Optimizing Baking Furnace Performance and Anode Quality at Hindalco Renukoot Smelter

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Abstract

The production of aluminium from alumina through the Hall-Héroult process requires carbon anodes as a key input. These anodes are primarily composed of calcined petroleum coke and coal tar pitch, along with reusable anode butts. Anode production involves three critical stages: green anode manufacturing, anode baking, and anode rodding. Among these, the anode baking process is crucial, as it significantly impacts anode quality through the baking level and heating rate, potentially resulting in physical defects such as cracks or air burn. These factors directly affect the anode performance in electrolysis cells. Ensuring precise control and efficient operation of the baking process is of utmost importance, as any deviations can compromise both safety and anode quality in the pot room. This paper discusses the various challenges encountered in the anode baking furnace at the Renukoot Smelter Plant (a unit of Hindalco Industries Ltd.). It explores technical challenges related to process, operations, and maintenance, along with in-house solutions implemented to sustain and enhance furnace performance, productivity, and environmental compliance. Additionally, the paper highlights the impact of furnace refractory conditions on the operation of the fume treatment plant (FTP) and their influence on anode baking quality.

Keywords: Carbon Anode, Aluminium Smelter, Anode Baking, Process Parameters, Anode Quality.

1. Introduction to Hindalco Renukoot Smelter

Hindalco, Renukoot, is one of Asia's largest integrated primary aluminium producers, with operations that span the entire process from bauxite mining and alumina refining to aluminium smelting and downstream activities such as rolling, wire rod production, and extrusions. The Hindalco Renukoot Aluminium Smelter Plant, commissioned in 1962, is one of India's oldest and most significant aluminium smelting units. It represents a pivotal milestone in India's industrial development and established Hindalco Industries Limited (HIL) as a leader in the aluminium sector. As an integral part of the Aditya Birla Group, the Renukoot smelter exemplifies operational excellence, integrated manufacturing, and long-term sustainability.

The smelter operates as a closed-loop aluminium production facility, strategically integrated with the Renukoot Alumina Refinery and supported by the Renusagar captive power plant. These integrations ensure seamless coordination and operational efficiency. The adjacent refinery supplies the essential raw material, alumina, while the Renusagar power plant provides uninterrupted and cost-effective power, offering a significant competitive advantage in this energy-intensive industry. The smelter utilizes the Hall-Héroult electrolysis process to convert

alumina into primary aluminium, leveraging technology originally provided by Kaiser Aluminium Corporation Ltd of the USA.

Over the years, the facility has undergone multiple phases of technological upgrades and modernization to enhance operating performance and productivity. The smelter plant comprises 11 potlines with 2 138 operating pots. The potlines are supported by a carbon plant to ensure a continuous supply of anodes and rectifier units for reliable power supply.

2. Introduction to Anode Baking Furnace

The carbon plant ensures the production of the pre-baked anodes required for the smelter. The carbon plant at Renukoot comprises of 3 production units i.e. Green Anode Plant (GAP), Anode Baking Furnace (ABF) and Anode Rodding Shop (ARS). In GAP the initial anodes, termed as green anode is being produced using calcined petroleum coke and coal tar pitch as primary raw material along with the spent anodes recycled material (butts) received from pot room. In the next step, this green anode is subjected to a controlled heat treatment process termed as anode baking at Baking Furnace. During Anode baking step, the thermal, electrical and chemical properties of anode get enhanced to sustain the operating parameters of electrolysis process at pot room. After baking process, the baked anodes are subjected to rodding process where the carbon anode is fixed with an electrically conductive metallic hanger i.e. rod for the current carrying as well safe handling of anode block.

To meet the anode requirement of smelter plant, carbon plant has gradually upgraded its production capacity to 2 260 anodes per day.

For the baking of green anodes, Renukoot smelter has installed 6 ABFs over the time to produce prebaked anodes for potlines. At present HIL Renukoot is running with 3 baking furnaces ABF 4, 5 and 6. ABF 5 and 6 are based on Riedhammer technology while ABF 4 is based on old technology. The Furnace wise capacity is mentioned in below Table 1.

Table 1. Furnace wise technical data sheet.

Furnace	ABF #4	ABF #5	ABF #6
Technology	Kaizer	Riedhammer	Riedhammer
Start of Production	1997	Installed in 2003 and refurbished in 2018	2014
Number of Sections	32	32	34
Number of Pits	7	7	9
Number of Anodes per pit	45	66	77
Number of Fire Groups	2	2	2
Fire Cycle Time (hours)	40	28	28
Production Capacity (anodes/day)	380	792	1 188

There are several challenges with respect to the operating parameters, baking performance and baked anode quality.

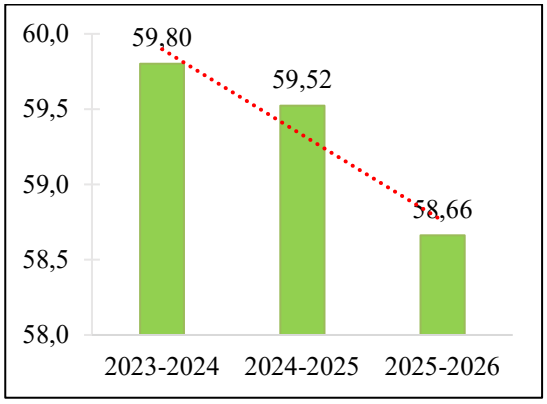

Fig 16: Electrical Resistivity (µΩ·m).

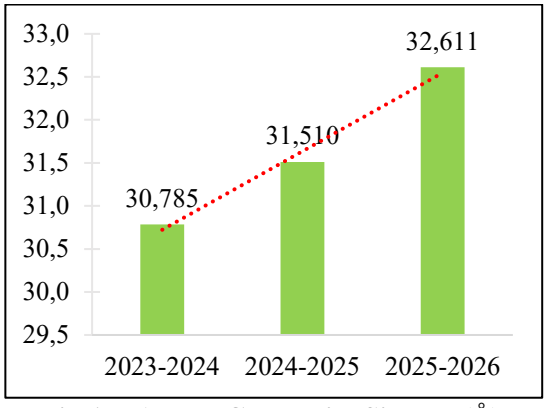

Fig 17: Anode Crystallite Size Lc (Å).

8. Conclusion

The journey of process and operation optimization in the ABFs of Hindalco Renukoot Smelter has enabled further sustainable performance of anodes in the potrooms. This paper explains this entire journey of enhanced ABF refractory maintenance practice, achievement of improved operational parameters and superior baked anode quality through a structured knowledge base development, detailed examination of the existing processes, data analysis and process modifications. After getting the positive results from the process optimizations, the SOPs were revised and ensured the proper adherence by the team members. The success of this initiative underscores the value of leveraging internal capabilities, fostering a culture of ownership, and aligning process improvements with strategic business objectives. Moving forward, the established framework offers a scalable and repeatable model for further optimization and quality excellence across other operational areas.

9. Acknowledgement

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