Studies on Influence of Recycled Anode Butts on Properties of Prebaked Anodes used in Aluminium Electrolysis

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Abstract

In the electrolysis process of aluminium, anode butts are recycled and used together with calcined petroleum coke and coal tar pitch for the manufacture of prebaked anodes. The dry aggregate of green anode consists of 25-35 % butts along with various fractions of calcined petroleum coke. The quality of these butts has a strong influence on the properties of the anodes. This paper covers few studies carried out at NALCO (National Aluminium Company Ltd) smelter plant to investigate the effect of quantity and quality of butts on properties of anodes. It has been observed that increased quantity of butts in the anode recipe helps in improvement of mechanical properties of anodes whereas use of improperly cleaned butts and soft butts have a deleterious effect on the reactivity behaviour of anodes.

Keywords: Aluminium electrolysis, Prebaked anodes, Recycled butts

1. Introduction

The Hall-Héroult process used to produce aluminium uses carbon anodes as positive current carriers. These anodes get consumed during the electrolysis process and need to be replaced on a regular basis. For production of one tonne of aluminium metal about 1.95 tonne of alumina and 0.45 tonne of carbon are required. The useful life of an anode inside the electrolytic pot is around 24-25 days. The unconsumed part of anode is called spent anodes or anode butts, which upon removal from the cells are cleaned for removal of adhering bath material. The cleaned butts are further processed for recycling into the carbon making process.

The NALCO smelter plant potlines with a production capacity of 0.46 million tonne aluminium production per annum consists of 960 AP18 technology cells. A direct electrical current 180-185 kA is passed through the electrolyte, entering the cell through prebaked carbon anodes and conducted out of the cell through steel current collector bars that are fixed in the carbon lining. The aluminium oxide is decomposed into aluminium and oxygen. The aluminium metal deposited at the bottom acts as cathode. The oxygen formed then reacts immediately with the carbon anode to form carbon dioxide and carbon monoxide. The overall reaction is represented by the following equation (1) assuming no CO is formed.

$$2Al_2O_3 + 3C = 4Al + 3CO_2 \quad (1)$$

The prebaked anodes are manufactured in the NALCO carbon plant which is equipped with two green anode plants, three anode baking furnaces and two rodding shops. Prebaked anodes of size 1450x1000x550 mm and weight 1185-1190 kg are used in NALCO pots. The anodes are made of 55-65 wt% petroleum coke, 14-17 wt% coal tar pitch and 15-30 wt% recycled anode butts and are replaced on a regular schedule in 72 shifts (24 days) or 76 shifts (25.3 days) depending on anode quality. As per the design of the rodded anodes usually 70-75 wt% of the anodes is consumed and the residual 25-30 wt% of the initial weight of the anodes (butts) are sent to rodding shop for recycling. These anode butts are cleaned of any adhering particles of bath (electrolyte) in the butt cleaning shop, shot blasted, crushed and are then recycled back to green anode plant for the production of new anodes.



(a) **(b)** **(c)**

Figure 1. Images of (a) full anode, (b) anode butt with cover material and (c) cleaned anode butt.

Because the anode butts are re-used, their quality features are of great importance. It is well known that the amount and cleanliness of the butts influence anode physical properties such as the mechanical strength as well as the reactivity behaviour, thus have a strong impact on the properties of the anodes. The quality of butts is dependent on anode quality and performance of anodes during pot operation. It has been ascertained that good butts are hard, have low sodium contents, a high ignition temperature in air and low reactivities in CO_2 and air. Butts of bad quality are soft and very reactive. It was found that when poorly cleaned or soft anode butts are used, the anode quality suffers considerably [1]. The butt quality, quantity used and their influence on the anode quality have been examined and described in this paper.

2. Role of Anode Butts in Anode Making Process

Anode butts though recycled back are one of the major raw materials for anode making. All smelters are equipped with butt cleaning and stripping facilities in the rodding shop. Bath material sticking to the butts are removed first and then anodes are shot blasted for removal of residual bath from the surface of the anodes, crushed and recycled back to green anode plant. The ideal butt properties are low sodium content, hard butts, low air and CO_2 reactivity and high ignition temperature [2].

In any aluminium smelter, visual inspection of butts after shot blasting stage provide an indication about

- Anode quality used in the electrolysis process
- Anode behaviour in the electrolysis process
- Anode butt cleaning efficiency

The butt height and weight help in calculation of net carbon consumption, presence of any bath layer on the surface of butts indicate about the cleaning efficiency of shot blasting operation. Increase in sodium level in anodes is attributable mainly to improper cleaning of butts. Effective cleaning of butts ensures low sodium content in anodes. The height of anode butts under the pin help in deciding the shift cycle.

