. Additionally, the smelter also produced specialized tools to improve the coke bed quality, aiming at maximizing the contact area between the coke particles and the anode carbon block. This increased the effective conductive area, achieving a more balanced anode current distribution and promoting uniform heating and expansion of the anode.

3.2 Preheat Flex Installation

After repeated use, the two contact surfaces of the flexes became uneven, preventing full contact with the anode stem and the cell anode beam, thereby reducing the conductive area. These contact surfaces were polished along with the anode stem and the anode beam, improving the contact voltage drops and the uniformity of anode current distribution after power-on.

3.3 Optimizing Anode Cover During Cell Preparation

Originally, the top of the central channel was not closed when preparing the cell. The high-temperature flue gas generated during preheating escaped directly through this channel, resulting in significant heat loss and insufficient preheating temperature. Additionally, the gaps between anode were not closed during covering, causing material to fall into these gaps. As a result, when the anode heated and expanded during preheating, it could expand upwards only rather than sideways, generating uneven anode current distribution during preheating. To address this issue,

6. References

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