Novel Anode Baking Furnace Design for Improved Pit Temperature Uniformity and Anode Quality

Li Han[1], Yanfang Zhang[2], Yingtao Luo[3], Ziwei Su[4], Xiangyu Cang[5], Yujie Wang[6] and Qiaoyun Liu[7]
1. Senior Engineer
2, 3, 4. Professor Level Senior Engineers
5. Assistant Engineer
6, 7. Engineers
Zhengzhou Non-ferrous Metals Research Institute of Chalco (ZRI), Zhengzhou, China
Corresponding author: yanfang_zhang@chinalco.com.cn
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Abstract

With respect to the problems of large temperature differences between the upstream and downstream of the flues and uneven temperature distribution in the pits of traditional flue structure baking furnaces, this study proposes a new flue structure baking furnace. A comparative analysis of temperature distribution uniformity in the pits between traditional flue structure baking furnace and new flue structure anode baking furnace conducted through numerical modelling using CFD software demonstrated that the new baking furnace achieved more uniform temperature distribution in the pit. Test data from an industrial test of the new baking furnace conducted at a carbon plant in Baotou revealed significant improvements in temperature uniformity in the pit of the new structure baking furnace where the average electrical resistivity of calcined anodes decreased by 2.26 μΩ·m, establishing essential conditions for upgrading and enhancing efficiency in aluminium electrolysis production.

Keywords: New baking furnace, Numerical modelling, Anode quality.

1. Background

Carbon anodes in aluminium electrolysis, with the physical and chemical properties (electrical resistivity, bulk density, air permeability, CO_2 reactivity, air oxidation reactivity, mechanical strength, and thermal shock resistance) directly affecting the energy efficiency and operational stability of the electrolytic cell, are the core materials in smelting process. At present, the main open-type ring anode baking furnaces in China are largely based on the improvements of NLM Technology. With respect to the problems of large temperature differences between the upstream and downstream of the flues and uneven temperature distribution in the pits of traditional flue structure baking furnaces, although some companies have attempted to improve quality by adjusting baking curves or optimizing the thermal conductivity of fillers, limited by the fixed layout of the baffle wall of the traditional flue, there is a lack of revolutionary and viable optimization plans. In recent years, foreign researchers have conducted extensive studies and industrial tests on non-traditional (baffle wall-free) flue structure baking furnaces [1, 2], while domestic research on new baking furnaces and anode quality enhancement remains in its infancy [3–6].

Commercial software Fluent was used in this study to investigate and analyse natural gas combustion, flue gas flow, and temperature distribution in baking furnace. A new flue structure baking furnace was developed, and an industrial contrast test was conducted. The results of the industrial test show that the temperature uniformity of the new structure baking furnace has been significantly improved and the electrical resistivity of anodes in the test pit has decreased,

providing a new optimization solution for enhancing the anode quality of the carbon baking furnace.

2. Model Study

2.1 Object of Study and Physical Model

Taking a carbon plant in Baotou as the object of study, the computational domain comprises the representative part between the flue centreline and pit centreline, including flue walls. A schematic diagram of the baking furnace flue (traditional baking furnace) was established as shown in Figure 1.

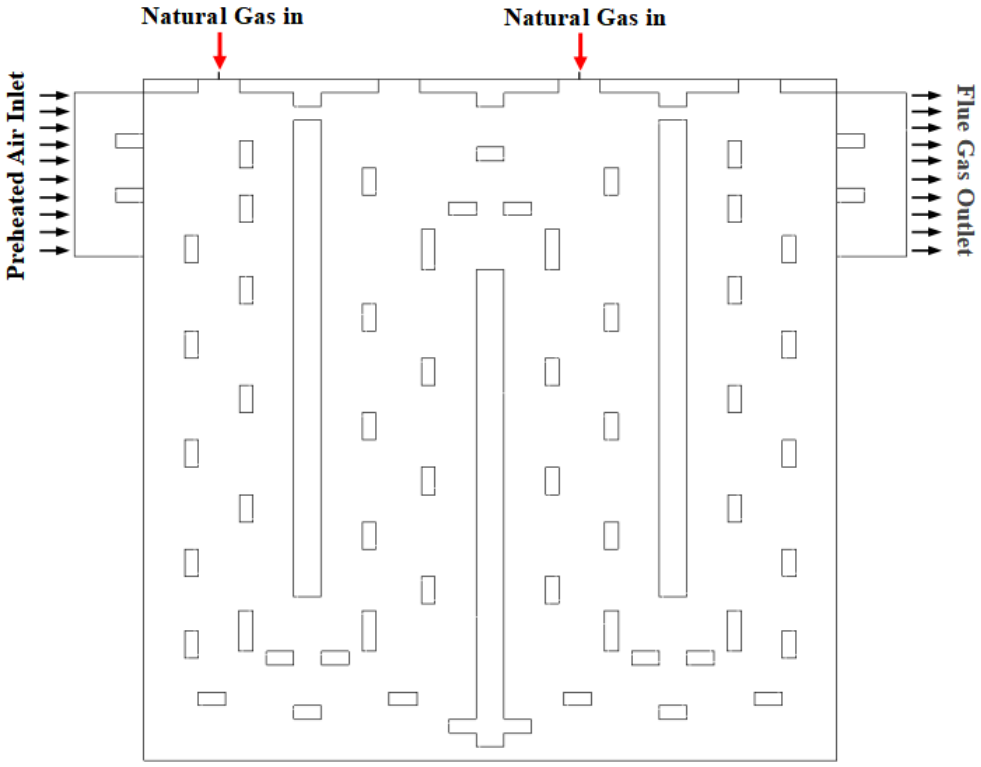

Figure 1. Schematic diagram of model structure and gas in/out.

2.2 Model Assumptions

The study focuses on the thermal performance inside the baking furnace under stable operating conditions of the baking furnace. To enhance computational efficiency of simulation and ensure accuracy of calculation results required for engineering, the following assumptions were made for the physical model:

1) Three layers of green blocks (21 closely connected vertical anode blocks) in the pit are considered as an integral anode block, regardless of gaps and fillers between individual anode blocks;

2) The inlet velocity and outlet pressure are uniform. The flue gas temperature at the inlet of the flue is the average value of the flue gas temperature at the outlet of the previous section;

6. References

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