Compendium of Climate Change Mitigation Practices at NALCO Smelter

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Abstract

National Aluminium Company Limited (NALCO) is one of the largest integrated bauxite-alumina-aluminium power complex in India. The company has been operating its captive Panchpatmali bauxite mines for the pit head alumina refinery at Damanjodi, in the District of Koraput in Odisha and aluminium smelter and captive power plant at Angul in Odisha. As a part of green initiative, NALCO has installed 198 MW wind power plants at various locations in India and 800 kW roof top solar power plants at its premises to join hands for carbon neutrality. NALCO is also adapting to sustainability challenges by continuously developing and implementing strategies and processes to abate and mitigate greenhouse gas (GHG) emissions and other pollutants at its mines, alumina refinery, smelter and captive power plant. In this paper, the innovative climate change mitigation technologies adopted in the smelter plant of NALCO through the efforts of research and developmental work, have been highlighted. CO_2 reduction through implementation of slotted anodes and higher stub hole depth anode technologies, low energy cell development technology and boric acid treatment of anode technologies have been elaborated.

Keywords: Greenhouse gas (GHG) emissions, Sustainability, Climate change.

1. Introduction

Aluminium is produced conventionally by the Hall-Héroult process, by the electrolysis of alumina dissolved in cryolite containing molten electrolytes at temperatures around 955-960 °C. In these Hall-Héroult cells, the anodes are usually prebaked carbon blocks which are electrochemically consumed.

The overall chemical reaction in the aluminium production is summarized as in Equation (1).

$$2Al_2O_3 \text{ (dissolved)} + 3C \text{ (solid)} \rightarrow 4Al \text{ (liquid)} + 3CO_2 \text{ (gas)} \tag{1}$$

Aluminium production is highly energy intensive and energy typically counts for roughly 30 to 40 % of the aluminum production cost and its price is, therefore, highly significant for the economy of the process. Energy consumption of aluminium production has decreased in recent years employing technological improvements in the process. Nevertheless, with the global demand for electric energy increasing steadily, energy savings in all parts of the production process is a very important task for aluminum producers. Moreover in India where aluminium production is dependent on coal based thermal power plants, energy conservation is vital for addressing the climate change phenomenon. The smelter of National Aluminium Company Ltd (NALCO) is located in the city Angul in the state of Odisha, India and has an installed capacity of 0.46 million tonnes of aluminium per year. The smelter has 960 electrolytic cells in four AP18 potlines. The AP18 electrolytic cells use prebaked carbon anodes, manufactured in two captive carbon plants. There are two green anode paste plants, three baking furnaces and two rodding plants operating the latest technologies.

The innovative climate change mitigation technologies adopted in the smelter plant of NALCO through the efforts of research and developmental work, are described in this paper. CO_2 reduction through the implementation of slotted anodes and higher stub hole depth anode technologies, low energy cell development technology and boric acid treatment of anode technologies have been elaborated.

A. Higher stub hole depth in anodes
B. Slotted anodes
C. Low energy cell technology development
D. Boric acid treatment of anodes

Details of technology adapted, absorbed, developed and implemented in smelter plant are presented in this paper.

2. Climate Change Mitigation Practices Adapted, Absorbed, Developed and Implemented in Smelter

2.1 Increased Stub Hole Depth in Anodes [3]

Increased stub hole depth in anodes reduce contact resistance and hence the anode drop during electrolysis. A simulation study on our pot model predicted a voltage saving of around 40 mV by increasing stub hole depth from 90 mm to 110 mm as shown in Figure 1 and Figure 2, due to an increase in pin to carbon contact area.

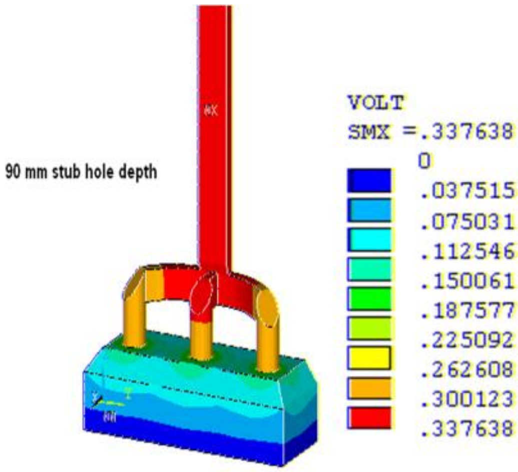

Figure 1. Anode voltage distribution 90 mm stub hole depth.

