Production Practice of Reducing Anode Effect Frequency

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Abstract

This paper presents a series of technical and managerial measures adopted in the production process of a foreign high anode current density aluminium reduction cell to reduce the anode effect frequency, as well as their practical results. Through appropriate adjustment of cell process parameters, enhanced production management, and improved operation quality, the anode effect frequency was effectively reduced, the stability and current efficiency of the reduction cell were improved. Also, energy-consumption was reduced, and negative environmental impacts were mitigated.

Keywords: Aluminium reduction cell, High anode current density, Anode effect frequency, Energy-consumption reducing

1. Introduction

During aluminium electrolysis, the occurrence of anode effects is unavoidable. An excessively high anode effect frequency exerts numerous adverse impacts on aluminium electrolysis, not only causing a significant increase in power consumption but also leading to the emission of pollutants such as fluorides, harming the environment, reducing current efficiency, and undermining the stability of the reduction cell. Therefore, reducing the anode effect frequency has become an important research topic for production efficiency and sustainable development.

1.1 Characteristics and Challenges of High Anode Current Density Cells

1.1.1 Impact of High Anode Current Density on the Cells

High anode current density significantly alters the electrochemical processes on the anode surface. The anode overvoltage increases, resulting in higher power consumption. Meanwhile, the uneven distribution of current in the bath intensifies, making local overheating and alumina concentration gradients more likely to occur, which further affects the dissolution and diffusion of alumina and increases the probability of anode effects.

1.1.2 Production Problems Related to the Anode Effect Frequency

Under high anode current density, an increase in the anode effect frequency leads to unstable operation of the reduction cell. Frequent anode effects cause drastic fluctuations in cell voltage, resulting in substantial energy waste. In addition, the high-temperature and strongly oxidative environment generated during anode effects accelerates the anode consumption, affects potlining, shortens its service life, and raises production costs. Moreover, the emissions of pollutants such as fluorides generated during the anode effect may fail to meet environmental protection standards.

2. Principle of Occurrence and Hazards of the Anode Effect

2.1 Principle of Occurrence

The occurrence of an anode effect is caused by excessively low alumina concentration in the bath, which alters the gas evolution process at the anode surface [1]. When alumina concentration drops below a certain critical level, a high-resistance fluorocarbon film forms on the anode surface, leading to a sharp rise in cell voltage and triggering the anode effect [2]. At the same time, a series of complex electrochemical reactions take place on the anode surface, generating large amounts of heat.

2.2 Hazards to Production

The anode effect causes a sharp increase in energy consumption of the reduction cell because cell voltage rises during the anode effect. An excessively high anode effect frequency disrupts the thermal balance of the cell, impairing its stability and service life. Frequent anode effects also reduce the quality of molten aluminium, increase impurity content, and release substantial quantities of fluorine-containing harmful gases during the process, leading to severe environmental pollution [3].

3. Technical and Managerial Measures to Reduce the Anode Effect Frequency

3.1 Strict Implementation of Process Specifications

Strictly control cell voltage to avoid excessively high or low levels. Excessively high cell voltage increases energy consumption, while excessively low voltage increases cell noise and decreases current efficiency. Maintain the bath temperature within an appropriate and stable range. Excessively low temperature slows alumina dissolution and makes anode effects more likely. Therefore, precise control of bath temperature is crucial for reducing the anode effect frequency. Maintain alumina concentration within a relatively stable and narrow range, avoiding sludge creation at high range and anode effects at low range. Keep the excess aluminium fluoride within a controlled and stable fluctuation range to avoid sharp rises and drops.

3.2 Anode Change Management

Establish strict anode change cycles and operating procedures. Determine the replacement timing reasonably based on the anode consumption rate and the operating condition of the cell. During the anode change, ensure accurate installation of new anodes, good contact with the bath, and strictly control replacement speed to prevent bath fluctuations and alumina concentration imbalance caused by improper operations, thereby reducing the anode effect frequency.

3.3 Strengthening Production Management and Monitoring Systems

Provide training and skill enhancement for on-site operators, reinforce professional training for cell operators, and improve their operational skills and understanding of cell operating principles. The training covers anode replacement, troubleshooting cell abnormalities during inspection, extinguishing anode effects, and diagnosis and handling of cell faults. Through regular training and strict assessments, ensure operators master the required skills, accurately judge the operating state of cells, and take timely and effective measures to prevent and handle anode effects, thereby reducing the anode effect frequency.

Implement monitoring and analysis of production data by establishing a comprehensive system to collect, store, and analyse in real time various operational parameters of the cells. These include

6. References

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