Coating of Anodes to Reduce Air Oxidation

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Abstract

The three major factors that contribute to high net carbon consumption are air burn, reaction with carbon dioxide and carbon dusting. Baked anodes are subjected to air oxidation mainly because of improper covering and redressing activities, porosity and thermal conductivity of the baked anodes and presence of chemical catalysts. Air burn leads to higher top oxidation and reduced butt weight, which in turn increases carbon dioxide emissions. However, using a coating material on the top and the four sides of the anodes can help prevent severe air burn by forming a barrier against the penetration of oxygen inside the pores, thereby reducing the top oxidation by 3-4 mm and increasing the butt weight by 15 kg, and increasing the air reactivity residue. The application of this coating material can reduce the cut-butt percentage significantly, especially for the anodes near breakers, help improve the butt profile, and reduce carbon footprint by a significant amount. Several trials have proved that there is no impact on the pot parameters like noise, voltage, bath temperature, excess AlF_3 and anode top temperature. The coating material does not affect the metal purity nor the covering material composition and chemical composition of the anode butts. Unlike other conventional methods to reduce air burn, the application of this coating material offers several advantages from economic as well as safety point of view.

Keywords: Net carbon consumption, Air burn, Anode top oxidation, Butt weight, Carbon footprint.

1. Introduction

In an electrolytic cell, the theoretical carbon consumption for producing 1 t of aluminium is 334 Kg, according to the reaction:

$$2Al_2O_3 + 3C = 4Al + 3CO_2 \tag{1}$$

However, the net carbon consumption (NCC) is much higher, mainly due to air burn, carboxy reaction an dusting [1], and varies typically, between 400-450 kg C/t Al. The chemical reaction of air burn is given by:

$$C + O_2 = CO_2 \tag{2}$$

The presence of chemical catalysts like iron, vanadium, titanium, nickel, calcium, sodium, lead, copper, zinc, etc., further aggravates the air burn. The most widely followed practice in aluminium smelters to prevent air burn is by covering the surface and sides of the anodes with a layer of crushed bath and alumina (28-35 % of alumina). However, sometimes due to improper covering of the new anodes or due to improper redressing of anode cover, the anodes, especially near the breaker region are subjected to a high amount of air burn, which in turn reduces the net carbon consumption.

There will be air burn of the baked anodes at temperatures above 450 °C if there is enough air access to the anodes and as the temperature of the anodes increases, the intrinsic air burn rate increases rapidly, following a typical Arrhenius exponential plot. The air burn reaction can be classified into three major zones: (a) diffusion-controlled (b) mixed zone and (c) reaction-controlled zone. At around 600 °C, the reaction rate becomes controlled by the rate of supply of oxygen gas and it typically depends on the integrity of the anode cover; anode properties have little role, in such a case. However, if it is possible to cover the pores of the anodes properly, with the help of a coating material, the supply of oxygen gas to the pores will be cut off, thereby reducing the risk of air burn.

To date, a large number of techniques have been employed by smelters worldwide to reduce air burn, like use of aluminium spray on the surface of the anodes [2], addition of boric acid to the anode paste [3, 4], but each technique, has its own inherent limitations, either due to safety hazards or due to impact on metal purity.

In this paper, we will show the results of alumina-based coating [5]. In our case, a 1 to 1.5 mm thick alumina-based coating, when applied properly, has been found to sufficiently reduce the cut butt percentage, reduce the top surface oxidation and increase the butt weight, thereby reducing the carbon footprint of the aluminium smelting process. The drying and curing time of the coating, although dependent on the relative humidity (RH), has been found to be fully cured in no more than two hours with air drying. The coating has been found to last more than a week and has been effective in reducing the high air burn in the crust breaker regions. Also, since there is a delay of about 4-8 hours, after anode change before covering the new anodes, this coating has been found to be effective in stopping the air burn between the completion of the anode change and covering of the new anodes.

2. Experimental Procedure

A systematic procedure was adopted for testing the integrity of the in-house developed coating solution for baked anodes. At first, a laboratory-scale trial (Stage-1) was conducted to assess the performance of the coating material. Two samples of drilled anodes were coated with coating recipe of different compositions by weight. Along with a normal non-coated drilled baked anode sample, the three samples were subjected to an air reactivity residue (ARR) test in the laboratory for 10 hours at 550 °C as shown, in Figure 1.

