Real Anode Temperature Measuring - From Investigations to a New Standard

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Abstract

Production of aluminum by smelting process is a highly energy-intensive task. The baking quality of carbon anodes plays a significant role in efficiency of the whole process. Underbaking or overbaking of the anodes is ongoing with substantial losses and/or troubles in the electrolysis due to unstable process conditions. Consequently, a highly controlled baking process is a guarantee for stable and good anode properties as well for the most energy efficient and environmentally friendly operation. The perfect anode baking process is mainly driven by correctly adapted baking curve with the target to reach the specified final anode temperature, smoothly. Therefore, it is important to know the final anode temperature for fine-tuning the system and adjusting the baking process. Unfortunately, a constant measuring of this temperature is not possible owed by the furnace concept, the process as such and the kind of anode handling. Prove of the final anode temperature is occasionally done by the so called “Equivalent Temperature” method that is quite complex and time-intensive, although that method is only reflecting the finally reached temperature and no temperature profile can be detected over the long baking process. It is of highest interest for a baking furnace technology provider to have a real anode temperature method available in order to optimize running facilities with the output of maximized anode quality, homogeneity and operational effectiveness, as well as design verification purposes with required feedback for the constant further system development. This paper describes the thesis at the beginning of the development that establishes a measuring procedure to receive the real anode temperature, since based on the state of the art for real anode temperature measurements in anode baking furnaces, it is known that no meaningful measurement procedure is currently available. Therefore the most common measuring procedures in this industry were researched and analyzed based on their accuracy and informative values. The investigations result in a clearly specified measuring method that has been verified in the field, and became an in-house standard as part of baking furnace performance tests, meanwhile is widely used for process analysis and consequential process optimizations.

Keywords: anode baking furnace, real anode temperature, baking curve, anode quality, furnace design.

1. Introduction

Industrial extraction of aluminium from alumina is via Hall-Héroult process. This energy-intensive process, which is known as smelting process, takes place in a molten cryolite-based electrolyte in presence of carbon anodes. Those carbon anodes are separately baked in an Anode Baking Furnace (ABF) before they be embedded in the fused-salt electrolysis. The baking quality of those carbon anodes plays a significant role in the efficiency of the whole smelting process [1,2]. Any deficiency in the baking process such as underbaking or overbaking of the anodes, off-target heat up gradient, etc. can lead to consequences as increased anode

consumption, unstable electrolysis process conditions or significantly higher energy consumption [1-3].
Therefore, baking high quality anodes homogeneously is a crucial step in the aluminium production industry. A highly controlled baking process is a guarantee for stable and suitable anode properties, as well as for the most energy efficient and environmental friendly operation. An optimized anode baking process is mainly driven by correctly adapting the baking curve with the target to reach the specified baking level, in such a manner to fulfill the specified heat up gradient criteria as well. Therefore, it is important to observe the anodes temperature during the process to fine-tune the system and adjust the baking process. This in turn requires implementation of a proper real anode temperature measurement standard method.
This paper is focused on the open top ring pit Anode Baking Furnaces as the widely-used ABF technology. In an open top ABF, green anodes locate inside the pits surrounded by two hollowed cavities called Flue Wall (FW), schematically shown in Figure 1 [1]. The flue gasses flowing through the FWs are guided by the Baffles and Tie Bricks, and exchange their heat with refractories, packing cokes and anodes. In ring pit furnaces, the loaded anodes remain stationary during the baking process, and all the firing equipment move around the furnace, shifting section-by-section by connecting into the provided peepholes.

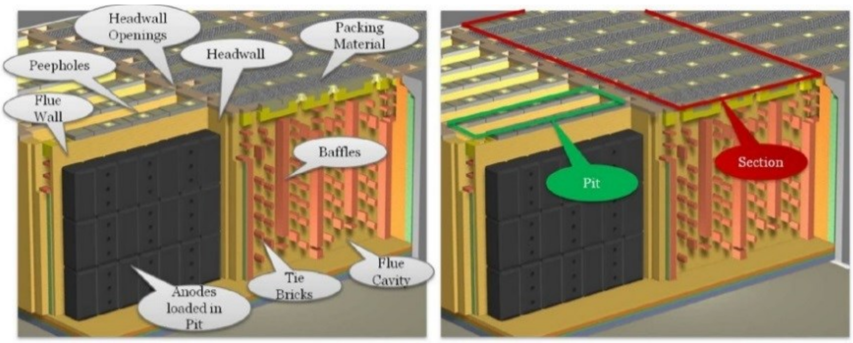

Figure 1. Schematic view and technical terms of an ABF

Considering a single pit, different anodes can experience different heat treatments during the process. The anodes close to the top and bottom of a pit are exposed to higher heat dissipations. Furthermore, different local heat distribution and flow pattern inside surrounding FWs as well as existence of occasional hot spots around burner flames and pitch burn area lead to different special heat treatment of anodes in a pit [1,2].
Due to the overall furnace concept, the baking process and the kind of anode handling, a continuous surveying of the baking level is not possible unfortunately. There are different methods as a proof to assure that the final target anode temperature is reached [1,2,4,5]. The most common method for that purpose is called “Equivalent Temperature” method in which the baking level is determined by analyzing crystalline structure characteristics of baked anodes [4,5].

As it is illustrated in Figure 2, the crystallite size of petroleum cokes, Lc, and anodes are related to their maximum reached temperature. In order to determine such relation a pre-calibration is required to link the crystallite size, Lc, with the baking level [2,4,5]. Therefore, initially small samples of petroleum coke are baked in laboratory up to 1500 °C. Concurrently, authentic samples are taken out from the baked carbon anodes with a drilling machine, small enough to keep the anodes intact for later use in the smelter [2,4].

5. References

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