It was observed that the butt weight can be predicted from butt height provided the butts generated have good shape and contour with more than 90% cross-section. However, the height of butts with exposed pins, cracks, excessive reactivity cannot be considered for the butt weight calculations.

From the butt weight data, net carbon consumption was derived for an operating current 185 kA, current efficiency 94 %, anode density 1.54-1.55 g/cm^3 ,assuming constant normalised baked anode weight and anode life 24 days with 16 anodes in one pot, as shown in Figure 7.

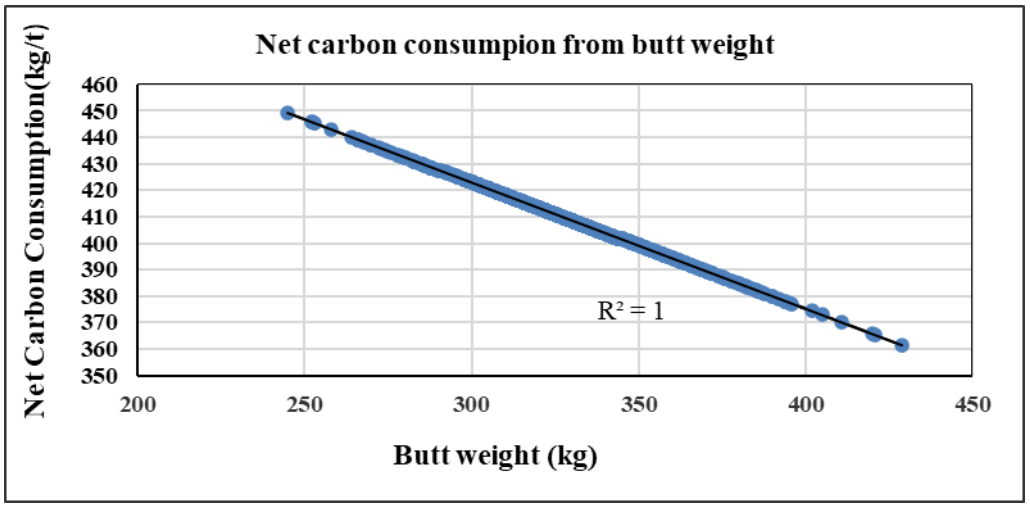

Figure 7. Correlation between butt weight and net carbon consumption.

It can be seen from the graph in Figure 7 that net carbon consumption kg C/tonne aluminium metal can be predicted theoretically from the measured butt weight in this manner and actions can be taken to improve the same.

4. Ongoing R&D Work – System Improvement

An inline automated butt inspection system developed by R&D has been installed in one rodding shop of carbon plant for continuous monitoring and analysis of anode butt parameters. The data e.g., butt height, butt weight, presence of bath on the surface of butts, carbon under the pin is recorded on a continuous basis.

5. Conclusions

From the studies carried out on the influence of quality and quantity of butts on anode properties, the following conclusions can be made:

i) Quality and quantity of anode butts play a significant role in prebaked anode making process. Good anode quality not only depends upon good quality of raw materials such as calcined petroleum coke, coal tar pitch but also depends upon good butt quality and quantity to be used in anode making.

ii) Butt hardness measurement can be employed as a tool for assessing the quality of butts generated from the electrolysis process. It provides an insight about the performance of anodes used in the electrolysis process so that improvements can be made in the carbon plant process and pot operation parameters.

iii) Carbon plant may maximize recycling of cleaned butts for anode making as increased quantity of butts in anode recipe helps in improvement in mechanical properties of anodes. Only limiting factor to watch for is sodium. Up to 35% anode butts in course

fraction of anode dry aggregate can be used safely without affecting any quality parameters of anodes.

iv) Increased sodium in anode butts which could be due to improper cleaning of butts, diffusion of Na from pot bath has a deleterious effect on reactivity behaviour of pots.

v) Soft butts and impregnated butts may be removed from the process loop and discarded as they contain very high level of sodium which has deleterious effect on anode quality and pot operation.

vi) Net carbon consumption can be predicted from butt height and butt weight.

vii) Study results and information presented in this paper would be helpful to smelter plant personnel in understanding the role and importance of anode butts in aluminium electrolysis process.

6. References

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