The Robustness of Ready-to-Use Cathodes (RuC®) - A Mature Technology Available for the Primary Aluminium Industry

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Abstract

The efforts to decarbonize the aluminium industry continue as smelters around the world implement initiatives to reduce their CO_2 footprint in the production of primary aluminium. On one side, the use of greener electricity as an energy source is being adapted at an increasing speed, but on the other side, initiatives to reduce energy consumption, such as new cathodic solutions based on copper-only conductors, have seen setbacks.

It has been confirmed and published that when using only copper as a metallic conductor in a cathode block to extract the current from one pot, the copper is alloyed, which increases its resistivity and volumetric expansion, leading to a rapid rise in cathode voltage drop (CVD), cracking of the cathode blocks and resulting in a short lifetime of the pot.

Thanks to the protected copper used with the RuC® technology, the above described effect is avoided. This is confirmed by the stable CVD evolution and long lifetime operation of the oldest group of RuC® pots discussed in this paper.

In addition, when applying modern cell design principles based on modelling, the increased electrical conductivity of the collector bar can lead to a more stable cell operation and optimized heat balance. This can result in a significant performance improvement.

Keywords: Ready-to-use Cathode RuC®, energy savings, pot lifetime, copper alloying.

1. Introduction

The aluminium industry is leading efforts to reduce its carbon footprint. According to the International Aluminium Statistics, the electrolysis process accounted for 71 % of the total greenhouse gas emissions of the aluminium sector in 2022, equivalent to 789 million tonnes of CO_2e. The energy mix plays a significant role in the CO_2 intensity of aluminium production, with benchmarks below 4 t CO_2e/t Al for renewable energy sources and 16 t CO_2e/t Al for fossil fuels. To reduce the carbon footprint, smelters have successfully incorporated renewable sources into their energy mix and have adopted copper inserts to reduce energy consumption as the new standard design.

Additional efforts to further reduce energy consumption with new technologies like RuC® are currently being tested. Some of these tests have encountered operational issues related to the alloying of copper with aluminium.

This paper explains the history of RuC® development, the lessons learned, and the measures taken to improve the design´s robustness. It also provides an overview of selected projects that have been operational for more than 1 700 days.

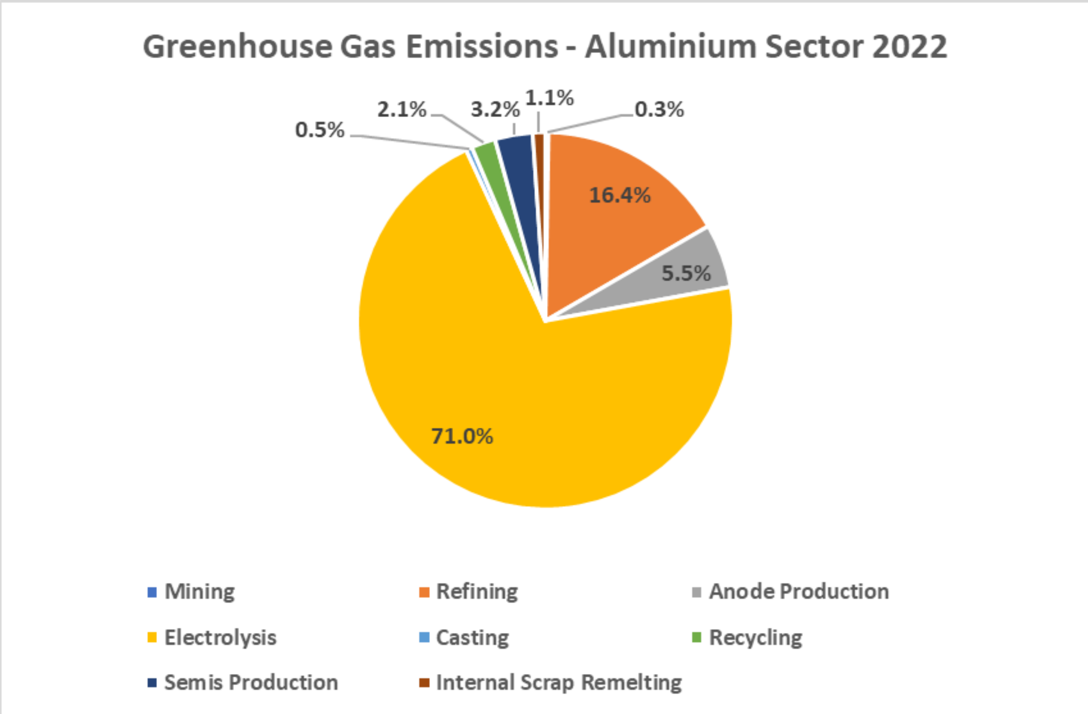

Figure 1. Greenhouse gas emissions - aluminium sector 2022 [1].

2. The Advantages of the RuC® Design

The Ready-to-use cathode (RuC®) was developed as a copper cathodic solution with the aim of eliminating the high-temperature casting process or sealing ramming paste operation needed to join the cathode block with the steel collector bars. By skipping this intermediate step, the overall safety of the shop floor workers is improved, enabling the smelter to concentrate on its primary objective of producing aluminium.

When replacing the steel collector bars with copper bars, the overall cathodic resistance of the assembly is reduced. Using modelling tools, a more insulating lining for RuC® can be designed to accommodate the higher heat losses from copper, resulting in a lower pot voltage and lower energy consumption in the pot.

Because the Cu cross-section is smaller compared to steel bars, additional cathode material remains on top of the conductors, potentially extending the lifetime of the pot. Additionally, an improved current density distribution in the metal pad enhances the pot stability, enabling anode-cathode distance (ACD) optimization and improving current efficiency. Finally, at the end of the lifetime, there is high potential to recycle the copper bars.

3. The Early RuC® Trials

Starting in 2015, a few RuC® trials have been initiated with one or two blocks in each pot. During this time, the goal of RuC® was to have a simple design to reduce production costs. Full copper bars were mechanically fitted in direct contact with the cathode slot. The cathodic resistance of

To prevent the copper alloying process due to early metal leakages or bath and Na diffusion, a barrier was designed to protect the copper in the new RuC® design. Intermediate autopsies conducted after 28 months of operation showed that the barrier effectively protected the Cu. With this knowledge, the RuC® design was improved to create a more robust system.

Two examples of RuC® projects with operating lifetime exceeding 1 700 days were presented. Performance parameters such as pot voltage, CVD and noise indicated stable pots with normal CVD evolution over their lifetimes, suggesting that the alloying process is prevented or significantly slowed down by the protection barrier. In a couple of years, when the oldest pots reach the end of their lifetimes, full autopsies will be conducted to assess the condition of the copper bars and to explore the recycling potential of the bars.

7. References

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