"Two-Step" Preheating of New Anodes with Anode Butts Wasted Heat

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Abstract

In order to reduce the energy requirement to make the aluminum metal and more importantly to reduce the cell thermal perturbation of the anode change operation, it would be beneficial to preheat the new anodes using the otherwise wasted heat of the anode butts. Several methods to do so have been either experimentally tested or modeled. Some have even been patented and industrially tested. Yet none have been implemented in smelters up to now. The preheat methods imagined so far are either not sufficiently efficient or too complex to implement logistically. A new two-step preheating method has been imagined and modeled. Obtained results are presented here.

Keywords: Anode preheating, thermo-electric model, waste heat usage, FEM simulation

1. Introduction

The idea of using the wasted heat of anode butts to preheat new anodes is not new. About 10 years earlier, the opportunity to reduce the process energy requirement and to stabilize the process was investigated by Fortini, Nowicki and Gosselin, [1,2]. Industrial tests were reported in China in 2017 by Song [3], and the technology was patented in China in 2013 by Wang, H. and co-workers [4], in which it was reported that natural air convection preheating technique could bring the new anode to 80 °C in 2 to 3 hours.

A preheating technique relying on direct conduction was evaluated in tests in Norway and reported in 2020 by Grimstad, M., Elstad, K. R, Solheim, A, Einarsrud, K. E, [5]. The preheating technique required two anode butts to preheat one new anode. The work led to tests using mathematical modeling of a more efficient configuration of direct conduction preheating that turned out to be four times more efficient [6]. In the more efficient configuration, the bottom face of the new anode is placed in direct contact with the bottom face of a hot anode butt. Testing this preheating configuration in a mathematical model was not a problem but performing it in practice would have been challenging!

Up to now, no efficient and practically manageable way of preheating new anodes using the wasted heat of anode butts has been industrially implemented. The present work aims at evaluating another method to preheat anodes using heat from anode butts using mathematical modeling. That new method still relies on direct conduction preheating on the new anode bottom face, but in a "two-step" process. In the first step, the anode butt is removed from the cell and placed in an insulating box directly on top of a metal block or plate of cast iron or copper. The anode butt is kept in the box long enough for the system to reach its thermal equilibrium. After that, the anode butt can be removed at any time, the box containing the preheated metal block or plate is carefully closed, in order to maintain the achieved preheat temperature. The second step consist of putting a new anode into the box in contact with the heated metal block just at the appropriate moment before the anode change in order for the bottom face of the new anode to reach its maximum temperature. That correct moment depends on the type of metal used and the thickness of the metal block.

In this study, the modeling work was conducted using an ANSYS® 12.0 based 3D transient thermal model for 3 different metal categories put in the bottom of an insulated box: a cast iron block, a copper block and a copper plate. Modeling results indicated which of those the 3 configurations is optimum for the preheat of the new anode and corresponding maximum bottom face temperature obtained for new anodes.

2. Case 1: Cast Iron Block (225 W/m^2 °C)

The first configuration modeled was using a cast iron block in the bottom of the insulated box. In Case 1, the thickness of the cast iron block is the same as the thickness of the anode butt.

The initial run simulates the transient evolution of the first step where the anode butt is removed out of the cell with a bottom surface temperature of 959 °C, and put into the insulated box in contact with the cast iron block which is at potroom temperature (20 °C). Figure 1 presents the initial temperature of the anode butt (top position) and metal block (bottom) system. Figure 2 presents the final temperature of the cast iron block after 4 hours of exchange with the anode butt.

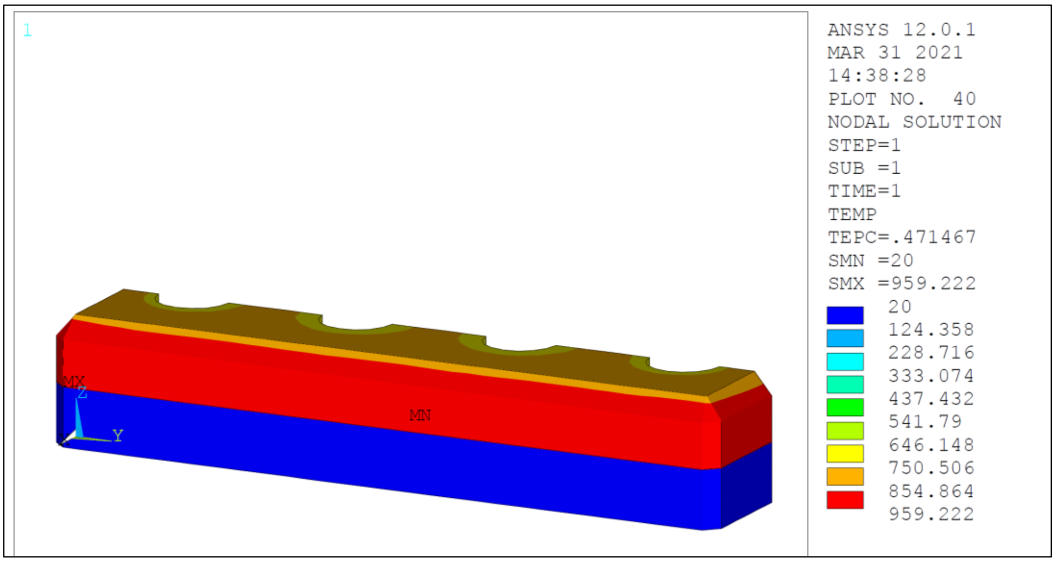

Figure 1. Initial temperature of the butt-cast iron block system for the first cycle.

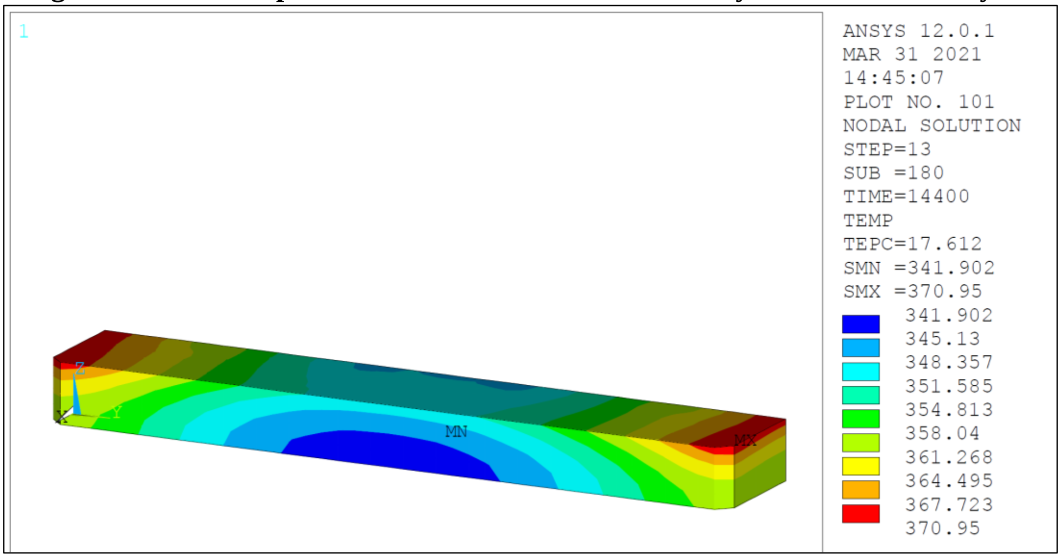

Figure 2. Temperature of the cast iron block after 4 hours for the first cycle.

8. References

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