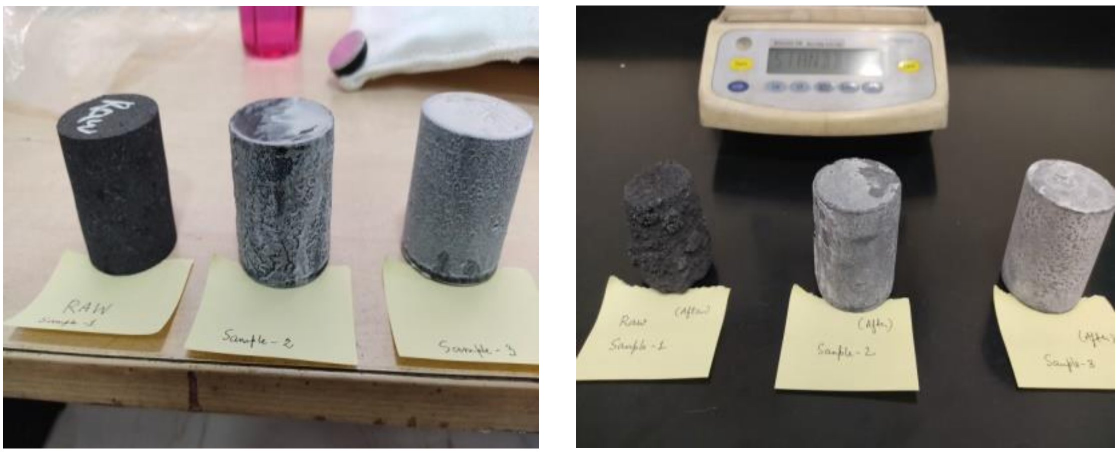

Figure 1. Air reactivity test of coated anode samples. Left: before, Right: after.

Following the lab scale trials, the constituents were mixed thoroughly, using an agitator in order to ensure homogeneity and the coating trial was manually applied on the surface of the previously weighed baked anodes on the top (excluding the cast iron collar) and the long sides and the short sides and the anode samples were used in a total of four pots in two plants for two anode change cycles (Stage-2). Pot parameters, such as anode current density, pot average voltage, noise, bath

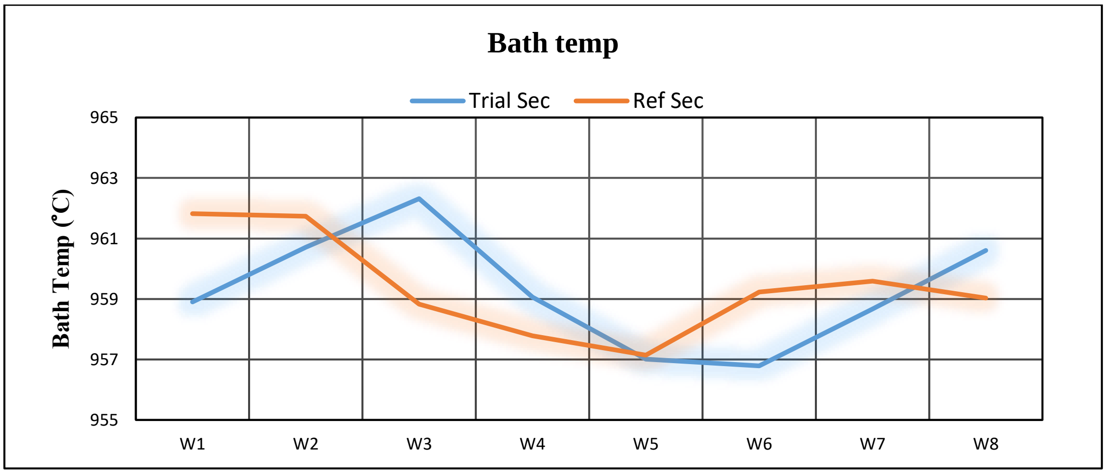

Figure 20. Average bath temperature weekly trend (Sec = Section).

4. Conclusions

We conclude that the use of the coating material has the potential to reduce air oxidation and net carbon consumption (NCC), without affecting pot parameters and composition of the butts. There is a butt weight increase of around 15 kg and a top oxidation reduction by 3.1 mm which is equivalent to a NCC reduction of 5-6 kg C/t Al. This NCC reduction in turn reduces the environment impact and thus, is a very cost-effective solution for reduction of carbon footprint. It can be seen from the age-wise study on butt weight and top oxidation, that there is a sharp rise in top oxidation and a sharp decline in butt weight after 10 days, indicating the end of the life of the coating at that stage of the anode life.

Despite the higher average vanadium content in the Plant-2 anode samples, the coating has proved to be effective in reducing the rate of air burn. This coating application also is better than conventional techniques from safety point of view. There is no chance of coating material breaking off even when the anodes bump against each other or during transportation from the rodding shop to the potline. In line with the encouraging results from the lab-scale and bench-scale trials, we are working on automating the coating application process in our rodding shop, with minimal manual intervention and no compromise on the quality of the coating application and the rodding cycle time.

5. References

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