Production Process and Control Optimization of a 240 kA Potline under SAMI's Deep Energy-Saving Cell Technology

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Abstract

In order to assist aluminum smelters to significantly reduce the energy consumption of primary aluminum production and promote the green transformation and high-quality development of the aluminum smelting industry, Shenyang Aluminum and Magnesium Engineering and Research Institute Co., Ltd (SAMI) has developed a Deep Energy-Saving Aluminum Electrolysis Technology System. In 2022, SAMI successfully applied this technology system to the 240 kA potline upgrading project of Guangxi Baise Guangtou Yinhai Aluminum Industry Company, achieving integrated application of Networked Self-equalizing Busbar Technology (NSBT), New Conceptual Cathode Technology (NCCT), "Long Healthy Life" potlining technology, Energy-saving and Eco-friendly Superstructure Technology, and new pot control system on the 240 kA potline. After recommissioning of the upgraded potline, the technical team proposed and developed a refined control process of gas preheating of the pots. By utilizing electric-thermal balance simulation, "Three-Low and One-High" Production Process Management Technology was developed, successfully increasing the operating current of the potline from 240 kA to 260 kA. Thanks to the design upgrade and production process optimization, the potline now operates stably with excellent KPIs, with average voltage < 3.945 V, the current efficiency > 94.5 %, and the DC power consumption < 12.450 kWh/kg Al. After the technical upgrading and optimization, the DC power consumption of the potline has been reduced by nearly 0.9 kWh/kg Al, and the annual primary aluminum production capacity has been increased by nearly 14 000 tonnes, with significant energy-saving and economic benefits.

Keywords: Aluminum electrolysis pot, Control system, Gas preheating, Low metal level, Production process optimization.

1. Introduction

In recent years, the gradual implementation of China's strategic policies such as "supply side reform", "dual control of both energy and consumption", "dual carbon" strategy, and "Tiered electricity pricing" has led to the peak production capacity of the high energy consuming electrolytic aluminum industry and accelerated green transformation. The industry's development

trend has shifted towards energy-saving upgrades and improvements in quality and efficiency. Simultaneously, aluminum smelters and research institutions are accelerating the development of energy-saving technology for aluminum electrolysis. They are focusing on optimizing the design of multiple physical fields and upgrading the production process, to explore the potential for energy conservation and consumption reduction throughout the entire process of aluminum electrolysis, including cell design, preheating, start-up, and production.

Starting from 2020, based on the improving thermal-electric-magnetic-flow multi physics field simulation and analysis technology platform in the development of electrolytic cells, SAMI has accumulated a lot of experience in deep energy-saving and consumption reduction of aluminum electrolysis cells by focusing on improving the magnetohydrodynamic (MHD) stability of electrolytic cells, reducing physical voltage drop, maintaining good thermal balance, improving gas collection efficiency, equalizing the distribution of alumina concentration, and improving digitalization and intelligence [1]. By conducting theoretical research using aluminum electrolysis cell multi physics field simulation as the primary method, combined with industrial experiments, potlines applications, and on-site testing verification, SAMI has successfully developed a deep energy-saving aluminum electrolysis technology system. The key sub-technologies included in this system are:

- Networked Self-equalizing Busbar Technology (NSBT)
- New Conceptual Cathode Technology (NCCT),
- "Long Healthy Life" lining technology,
- Energy-saving and eco-friendly superstructure technology,
- Narrow-Amplitude and Dual-Mode cell control technology,
- Preheating and start-up control technology,
- “Three Low - One High” Production Process Management Technology, etc.

In 2022, the aforementioned deep energy-saving technology system for aluminum electrolysis was successfully integrated and implemented in a 240 kA potline upgrading project of Baise Guangtou Yinhai Aluminum Co., Ltd (as shown in Figure 1). Once the significantly improved electromagnetic field, lining isotherm distribution, fume collecting and feeding efficiency had been achieved thanks to the application of the first four technologies mentioned above, the potline was set for a new target of 260 kA shortly after recommissioned. In this paper, production process management and control optimization, amperage increase from 240 kA to 260 kA will be described in continuation of the ICSOBA 2023 paper [2].

Figure 1. Aerial view of the 240 kA potline.

In Table 2, gross carbon consumption is calculated as:

Gross carbon consumption = (Current month anode purchase quantity + Last month anode inventory - Current month anode inventory)/(Current month aluminum production).

In recent years, the gross C consumption of China's aluminum smelters has been significantly reduced, mainly for the following reasons: (1) The butts are very thin, only 155~160 mm; (2) Many aluminum plants design the top shape of the anode carbon block to be small to minimize the weight of the butts; (3) Appropriately increase the overall height of anode carbon block; (4) The above three reasons also lead to the lengthening of the anode change cycle and the reduction of gross carbon consumption.

6. Conclusions

The optimized Gas Preheating Process in this project improves temperature control, prevents local overheating that could cause thermal stress concentration in carbon materials, and establishes conditions for the long-term safety and stability of lining materials, particularly carbon materials, after current increase.

Through the control algorithm and model innovation of the pot, SAMI has developed Narrow-Amplitude and Dual-Mode Cell Control Technology. Additionally, a new pot control system has been designed with high integration, low maintenance, easy expansion and increased digital intelligence. As a result, the control rate and current efficiency of main process parameters have been greatly improved.

The precision management technology of the “Three Low - One High” production process achieves stable maintenance of the superheat, regular legde shape, long-term stable CVD in the pot, as well as high current efficiency and low energy consumption during operation.

The excellent design of physical field, upgraded control system, and refined production process management technology has laid a solid foundation for the successful implementation of current increase in this potline. The application of SAMI’s deep energy-saving aluminum electrolysis technology system not only brings substantial economic value to smelters by increasing production and reducing consumption, but also significantly reduces their carbon emissions through lower energy and net carbon consumption.

7. References

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