Automatic Temperature Measurement of Three Steel Components on Cathodes of 500 kA Cells

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https://doi.org/10.71659/icsoba2025-al048

Abstract

China's electrolytic aluminium production technology uses only pre-baked cells. Three steel temperatures – potshell side, potshell bottom plate and collector bar – are cell operation and control parameters in Chinese cell technologies. The measurement of these temperatures is still made manually. This outdated method requires significant human and material resources, yields low efficiency, endangers the health of operators, and fails to promptly identify potential faults. Therefore, there is an urgent need to implement automatic, continuous, and real-time monitoring of the three steel temperatures. This paper introduces distributed optical fibre temperature sensing technology, which features high sensitivity, stability, reliability, anti-electromagnetic interference, and continuous distributed measurement capabilities, enabling real-time online monitoring of three steel temperatures. This technology can detect temperature changes at any position along the optical fibre, support long-distance and large-scale temperature monitoring, and is of great significance for improving safety and reducing labour intensity.

Keywords: 500 kA aluminium electrolysis cell, Automatic measurement of three steel temperatures, Real-time monitoring, Automatic warning.

1. Introduction

The aluminium electrolysis is a complex physicochemical process, multivariable and nonlinear time-varying process. For such production processes, advanced intelligent control technologies can achieve excellent control results when precise mathematical models are unavailable. The cell operational status directly affects the quality and output of primary aluminium. The three steel temperatures are key cell operation parameters. Accurate measurements of these temperatures are crucial for understanding the cell thermal balance, prevent cell tap-out accidents, and reduce energy consumption. Traditional manual measurement methods for three steel temperatures have many limitations and cannot meet the needs of modern aluminium production for automated control. Upgrading the temperature measurement to automatic measurement effectively improves the digital and intelligent cell control. In this paper, the automatic measurement technology was applied to 500 kA cells.

2. Technical Background

With the development of computer technology, automatic control theory and practice, and advancements in modern large-scale aluminium electrolysis equipment, the automatic control and management have been continuously upgraded. The AI technology has not only reduced manual labour intensity but also promoted the gradual increase in automation of the cells, achieving significant reduction in energy consumption carbon emissions. Modern high amperage cells are complex high temperature electrochemical reactors under the interaction of multiple phases (gas-melt-solid) and multiple fields (electrical, magnetic, thermal, flow, etc.). The complex effects of electrical, magnetic, thermal, and flow fields in electrolysis cells complicate the state of the bath and metal. The enlargement of the cells increases the difficulty of efficient and stable control under critical conditions, placing higher demands on automatic measurement technology. The main control objective during aluminium electrolysis production is to predict alumina concentration and bath temperature, and control alumina feeding and anode-cathode distance (ACD) to ensure the thermal and material balance of the cell.

2.1 Introduction to the Online Temperature Detection System for Three Steel Components of the Cells

This project is an online temperature detection system for three steel components of electrolysis cells in a 500 kA potline. It is necessary to install the mobile measurement equipment to meet the network communication system in the potrooms and select monitoring points in test cells.

2.2 Drawbacks of Traditional Measurement Methods for Electrolysis Cells

Traditional manual temperature measurement of three steel components in the cells mainly uses portable thermometers. It is difficult to standardize operations through manual measurement, since the results depend on the operator's skills and work experience; this makes it difficult to ensure measurement accuracy. Differences in temperature measurement point selection and measurement time among different operators lead to large data dispersion; the frequency of manual measurements is low, so it cannot reflect the dynamic changes of three steel temperatures in real-time. Temperature fluctuations may affect production, but the lag of manual measurements makes it difficult to promptly identify abnormalities and take effective control actions. At the same time, the working environment for manual measurement is harsh, and operators work near high-temperature structures and electrical conductors, posing safety risks. Drawbacks of manual measurements are:

1) Environmental complexity: In the potroom there are high magnetic fields, high temperatures of 950–960 °C in the cells, limited space, and emissions;
2) Lack of data from the cells: Relying on manual inference of the operating status of high-temperature liquids in the cells, lacking real-time temperature data and process information, making it difficult to predict accidents such as cell tap-out;
3) Potline safety risks: Cell tap-out accidents may cause potline open circuit and power outage, resulting in huge economic losses.

3. Online Temperature Measurement System for Three Steel Components of the Cathodes

3.1 Principle of the Measurement System

The automatic temperature measurement technology for three steel components of the cells is based on infrared sensors. The infrared temperature measurement principle utilizes the thermal radiation characteristics of objects. The radiation intensity is related to the object's temperature. High-precision infrared sensors receive infrared rays radiated from the surface of three steel components, and after signal processing and algorithm calculation, the accurate temperature is obtained. At the same time, advanced sensor technologies such as thermocouple sensors and thermal resistance sensors are used to monitor the measurement environment and other related parameters for compensation, improving the accuracy of temperature measurement. To realize automatic measurement of multiple temperature points, a distributed sensor network layout is used, and sensors are installed at key positions of the three steel components.

3) Safety: The detection part of the optical fibre sensor in the automatic temperature measurement system is passive and intrinsically explosion-proof, unaffected by environmental factors such as weather and dust, and has extremely high safety.
4) Standardization: In addition to complying with national standards, the design of the automatic temperature measurement system also meets the functional requirements of the system, achieving structuring and standardization, which can comprehensively reflect the current advanced technical level.
5) Economy: On the premise of achieving advancement, practicality, and reliability, full consideration is given to the economic benefits of the system, making its performance-price ratio optimal among similar systems and conditions.

9. Conclusions

The online monitoring technology for temperature measurement of three steel components of the cathode, is advanced, practical, and reliable and safer than manual measurements. After acceptance of the project on 74 test cells, unmanned intelligent measurement system can be gradually implemented in the rest of the potline to maximize savings compared to manual measurement costs. The automatic system practically eliminates cell tap-out accidents. After technology promotion, an automated temperature measurement system suitable for large-scale electrolysis cells can be developed to improve the company's digital and intelligent level, meeting both the company's production business process needs and maximizing benefits.

10. References

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