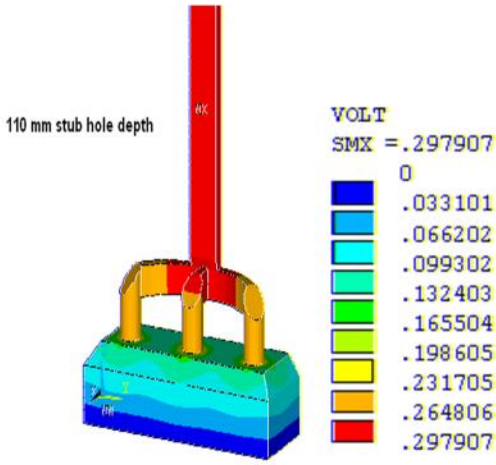

Figure 2. Anode voltage distribution 110 mm stub hole depth.

The saving in mV in pot voltage would lead to reduction in specific DC energy consumption and marginal increase in operating current. Preliminary measurement in the plants and a detailed study of the logistics favoured an increase in stub hole depth. Stub hole depth of anode is 90 mm by design. By increasing this to 110 mm, an increase of 22.2 % contact area between the anode pin and carbon is ensured. This results in reduction of contact resistance.

2.1.1 R&D Trial

Modification in hole formed in the green anode plant was done to achieve 110 mm depth stub holes in green anodes. A limited number of anodes were produced and properly segregated for R&D trial purpose. The trial was designed for three test pots and three adjacent reference pots for comparison. The experiment was done for a period of four months. Pot voltage reduction of pot technology named AP2XN0. The project aimed to reduce the specific energy of the electrolytic pot by reducing the set point pot resistance and thus the pot voltage. This project involves a new design of pot lining, optimized for graphitized cathodes.

2.4.1 R&D Trial

NALCO AP18 pot design measurements and operating data collection was carried out by NALCO R&D for the base case input for modelling purpose. Modelling was carried out by AP and they recommended the design specifications suitable for NALCO AP18 pots. Lining material as per new design specifications was procured by NALCO R&D and lining and startup of new technology pots was carried out under the supervision of AP experts. R&D trial was carried out in 15 test pots and performance was compared with 15 low age reference pots in the same line. The 15 test pots data were compared with reference pots. The trials have demonstrated reduction of pot voltage by 40 m V and specific DC energy consumption by around 150 kWh/tonne during the electrolysis process used for the production of Aluminium resulting in a reduction of the equivalent quantity of coal consumed for power generation and reduction in CO_2 emission from power generated at captive power plant (CPP). The pot lining material is modified to the specification of the technology and its design. Reduction in CO_2 generation to the tune of 4 397 tonnes CO_2 per year for 60 pots has been accounted for.

3. Conclusions

The energy saving initiatives adopted by NALCO smelter have resulted in key benefits of GHG emission reduction. The increased stub hole depth and slotted anode technology, boric acid addition in anodes technology have been fully adapted in NALCO's smelter plant whereas measures are being taken for implementation of AP2XN0 low energy cell technology. Research and Development efforts are also in progress for voltage reduction in electrolytic pots by decreasing other anodic and cathodic contact drops and improvement of anode quality etc.

The aluminium industry is facing the global challenge of greenhouse gas emissions. The global challenge is to reduce the carbon footprint and prevent carbon leakage. Reduction of these emissions is now the main environmental challenge for the aluminum industry. The world is now pushing for a low-carbon future. The emissions are increasing because of the growing demand for aluminum and the limited supply of electrical energy generated from renewable sources. The development of sustainable, innovative and breakthrough technologies to reduce energy consumption, reduction of GHG emissions, and de-carbonization are needed today to combat the adverse effects of climate change.

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