Study on Oxidation Resistance Technology for Aluminium Electrolysis Anode Stubs

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Abstract

The anode stubs in aluminium electrolysis operate under high-temperature and corrosive conditions for extended periods. To improve their oxidation resistance, this study used a molten infiltration coating method to prepare an anti-oxidation coating on the surface of conventional stubs. Through metallographic microscopy, scanning electron microscopy (SEM), oxidation tests, thermal shock tests, and friction-wear tests, the microstructure, high-temperature oxidation resistance, thermal shock resistance, and abrasive wear performance of the molten infiltration coating were analysed. The results indicate that the molten infiltration coating and the stub substrate undergo elemental interdiffusion, forming a strong metallurgical bond. The oxidation rate of the coating at 850 °C is only 0.52 mg/cm^2·h. Industrial tests conducted at a Chinese aluminium smelter demonstrated that the oxidization rate of the anode stubs with molten infiltration coating was reduced by 2.14 mm/cycle compared to currently used anode stubs, significantly extending the service life of stubs. This technology is important for reducing production costs in the aluminium smelter.

Keywords: Aluminium electrolysis, Anode stubs, Molten infiltration coating, Oxidation resistance.

1. Introduction

In 2024, China's electrolytic aluminium output reached 43.393 million tonnes (according to International Aluminium Institute statistics), maintaining its position as the world's largest producer for 24 consecutive years and producing more aluminium than the rest of the world for the last 12 years. In the aluminium electrolysis process, anode stubs are subjected to oxidation due to high-temperature, abrasion from electrode materials, and corrosion by the electrolyte, leading to the formation of a "narrow neck" phenomenon (as shown in Figure 1), which shortens their service life. Additionally, iron oxides formed by the oxidation of stubs enter the electrolyte, increasing iron impurity content and degrading the quality of primary aluminium [1, 4]. Currently, the protective methods for anode stubs mainly focus on technologies such as anode stub protection rings, anti-oxidation coating spraying (as shown in Figure 2), and stub wrapping [5, 8]. Among these, while the protection ring can isolate the stub from the covering material, it fails to address the issue of air oxidation and corrosion. The anti-oxidation coating spraying technology is effective in preventing anode stub corrosion. However, the coating is prone to peeling off under high temperatures and requires reapplication during each anode replacement [4, 6]. This paper investigates the oxidation resistance technology of anode stub materials. By employing a coating molten infiltration method, an oxidation-resistant alloy layer is formed on the surface of the stubs. Under high-temperature conditions, this layer can in situ generate a ceramic protective coating,

which is uniform, dense, and free from cracking or peeling, thereby providing effective protection for the anode stubs.

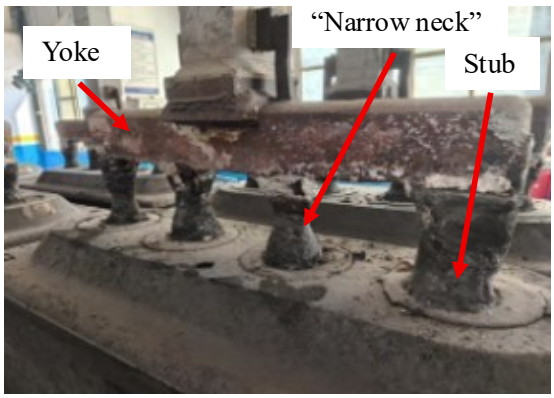

Figure 1. Morphology of oxidized/corroded stubs with "narrow neck".

Figure 2. Application of anti-oxidation coating.

2. Test

2.1 Test Materials

This test used Q235B, a type of section stub material, as the base material for the anode stubs. The molten infiltration coating material used was a powder material developed by our institute, primarily composed of a composite of alloy powder and ceramic powder. Its specific microstructure is shown in Figure 3.

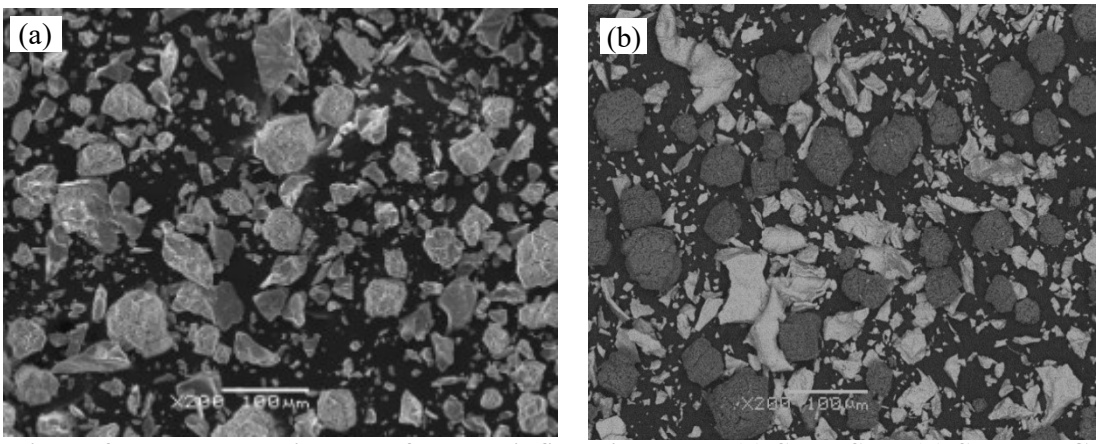

Figure 3. Morphology images of molten infiltration agent (a) SEM-SEI; (b) SEM-BEC.

2.2 Test Method

After surface derusting, the Q235B material is placed in a prefabricated molten infiltration box, which is then sealed and heated in a resistance furnace to facilitate high-temperature diffusion of elements. The molten infiltration box is equipped with a one-way exhaust device to discharge volatilized gases at high temperatures while preventing air ingress, thereby avoiding oxidation of the Q235 material.

3. Results and Discussion

3.1 Morphology Analysis

(3) The oxidation-resistant anode stubs prepared by the coating molten infiltration method have identical welding and casting processes as conventional stubs. Industrial tests have demonstrated that the oxidation-resistant stubs show an average wear rate of 0.21 mm/cycle, indicating significant oxidation resistance.

5. References

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