A Novel Cathode Design Using Copper Collector Bars for High Amperage Technologies

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Abstract

The implementation of copper conductors in the Ready-to-Use cathodic system not only allowed to fully avoid rodding but also significantly decreased the specific energy consumption, reducing the carbon footprint of the Hall-Héroult process of high amperage technologies. The basic concepts, the cathode implementation and the operating figures in smelting technologies ranging up to 600 kA for more than two years in operation are highlighted. The robustness of the copper collector bar design is proven by stable low cathodic resistance allowing energy savings per kg aluminum, and the fully intact copper part was confirmed by an autopsy after more than thousand days in operation. Core samples were machined through the cathode and collector bars at different locations and chemically analyzed, concluding that most of the copper value can be recovered after its useful life through conventional recycling processes. Based on these positive results, further cells are planned to be started soon.

Keywords: Aluminum electrolysis cells, Cell design, Copper collector bars, Energy saving, Magneto-hydrodynamics.

1. Introduction

The concept of Ready-to-Use Cathodes (RuC®) was presented for the first time in 2016 [1] and a follow up on the performance of several RuC® high amperage projects is presented. The main philosophy of the Ready-to-Use Cathode is to avoid the costly and hazardous rodding process and to use copper conductors which offer additional advantages in terms of lower pot voltage, lower energy consumption, lower noise level, increased current efficiency, longer lifetime and can be easily recycled at the end of their useful life. Figure 1**Figure** illustrates examples of a cast iron-rodded copper-insert collector bar and a RuC® design. More than 1300 RuC® blocks are installed in 60 cells and started.

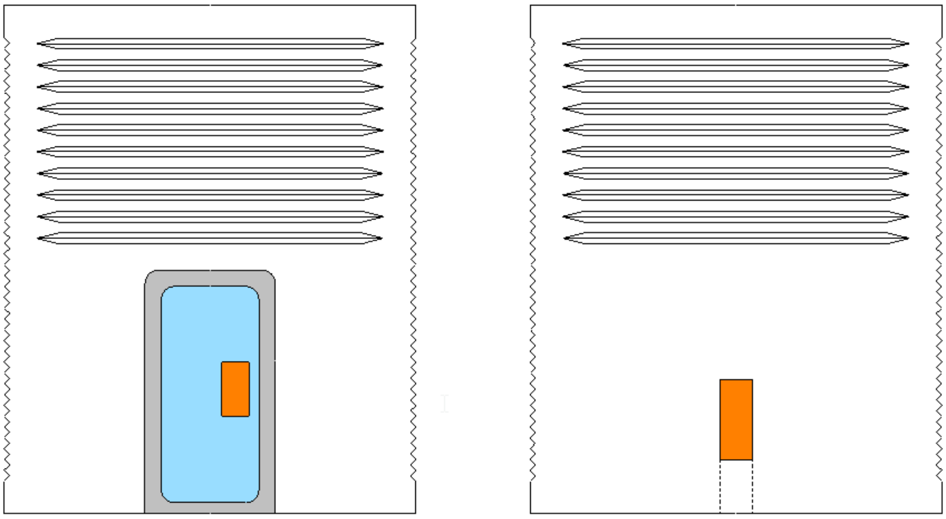

Figure 1. Copper-insert collector bar design example (left) and typical RuC® design (right).

RuC® is a flexible cathodic system, which allows for all smelting technologies an optimized design for thermal balance combined with an improved current distribution, improving the magnetic hydrodynamic (MHD) behavior of the cell, metal pad and lower cathode voltage drop (CVD). Energy saving is a result of the lower pot voltage and improved current efficiency (CE), reducing the carbon footprint of the Hall-Héroult process. By energy saving and increased productivity the electrolysis process gets "greener" and more economical with a lower carbon footprint. The fast and easy implementation caters to the world-wide greenhouse emission reduction targets.

The RuC® stability in CVD with low electrical contact resistance is achieved despite of the lower contact surface (-60%) compared to conventional cathodes. The low level and stable trend of CVD proves the robustness of the cathodic system.

Start-up procedures do not need to be modified when using RuC® but could even be shorter compared to conventional cathodes. Increased stability could be observed by faster stabilization in the early operation phase. By this the pot voltage set point can be reached faster and at a lower level.

This RuC® performance update presents only high amperage projects, operating in the range 300 kA to 600 kA. These RuC® projects are energy saving projects, other running projects aiming only at rodding avoidance and cell life expansion are not presented. RuC® is implemented in the most modern western smelting technologies as well in the Chinese flagship technologies of NEUI. The reference cells and their performance could vary from paste-sealed steel bars to cast iron-rodded steel bars with copper inserts, as well graphitized cathode blocks or semi-graphitic grades. The full copper recycling at the end of cell life constitutes a high residual value for the smelters. Several planned intermediate autopsies were conducted to validate the recycling value by an analysis of copper bars after 1.5 years and 3 years in operation. Metallurgical tests were performed on the collector bars and their integrity was confirmed. Less than 20 ppm additional impurities were found in the copper area close the surface of the bar, which allows the full recycling of copper in a standard and most valuable way.

Because of the high electrical conductivity of copper compared to steel and cast iron, RuC® needs much less metal volume inside the cathode block. The reduced metal volume is replaced by carbon cathode material which increases the distance from the collector bars to the cathode

Figure 13. Copper analysis after 800 days in operation, measurement positions

4. Conclusions

The operation of more than 1300 RuC® cathode blocks in 60 cells and data for more than 800 days of operation confirm that the aluminum industry has a new solution to minimize its carbon footprint. Indeed, a reduction of 0.3 kWh/kg represents a saving worldwide of 19 500 GWh/year or 2.2 GW power (for 65 million tons of aluminum produced per year). RuC® demonstrated a stable CVD performance in high-amperage cells with significant energy saving in between 0.2 to 0.5 kWh/kg and with high residual value on the copper bars.

5. References

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