Development and Application of Aluminium Electrolysis Energy Saving Series Technology Based on Steady Metal Flow and Heat Preservation

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Abstract

In response to the major common technical difficulties in high-efficiency production of aluminum electrolysis cells under low voltage and low energy consumption, Zhengzhou Non-ferrous Metals Research Institute Co. Ltd of CHALCO has successfully developed Aluminum Electrolysis Energy Saving Series Technology based on Steady Metal Flow and Heat Preservation through systematic research on "optimization of conductive materials and structures-cathode current stabilization-isotherm control-physical field balance optimization", effectively solving the technical problems of high energy consumption, low efficiency, and short service life of aluminum electrolysis cells. The goal of significant energy conservation and emission reduction has been achieved. This technology was developed in 2013 to form the prototype FHEST 1.0, achieving DC power consumption < 12 500 kWh/t Al. By 2020, on the basis of FHEST 1.0, the FHEST 2.0 was iteratively upgraded to achieve DC power consumption < 12 300 kWh/t Al. At present, this technology has been promoted and applied in approximately 3 000 cells of different types, ranging from 180 kA to 500 kA, achieving a total of 3.55 billion kWh of electricity savings and 2.114 million tonnes of carbon dioxide emissions reduction. Starting from 2023, FHEST 3.0 is being developed, and the test cell has achieved DC power consumption of less than 11 800 kWh/t Al. This article provides a detailed introduction to the development, industrial testing, and industrial implementation, and application of FHEST energy-saving cell technology. This technology provides technical support for the smelters to achieve large energy conservation and carbon dioxide emission reduction.

Keywords: Aluminum electrolysis, Low cell voltage, High efficiency, Steady current insulation.

1. Introduction

China has set the goal of peaking carbon dioxide emissions before 2030 and achieving carbon neutrality before 2060. This has increased the pressure on the aluminum reduction industry to "dual control of both energy consumption and intensity", and promoted the green transformation and high-quality development of the electrolysis aluminum industry. China's aluminum reduction industry will continue to develop environment-friendly and highly energy-efficient technologies. Since 2013, Zhengzhou Non-ferrous Metals Research Institute Co. Ltd of CHALCO (ZRI) has been focusing on the technical challenges of low voltage, low energy consumption, and high efficiency production technology for aluminum electrolytic cells. A series of technical research and industrial experiments have been carried out [1-5], and a deep knowledge in energy-saving

technology system for aluminum electrolysis has been formed. Aluminum Electrolysis Energy Saving Series Technology based on Steady Flow and Heat Preservation (FHEST) has been successfully developed.

The technical route of the FHEST technology is shown in Figure 1:

1) Reduce the voltage drop of conductors in various parts of the electrolytic cell, including anode voltage drop, bubble voltage drop, cathode voltage drop, anode clamp voltage drop, and busbar voltage drop, etc;
2) Improve the magnetohydrodynamic stability of electrolytic cells, including optimizing the material and structure of cathode carbon blocks and steel collector bars to reduce horizontal current and open ACD;
3) Improve the raw material quality, including the conductivity and oxidation resistance of prebaked anodes, as well as the particle size and solubility of metallurgical grade alumina, etc.;
4) Assist with reasonable thermal balance design, process technical parameters, and intelligent control system optimization and upgrading.

This technology was developed in 2013 to form the prototype FHEST 1.0, achieving DC power consumption < 12 500 kWh/t Al. By 2020, on the basis of FHEST 1.0, the FHEST 2.0 was iteratively upgraded to achieve DC power consumption < 12 300 kWh/t Al. Starting from 2023, FHEST 3.0 is being developed, and the test cell has achieved DC power consumption of less than 11 800 kWh/t Al.

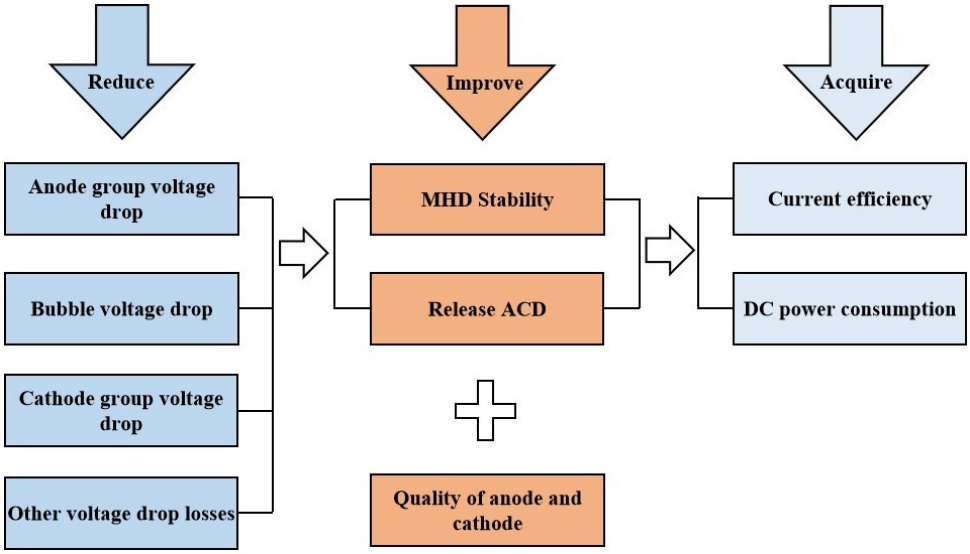

Figure 1. Technical route of FHEST technology.

2. FHEST 1.0

2.1 Technical Approach

Starting the research in 2013, this technology aims at low DC power consumption for aluminum reduction. Based on numerical simulation modeling, integrated design with steady metal flow, low cathode voltage drop technology, redesigning the side wall ledge distribution and taking into account cell operation, the new design criterion is established for FHEST 1.0. The main techniques include: steady metal flow optimization techniques, voltage balance optimization techniques, thermal field design optimization technology, cell operation parameters optimization. Schematically, this is presented in Figure 2.

Figure 7. Left: Intelligent control system for FHEST 3.0 technology test cell, Right: Insulated hoods for FHEST 3.0 technology test cell.

5. Conclusions

Zhengzhou Non-ferrous Metals Research Institute Co. Ltd of CHALCO has successfully developed Aluminum Electrolysis Energy Saving Cell Technology based on steady flow and heat loss reduction through systematic research on "optimization of conductive materials and structures, cathode current optimization, cathode freezing-isotherm control, and the physical field balance optimization". This technology was developed in 2013 to form the prototype FHEST 1.0, achieving DC energy consumption < 12 500 kWh/t Al. By 2020, on the basis of FHEST 1.0, the FHEST 2.0 was iteratively upgraded to achieve DC power consumption < 12 300 kWh/t Al. As of now, FHEST technology, including FHEST 1.0 and FHEST 2.0, has been promoted and applied to approximately 3000 cells in 180 kA to 500 kA potlines, achieving a total of 3.55 billion kWh of electricity savings and reducing carbon dioxide emissions by 2.114 million tonnes. Starting from 2023, FHEST 3.0 is being developed, and the tests cell have achieved DC power consumption around 11 950 kWh/t Al, with the aim of achieving 11 800 kWh/t Al in near future.

6. References

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