Challenges in Reduction of Stub-to-Carbon Voltage Drop for Amperage Increase

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Abstract

Mahan Aluminium Smelter of Hindalco Industries is in Madhya Pradesh, India. The smelter employs AP30 technology with the design capacity of 360 kt/y. Presently Mahan Smelter is in the process of amperage creep to increase the hot metal production. Potline amperage has been increased from 360 kA to 374.5 kA at present. Pot voltage is the key parameter to be monitored and controlled in any amperage creep projects to ensure minimum change in energy input due to amperage increase. The anode drop forms a major part of the voltage drops of the electrolytic cells and this in turn is significantly influenced by the voltage drop between the stub (also called pin) and carbon anode, called stub-to-carbon voltage drop. There was a significant increase in the stub-to-carbon drop during the amperage increase. Stub-to-carbon drop has been studied extensively at Mahan through inhouse experiments, application of digital tools, Process optimization while finding out the optimum conditions to achieve lower stub-to-carbon drop. Lots of factor lead to the deterioration of the stubs like toe-in effects, erosion, mechanical wear & tear etc. which in turn lead to the change in structure of stub-to-carbon connection increasing the voltage drop. The key causes for the increased voltage drop were found to be uneven pin diameter, elongated pin length and cast-iron composition. Due to the difference in pin diameter, pin length, cast iron thickness the contact pressure was found varying. This paper discusses the practical methods employed at Mahan for reducing the Stub-to-carbon drop by 15 mV which will help in increasing the amperage in the potline.

Keywords: Anode voltage drop, Anode pin length, Anode pin diameter, Cast iron thickness, Contact pressure.

1. Introduction

Mahan Potline uses AP technology with the design amperage of 360 kA. The potline was commissioned with the initial amperage of 367 kA in 2013 and was operated and stabilised at this amperage till 2021. From end of 2021 the project of increasing the amperage of the cells to increase productivity was taken. Since then, the amperage has been gradually increased to 374.5 kA without any major design changes.

The copper insert cathodes which were primarily aimed to reduce the energy consumption have also helped to increase the amperage as they are more stable. However, there are many old design cells also operating at the higher amperage of 374.5 kA. The amperage has been increased mainly by modifying work practices, optimising process control parameters, increasing heat loss through lower thickness of anode cover and increased metal height.

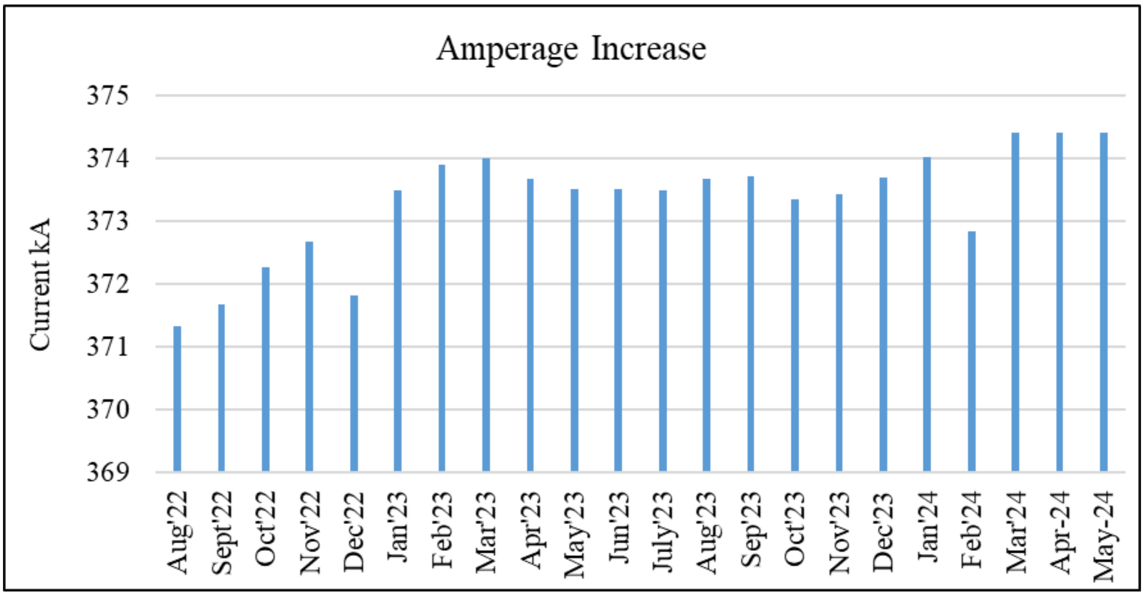

Figure 1. Amperage trend.

Monitoring and controlling pot voltage is crucial in amperage increase projects to minimize energy input caused by amperage increases. The increase in pot voltage during amperage increase largely depends on the ohmic voltage drop.

Addressing ohmic voltage drop increases is challenging because it typically necessitates design changes involving significant capital expenditure and longer implementation timelines (such as adjustments to bus bar and anode stem dimensions).

Our primary objective was to prevent any high voltage drops which would be more than the expected increase due to amperage escalation.

1.1 Pot Voltage and Stub-to-Carbon Voltage Drop

In the aluminium electrolysis the voltage components of the cell are:

$$V_{pot} = V_{anode} + V_{cathode} + V_{bath} + B_{emf} \quad (1)$$

The anodic voltage drop is a critical component of the overall pot voltage in an electrolytic cell. The anodic voltage drop typically accounts for about 7–9 % of the total pot voltage. Despite its smaller proportion keeping the anode drops in control gives better operating window for amperage increase.

The rodded anode assemblies being used in Mahan Pot lines is shown in the Figure 2. The assembly consists of the anode stem with twice three pins of diameter 180 mm and length 320 mm**.** with slotted carbon block size of length:1558 mm, width: 650 mm and height: 680 mm. The anode voltage drop comprises of

- Stem-to-beam drop.
- Stem drop.
- Clad drop.
- Stub-to-carbon drop (including steel bracket and stub drop).

This system enables tracking of anode stem deterioration across cycles, determining which require trimming and reuse. It facilitates proactive budget planning for stem repairs and estimates voltage drops from stub-to-carbon in advance, enabling planned adjustments to amperage changes.

3. Conclusions

The pin dimension analysis has demonstrated a clear correlation between the reduction in variation in pin length and the subsequent decrease in the stub-to-carbon voltage drop. By optimizing these dimensions, the electrical contact resistance within the stub-to-carbon interface is significantly reduced. This optimization is crucial for enhancing the overall efficiency of the aluminium electrolysis process, as it minimizes energy waste and improves system performance. The findings underscore the importance of precise pin manufacturing and trimming techniques in achieving optimal electrical performance in potlines. Implementing these dimensional adjustments can lead to substantial energy savings, operational improvements, and unhindered amperage increase.

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