Controlling the Electrical Resistivity of Vacuum Vibrated Anodes while Maintaining High Density

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Abstract

The use of vacuum on modern compactors producing anodes for aluminum smelting has become widespread due to the increase in density and improvement in other anode properties that can be achieved. In response to EGA's Jebel Ali smelter increasing metal production in the potlines, the Carbon Plant increased anode size and retrofitted both Paste Plant compactors with vacuum. This allowed the larger anodes to be made with higher densities than previously. In the period following the retrofit, there were issues with unexpectedly high anode electrical resistivity values. This paper summarizes the work done in the Carbon Plant to regain control of anode electrical resistivity without losing the desirable increase in anode density.

Keywords: Carbon paste plant, vibrocompactor, vacuum compaction of anodes, anode electrical resistivity, anode density.

1. Introduction

Emirates Global Aluminium produced 2.6 million tons of cast metal in 2017 from two production sites - Jebel Ali, which operates 6 different cell technologies, and Al Taweelah, which operates 2 different cell technologies. The original cells at EGA were started in 1979 at Jebel Ali with the plant expanded with more modern cell technologies at regular intervals since then. The Al Taweelah site was started up in 2009 and expanded in 2013 - 2014.

To support further amperage increase at JA plant, EGA has decided in 2014 to upgrade its anode production unit to be able to produce anodes up to 1600 mm long [5]. The project included the revamping anode forming and cooling sections, anode conveyors, cleaning machines, baking furnaces height increase and adding anode slot cutting machines. The upgrade of the forming machine provided the opportunity to include the state-of-the-art features such as vacuum, top counter pressure and density control. After the retrofit the plant faced challenges in maintaining anode quality mainly in terms of anode electrical resistivity. In this article we will share what are the advantages observed and the difficulties we faced after the introduction of vacuum compaction, the investigations conducted and the process changes made to improve anode resistivity. We will also discuss the impact of anode resistivity change on performance of the reduction lines.

2. Advantages of Vacuum Compaction

2.1. Forming at High Temperature

Forming anode at higher temperature can increase anode density for a given paste quality as the fluidity of the paste allows a better compaction. But with atmospheric pressure compaction, there is a threshold forming temperature (generally between 148 to 150 °C) above which the risk of anode cracking is very high. Compacting under vacuum allows going beyond that threshold without cracks, hence allows increasing anode density. During our trials at EGA Jebel Ali, we observed a gain of density of around 0.008 g/cm^3 with an increase of forming temperature of 10 °C. (See Figure 1). After the upgrade we have increased forming temperature by 15 °C. Forming at high temperature can also help reducing the amount of water required for paste cooling providing the opportunity to explore higher mixing temperatures.

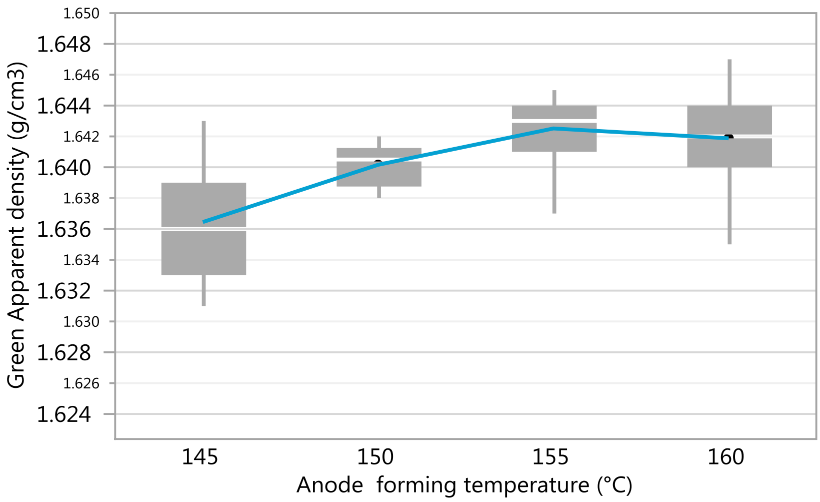

Figure 1. Green anode density and forming temperature.

2.2. Anode Density Improvement

Vibroforming under vacuum was introduced in anode manufacturing in the late 1980's. The principle was to remove air, water vapours and pitch fumes entrapped in the paste, hence reducing the porosity of the paste and increasing density.

Trials conducted at EGA have provided some more insights on the mechanism of densification by vacuum. We found that apart from the impact of forming at higher temperatures discussed above, anode formed under vacuum has higher dimensional stability after ejection. By comparing the height of the anode at the end of the compaction and after ejection, we found that anode formed without vacuum expanded by 6 mm (in height) while there was no expansion for anodes formed under vacuum. Vacuum formed anode could retain in full the density achieved during compaction, while the anode formed at atmospheric pressure shows a reduction of its apparent density by 0.015 g/cm^3 due to "swelling". Figure 2 shows the contributions of forming temperature and dimensional changes after ejection to anode density.

However, vacuum formed anodes have also shown higher electrical resistivity due internal cracking during baking. The deterioration of anode electrical resistivity has led to higher instability in cell operation and a significant increase in anode problems, impacting overall plant performance. To improve anode electrical resistivity while retaining the density improvement, EGA had to find process adaptations other than switching off the vacuum. Several trials were conducted focusing on recipe changes, mainly on reducing percentage of fines fractions in the recipe. The results of the trials showed that a reduction of fines by 9 % from the reference recipe lowered significantly the anode resistivity. After full scale implementation of the best trial recipe, the objective of reducing anode resistivity while maintaining higher anode density was achieved.

These results demonstrate the importance of using extensive data analysis, plant trials and design of experiments to investigate deviations and improve the process and the quality.

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