Development of Vedanta Lining Design

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Abstract

The aluminium industry is facing challenges to improve its sustainability and to reduce carbon footprint. With these goals in mind, Vedanta Limited is improving the cathode lining design used in Jharsuguda plant. The new lining was designed using numerical computational modelling techniques that simulate electrical and thermal behavior of the cell. The concept was to use a copper inserted collector bar associated with a cathode lining insulation in the most efficient way. The prototypes key performance parameters are presented, along with the measurements of cathode voltage drop, collector bar temperature and internal lining temperatures. The initial trials indicate a significant reduction in cathode voltage drop (CVD) and improved current efficiency of the cell. These indicate the possibility of increasing the current as well as reducing the specific energy consumption (SEC) of the cell.

Keywords: Copper collector bar, Energy saving, Cathode voltage drop, Current creepage, Cell numerical modelling.

1. Introduction

Primary aluminium production is an energy intensive process, which amounts to around 1/3 of the production cost. There have been widespread initiatives [1-3] taken by smelters to improve energy efficiency and thereby contribute towards sustainable operations by retrofitting of existing potlines with upgraded busbar systems, cell designs or control systems. Major driving factors are: prolonging pot life, reducing specific energy consumption (SEC), improving current efficiency and volume production with minimal changes in existing infrastructure. Vedanta has continuously been driven for enhanced capabilities and improvements in pot cell operation to achieve productivity excellence with sustainable developments. The performance of the pots depends on 4 major factors which are cell design, cathode construction, pot start-up and pot operations. The cell lining design has a significant contribution in improving energy efficiency, enhancing production and prolong pot life.

Since its inception, the Vedanta potlines were equipped with cathode lining that could deliver specific energy consumption of around 13.8 kWh/kg Al. Gradually, over a journey of 12 years, the lining was modified to designs with higher grade cathode, moving first to graphitic, then to graphitized cathodes, which are now delivering specific energy consumption of 13.1 kWh/kg Al and improved pot life performance. This has also contributed to reduction of hazardous wastes generated associated with cell shutdown.

To achieve further improvements in terms of energy efficiency and pot life, “Vedanta Lining Design” (VLD) concept was proposed. This includes cathodes having copper insert collector bars with cold sealing and modification in lining refractory layers without major changes in materials or methods of construction.

Copper insert bars are being researched by many smelters for use in high amperage cells [4-6], that requires high heat dissipation. However, this needs an evaluation of thermal balance when using in low SEC cells as use of copper increases the heat loss from collector bars [7].

This paper focus on the insights on thermoelectric evaluation of the existing cell design operating at 340 kA and the development of an optimum lining design using copper inserts. 3D thermoelectric modelling results and measurements of existing and new design are shown. The building of prototypes, cell preheating and early life operation, as well as preliminary results are also shown.

2. Modelling Approach

In a first phase, the existing situation was assessed using numerical models and measurements. The performance of the existing lining design as well as the capacity of busbar systems built the basis for improvements in the cell design. The modelling approach included thermal electric modelling (Figure 1) of lining and busbar network, magnetohydrodynamic (MHD) modelling and structural models of pot shell and cradle supports. Modeling results showing current density, heat flux and temperature distribution are presented in Figures 2 and 3.

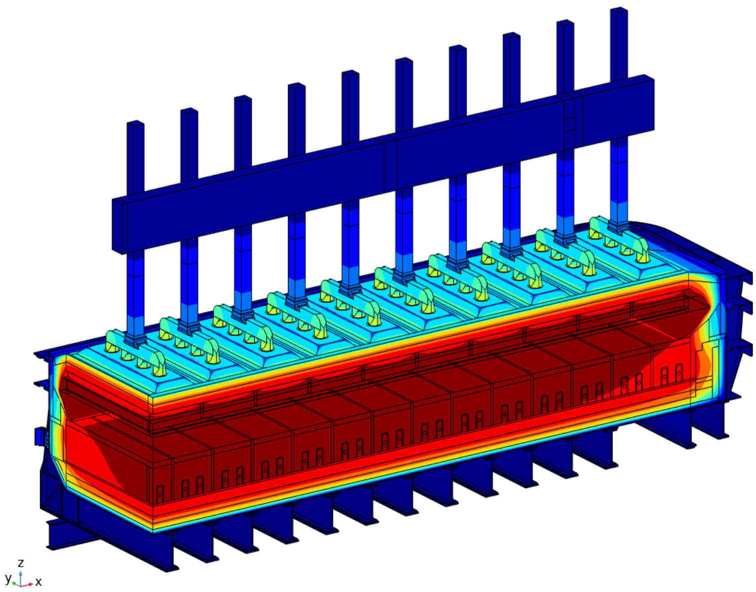

Figure 1. 3D thermal model of existing cell.

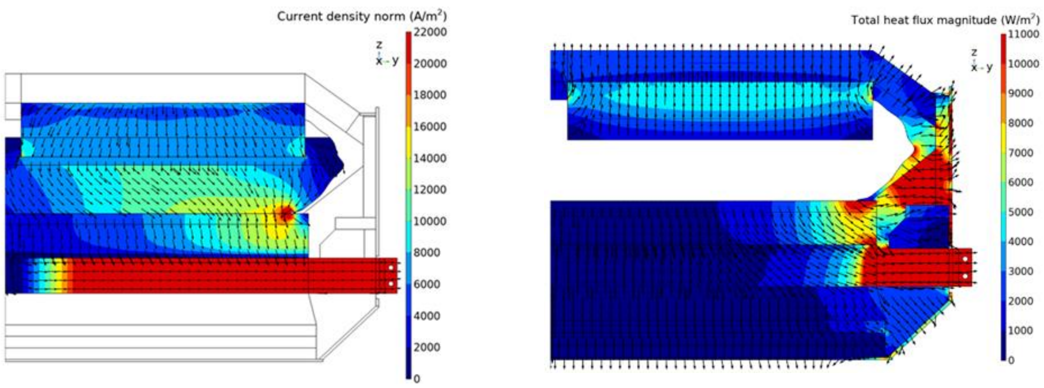

Figure 2. Existing cell sidewall section. Left: current density magnitude and vectors (A/m²). Right: total heat flux magnitude and vectors (W/m²).

8. References

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