Thermo-Electrical Analysis of an Anode Design

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Abstract

Anode design has significant effects on power saving of aluminium production. In this paper, the effects of an existing anode design on anode voltage drop have been investigated using thermo-electrical analysis. In this design, used currently in some Chinese smelters, a pin was added in the bottom of the centre of the stub hole. This part, originally designed for rodding process, could help to reduce the anode total voltage drop through improving the electrical contact resistance between cast iron thimble and carbon. For this purpose, a thermo-electrical model was developed using ANSYS software and different contact scenarios were taken into account in order to estimate the anode total voltage drop reduction. Simulation results show that this design leads to a non-negligible voltage drop reduction ranges from 2.3 to 5.6 mV, which can bring electrical cost saving from 145 792 $ to 353 206 $ per year for a smelter producing approximately 500 kt/y of aluminium, if the energy cost is 40 $/MWh.

Keywords: Aluminium production, anode design, anode voltage drop, thermo-electrical analysis.

1. Introduction

Primary aluminium production is a high-energy consumption process. The power consumed is about 13.0 kWh/kg Al, but the electric energy efficiency is only about 50 %. What's more, the CO_2 emission due to the aluminium production is also a problem. In modern aluminium reduction process, the anode voltage drop is over 300 mV, according for 7.5 % of the total voltage drop [1]. Therefore, the optimization of the anode design is of great interest and could help to reduce the power consumption of Hall-Héroult process.

Researchers have tried different designs to reduce the anode voltage drop, especially the stub to carbon contact voltage drop. Tsomaev [2] proposed an anode design which uses a mechanical assemble instead of pouring cast iron in stub hole. The “stub” has a bigger head on its end, and the anode has a slot with the same shape (Figure 1). Its advantage is that there would not be air gap without cast iron. What’s more, the contact area increased. However, this one is difficult to maintain if the “stub” deforms with time.

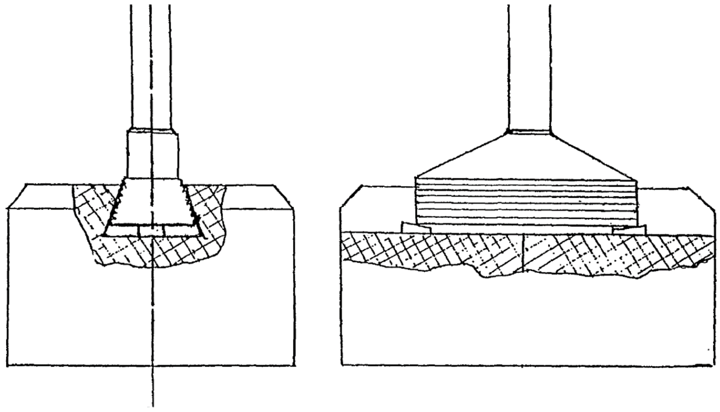

Figure 1. The stub proposed by Tsomaev [2].

Fafard et al. [3] has also published a patent about a new kind of anode connection method, as shown in the Figure 2. There is a slot on the top of the carbon block where the stub can be put into it. This design can increase the contact area between the cast iron and the carbon which will lead to a reduction of the electrical contact resistance. However, the rodding process would be very complicated due to the geometry of the stub.

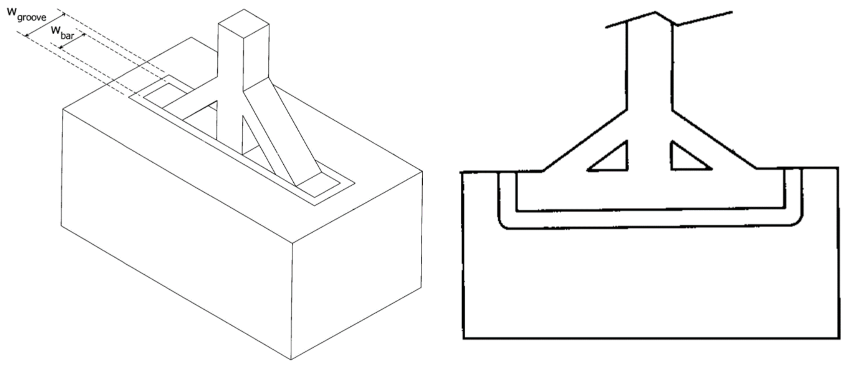

Figure 2. The anode proposed by Fafard et al. [3].

Tremblay et al. [4] also proposed a new anode design where only one stub hole is used and metal components were incorporated in the anode as shown in Figure 3. During the anode baking process, metal connectors are sealed to the carbon block with such a design it is expected that the air gap induced by the shrinkage of cast iron will be reduced. Furthermore, it can lead to a reduction of the electrical contact resistance. Nevertheless, the effect of metal components on the anode behavior, especially clearing the baking process, has to be investigated.

Postdoctoral Science Foundation (Grant No.2017M610183), the National Natural Science Foundation of China (Grant No. 51228401, 51529401, 51434005, 51574070, 51474060), the National Key Technology Research and Development Program of the Ministry of Science and Technology of China (Grant No. 2012BAE08B01) for supporting the present research. A part of the research presented in this paper was financed by the Fonds de Recherche du Québec-Nature et Technologie (FRQNT) by the intermediary of the Aluminium Research Centre-REGAL.

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