Study on The Wear-Resistance of Crust Breaker for Aluminium Electrolysis

Dongsheng Li[1], Guanghui Hou[2], Yanan Zhang[3], Yongfeng Cao[2], Dan Liu[1] and Junyi Ma[1]
1. Intermediate Engineer
2. Senior Engineer
3. Deputy Engineer
Zhengzhou Non-ferrous Metals Research Institute of CHALCO, Zhengzhou, China
Corresponding author: 15093294433@163.com
https://doi.org/10.71659/icsoba2024-al047

Abstract

In order to improve wear resistance of crust breaker head in aluminium reduction cells, plasma surfacing was used to prepare composite wear resistant coating on Q235 steel. Scanning electron microscope, UMT-3 friction wear testing machine and others were used to study the interface morphology and wear resistance of the surface coating. The results show that the surface coating forms a solid metallurgical bond with the carbon steel matrix, and the carbide strengthening phase is distributed uniformly in the coating material as island shapes, which effectively plays the role of skeleton and support. The scratches on the surface of the surface coating are smooth, the thickness is 150 μm, and the mass loss is only 0.06 mg. The wear resistance of the surfacing coating is more than 40 times that of the ordinary breaker material. The wear-resistant coating prepared by plasma surfacing can obviously improve the wear-resistant performance of the crust breaker head and greatly increase its service life, which is of great significance for reducing the production cost for smelters.

Keywords: Aluminium reduction cell, Crust breaker, Q235 steel, Plasma surfacing, Coating, Wear resistance.

1. Introduction

As an important part of the automatic feeding system for aluminium electrolysis cells, the crust breaker needs to periodically open the electrolyte crust surface to add raw materials. Due to prolonged frictional wear and abrasion from the hard crust, as well as abrasion from the electrolyte, raw material and high-temperature corrosion by the molten electrolyte salt, the breaker material continuously deteriorates. Eventually, this leads to a reduction in size at the end of the breaker, resulting in a "pencil tip" shape and failure [1-2], as shown in Figure 1. The commonly used materials for these breakers in aluminium smelters are Q235 steel or 45# steel, which have poor wear resistance with a typical lifespan of 3-6 months. Frequent replacement and maintenance of these crust breakers not only increase labour intensity for electrolysis operators but also raise production costs for companies. Additionally, the lost breaker material enters into the aluminium melt, leading to excessive Fe impurity content and causing a decline in original aluminium quality [3-4].

Plasma Transferred Arc (PTA) welding is an advanced technique that utilizes a high-temperature plasma as the heat source to simultaneously melt alloy powder and the near-surface layer of the work piece (Figure 2). This process involves the rapid heating, melting, mixing, diffusion, and solidification of the alloy powder and base material surface as the plasma arc moves. Upon departure of the plasma beam, self-quenching occurs, resulting in the formation of a high-performance alloy layer on the work piece surface. The key features of PTA welding technology are as follows: (1) produces various types of functional coatings; (2) forms metallurgical bonds with the substrate, ensuring strong adhesion; (3) achieves a uniform coating-substrate structure; (4) has low dilution rate for coated layers; and (5) it is easy to mechanize and automate [5-6].

This paper applies PTA welding technology to the crust breaker used in aluminium electrolysis cells to deposit a wear-resistant coating on its surface. The goal is to enhance the wear resistance of the crust breaker, thereby extending its service life, reducing impurity content in molten aluminium, improving primary aluminium quality, relieving labour intensity of workers, and lowering overall production costs.

Figure 1. Crust breaker in aluminium reduction cell.

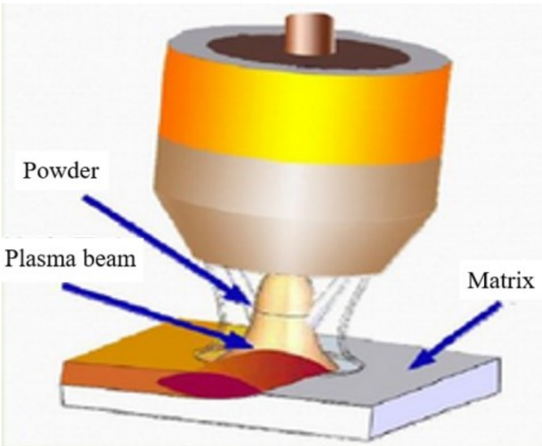

Figure 2. Schematic diagram of the PTA welding.

2. Experimental

2.1 Matrix Material

Q235 steel with excellent weld ability and low price is selected as the best matrix material. The composition of Q235 steel is shown in Table 1.

Table 1. Composition of Q235 steel.

Composition	**C**	**Mn**	**Si**	**S**	**P**	**Fe**
Content	≤ 0.22 %	≤ 1.4 %	≤ 0.35 %	≤ 0.05 %	≤ 0.045 %	remain

5. References

1. Wenxiang Jiang and Zhongsheng Su, Analysis and improvement of electrolysis aluminium hitting crust breaker head melting [J], *Henan Metallurgy*, 2006, 6: 50-56.
2. Tongshun Fu et al., Development and Application of New Anode Hoist for Aluminium electrolyzer [J], *Light Metals* 2001, 8: 39-41 (Chinese).
3. Yexiang Liu, Research and development progress of inert anode and wet table cathode for aluminium electrolysis [J], *Light Metals* 2001, 5: 26-29 (Chinese).
4. Guodong Zhang, Li Li, Nian Li and Hongmei Cao, Structure and Properties of Nickel-based Surfacing on Crust breaker Deposited by Plasma Arc Welding [J], *Journal of Mechanical Engineering*, 2014, 20: 70-76.
5. Haiying Liu, Study on Micro structure and Properties of Fe90/WCp Composite Coatings [D], *Dalian University of Technology*, 2017.
6. Yan Luo et al., Effect of Ti and Cr_3C_2 on Micro structure and Properties of the Fe-based Alloy Coatings produced by Plasma Transferred Arc Weld-surfacing Process [J], *Journal of Anhui University of Technology (Natural Science Edition)*, 2014, 31: 33-38.
7. Ming Luo, Micro structure, mechanical properties and wear resistance of Fe-based coating deposited by PTA hard facing [D], *Central South University*, 2014.
8. Lin Zong et al.; Micro structure and wear resistance of plasma clad Fe-based hard facing alloy [J], *Journal of Shenyang University of Technology*, 2011, 38: 382-387.
9. J.W. Yoo et al., The effect of boron on the wear behavior of iron-based hardfacing alloys for nuclear power plants valves [J], *Journal of Nuclear Materials*, 2006, 352 (1-3): 90-96.
10. C. Sudha et al., Micro chemical and micro structural studies in a PTA weld overlay of Ni-Cr-Si-B alloy on AISI304L stainless steel [J], *Surface & Coatings Technology*, 2008, 202 (10): 2103-2112.
11. T.B. B. Wolfe, Homogeneity of Metal Matrix Composited by Plasma Transferred Arc Welding [D], *Edmonton, University of Alberta*, 2010.