High Purity Aluminium Production at Mahan and Aditya Smelters

Gaurav Verma[1], Pramod Singh[2], Vinay Agarwal[3], Amit Bharadwaj[4], Amandeep Sood[5] and Anup Kumar[6]

1. Vice President, Smelter Potroom
2. Deputy General Manager, Smelter Mechanical & Facilities
3. Deputy General Manager, Smelter Cast House

Hindalco Industries - Mahan Aluminium, Singrauli, India.

4. Assistant Vice President, Smelter Carbon
5. Assistant Vice President, Smelter Cast House
6. Vice President, Smelter Potroom

Hindalco Industries - Aditya Aluminium, Lapanga, India

Corresponding author: gaurav.verma@adityabirla.com

https://doi.org/10.71659/icsoba2025-al023

Abstract

Demand for high-purity aluminium is rising as it is essential for advanced applications in electronics, aerospace, and various specialized manufacturing setups. Its production at an aluminium smelter requires stringent process control and high-quality raw materials.

Over the last 5 years, Mahan and Aditya Aluminium have developed and implemented innovative operational practices to produce high purity aluminium within their existing electrolytic cells. This initiative enhances the value of the aluminium produced beyond commercial grade aluminium while maintaining cost competitiveness amid fluctuating LME prices and rising power costs. The production of high-purity aluminium has allowed both the smelters to maximize value and strengthen their position as a global leader in high purity smelter grade aluminium production. This paper presents the journey of Mahan and Aditya Aluminium towards high purity production and explores key factors influencing high purity aluminium production including the selection of right grade of raw materials. The operational focus and operating parameter setting is necessary to successfully implement and sustain high purity production. Data will be presented to show the impact, challenges in operational practice and how these are being managed to maintain high purity production economically.

Keywords: Aluminium smelting, High purity aluminium production.

1. Introduction

Hindalco Mahan and Aditya Smelters are two primary aluminium smelters operated by Hindalco Industries Limited, the metals flagship of the Aditya Birla Group. These integrated plants each house a 359 000 tonnes per year aluminium smelter, supported by a 900 MW captive power plant, positioning Hindalco among the leading aluminium producers in India.

Both smelters are equipped with advanced AP36 technology, featuring potlines with 360 cells. The smelters also include modern cast houses and carbon plants for anode manufacturing, forming a comprehensive production system.

The Mahan and Aditya smelters produce a wide range of aluminium products, including ingots, wire rods, billets, and sows. More than 40 % of their output is exported to global markets such as the USA, Japan, Korea, Mexico, and Israel. Their high purity grades of sow are particularly valued in international markets, serving critical applications in aerospace, advanced electronics, communications, and semiconductor industries.

Global demand in high purity aluminium has experienced incredible growth over the past few years and is likely to continue growing in line with the expansion of manufacturing industries. Technology advancements require ever-higher levels of purity for specific applications due to aluminium lightweight, corrosion resistance and superior conductivity in aerospace and military, semiconductors and electronic devices.

2. Hindalco's High Purity Journey

Since 2022, Hindalco's smelters have achieved a significant milestone by producing high purity 3N4 (99.94 %) aluminium resulting in an average potline metal purity exceeding 99.91 % (Figure 1). Both smelters have produced aluminium with purity level of 3N4 (99.94 %), marking the first instance of aluminium of such exceptional quality being produced in India. The achievement was the result of an in-depth, cross-functional initiative involving rigorous studies and collaboration across multiple departments to optimize key elements of the production process. This breakthrough not only underscores Hindalco's technological leadership but also positions the company at the forefront of high-end aluminium manufacturing on a global scale.

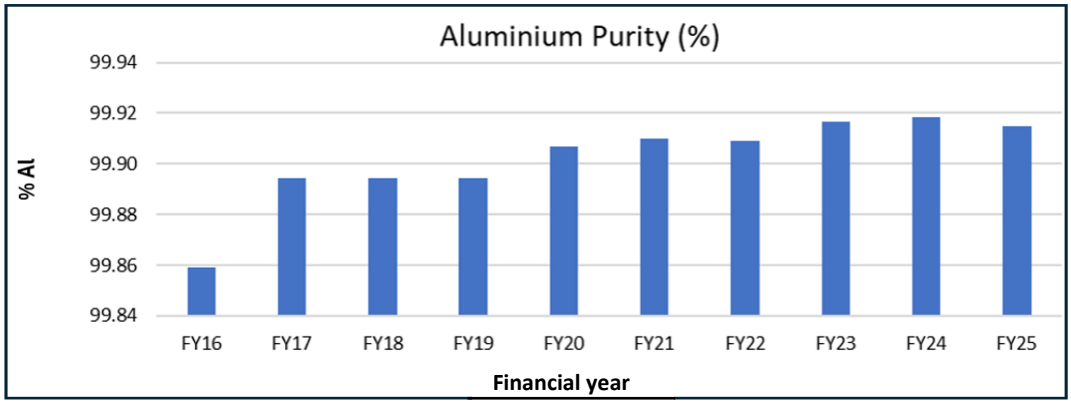

Figure 1. Trend of aluminium metal purity (%).

3. Raw Material Control: A Key Enabler for 3N4 (99.94 %) Aluminium Purity

Impact of raw materials in hot metal production is significant in terms of process stability and metal purity. Key raw materials in aluminium smelting are alumina, carbon anodes [1], anode cover mix, cryolite, and additives – AlF_3 and CaF_2. Given the variability in raw material quality, it is essential to closely monitor incoming supplies and implement adaptive strategies to mitigate their impact.

Impurities in alumina (Fe_2O_3, SiO_2, Na_2O, CaO, TiO_2) lead to higher impurity of molten aluminium. Carbon anodes are a mix of calcined petroleum coke, pitch and processed anode butts. Contaminants in anode coke or pitch (like sulphur, ash, or metals such as vanadium or nickel) can introduce trace metals into aluminium. As global oil reserves degrade [2], the quality of petroleum coke is also declining, making it increasingly difficult to source raw materials with lower impurity levels with increasing cost.

A critical factor in achieving high purity 3N4 grade aluminium production is the meticulous selection and segregation of raw materials. By carefully sourcing alumina, coke, and pitch with consistently low impurity levels – and ensuring strict segregation throughout handling and processing – the final purity of aluminium was significantly improved. This raw material strategy played a pivotal role in reaching high purity 3N4 aluminium quality benchmarks.

Stability in the smelting process is essential for efficient operation. This involves regulating parameters such as bath height, % excess AlF_3, bath temperature, and alumina concentration.

Consistent delivery of anodes and metal crucibles is achieved through synchronized scheduling and real-time monitoring to align with production demands.

9. References

1. Stewart Hamilton and Ray Cook, Impact on smelter operations of operating high purity reduction cells, *Light Metals* 2013, 27–32. https://doi.org/10.1002/9781118663189.ch5
2. Gyan Jha, Frank Cannova and Barry Sadler, Increasing coke impurities - is this really a problem for metal quality?, *Light Metals* 2012, 1303–1306. https://doi.org/10.1007/978-3-319-48179-1_225