AL13 - Numerical Study and Industrial Testing on Optimizing New Anode Behavior by Changing Additional Voltage Strategies

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Abstract

Anode change is one of the necessary operations in modern aluminum electrolysis industry, which introduces huge impacts on thermal field, electric field, and cell stability. In this paper, a numerical model was developed to investigate the coupled thermo-electric-flow behavior after anode change in different locations (corner anodes or internal anodes). It was found that the effect of corner anode change on cell thermal balance is greater than that of internal anodes. It is possible to provide a larger additional voltage magnitude or a longer additional voltage time to increase the cell heat input and speed up the recovery rate of bath temperature. In this sense, two kinds additional voltage strategies were proposed and applied in corner anode change in an aluminum smelter. It was found that both strategies played a positive role in improving thermal and electrical behavior of new anodes without any thermal issues, especially for the one with longer additional voltage time.

Keywords: Aluminum reduction cell, anode change, thermo-electric-flow multi-field.

1. Introduction

The size and amperage of modern aluminum reduction cells have been continuously increasing during the past decades; now, there is even a clear evidence that some scholars have started discussing the possibility of 1000 kA cells [1]. As the heart of aluminum reduction cells, the size of anodes also shows an increasing trend. Because of anode consumption, the anodes need to be periodically replaced in 28 to 33 days. Therefore, anode change has become one of necessary operations in modern aluminum smelting industry.

The influence of new anodes (cold anodes) on aluminum reduction cells can be mainly concentrated in two aspects: a) The massive anodes with low temperature would introduce huge impact on the thermal balance of aluminum reduction pots, a new anode normally requires 16 to 28 hours of heating to gradually reach the electrolysis temperature [2]; b) The just settled new anodes would be covered by a layer of insulating solidified electrolyte, which generates notable horizontal current in the aluminum pad [3]. The magnetohydrodynamic (MHD) stability of the cell would be perturbed by this operation, and it also needs about 24 hours to pick up the full anode current. The adverse impact of anode change is embodied in the loss of current efficiency. In one such study, a current efficiency loss of 2.2 % was reported by one anode change [4].

In order to reduce the negative influence of anode change, EGA and Alcoa developed an anode preheating technology using external heating equipment [5-6]. However, there is no further public report on any industrial scale application. The extra investment of heating furnace may be a possible reason.

Actually, the picture of the behavior of new anodes is not very clear, which involves complex transient thermal and electric redistribution, bath flow, and its related solidification and melting phenomena. Most researches focused their attentions on thermal-electric coupling analysis [7] or just single flow field analysis [8]. Recently, a few scholars began to investigate the anode change process by coupling multi-field and bath solidification and melting together [2, 9]. How to improve the understanding of the anode changing process in view of multi-field and multi-level phenomena occurring, optimize the process, and reduce its impact on the steady-state operation is still one of the important emerging problems.

This paper describes a numerical model developed to investigate the coupled thermo-electric-flow behavior after an anode change at different locations (such as corner anodes or internal anodes). Then, two kinds of additional voltage strategies were proposed and applied in corner anode change to speed up its recovery rate. Both numerical analyses and industrial testing are presented in this paper.

2. Model Description and Case Setting

2.1 Model Description and Boundary Condition

A 500 kA cell containing 48 anodes was chosen as our physical geometry. In order to save computing time and resources, only the anodes and the bath layer were considered in this work. Figure 1 illustrates the simplified geometry and its boundary conditions.

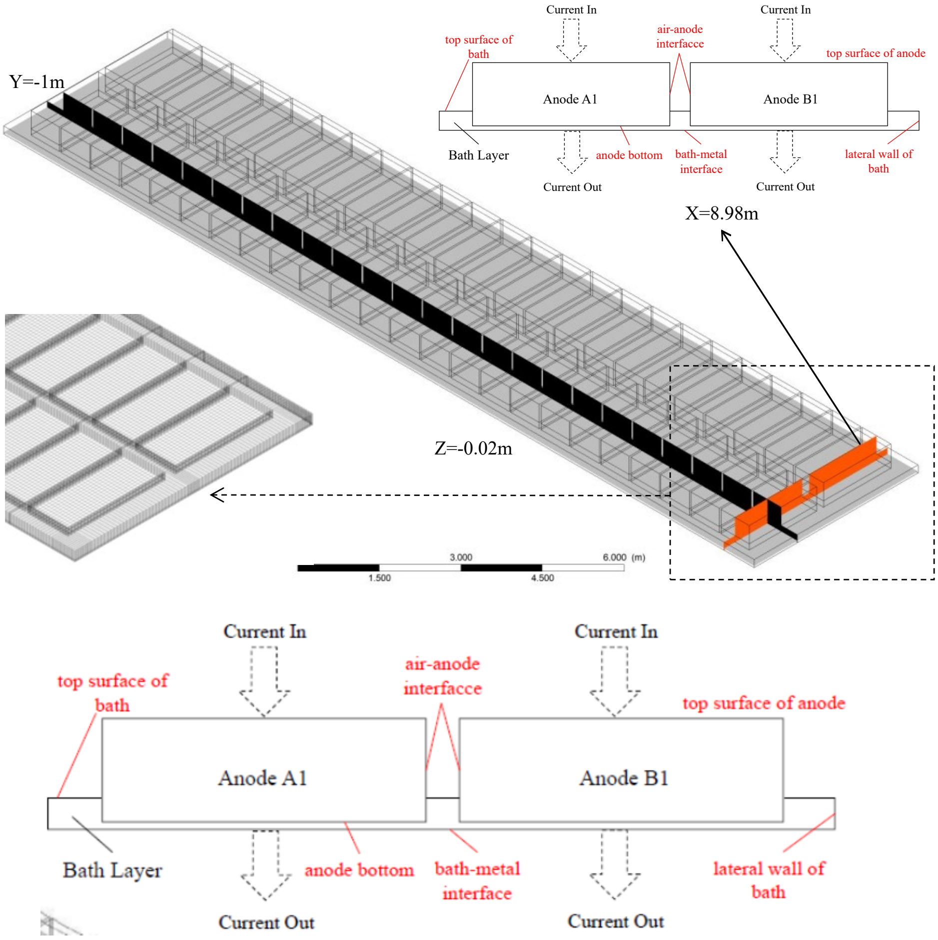

Figure 1. Geometry and boundary conditions. Bottom: upper right image magnified.

4. Conclusions

A numerical model for anode change was developed by considering the solidification and melting process of electrolyte. The model can simulate and analyze the heat balance, electric field redistribution and bath flow after anode change. The following main conclusions can be drawn from this work:

(1) Both industrial measurement and numerical analysis showed that the impact of corner anode change was greater than that of internal anode change. The temperature recovery and current pick-up rate could be improved by increasing the magnitude or time of additional voltage.
(2) The two additional voltage strategies had no obvious negative effect on the thermal balance of the aluminum reduction cell, but the one with longer time gave better results. Based on the industrial test, the aluminum plant extended this additional voltage strategy with longer time for corner anode changing to the whole potline.
(3) The method of applied different additional voltage for different locations can be extended to other kinds of aluminum reduction cells, which may play positive role in the design and optimization of industrial anode change strategy.

5. References

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