The Use of Copper in Cathodes of Aluminium Reduction Cells

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Abstract

The use of copper inside the cathodes of aluminium reduction cells is becoming a standard. The advantages are numerous if used in a correct manner. This paper is reviewing the main features that can be achieved when using copper in the most efficient way as a final component of a ready- to-be-used cathode. Industrial applications have demonstrated the possibility of increasing the current as well as decreasing the specific energy significantly. Modelling work, measurements as well as industrial achievements are discussed.

Keywords: Cell design; Energy saving; Current increase; Current efficiency; Measurements

1. Introduction

More and more smelters are implementing copper in the cathode of the electrolysis cells. Some aspects have been reported in References [1, 2, 3]. The use of copper is strongly linked to the cathode design [4, 5]. Reference [6] presents possible use of direct copper inserts in the cathode. This paper is highlighting the impact of copper in the cathode on the key operating parameters for two technologies. Thermal and magneto-hydrodynamic effects allow operating with different levels of line current and cell voltage. The impact on the cell productivity and specific energy consumption may be significant. Moreover, cell life and recycling may be improved when compared to traditional collector bars design.

1.1 Copper Bars

Copper bars vary in shape, in weight and in the way they are implemented in the cathode. Two examples of copper bars cross-section are shown in Figure 1.

Figure 1. Example of copper bar cross-sections.

Many parameters are important to achieve the desired effects. The cross-section of copper bar, the length, the position inside the carbon cathode, the type of cathode (graphitic, graphitized, etc.), the positions of the anodes, the cathode current density, the external busbars, the metal height, the cell lining, etc. In other words, the full cell design must be in good balance with the use of copper bars. A large copper cross-section may lead to low cathode voltage drop (CVD) but can generate ledge at the cathode surface (ridge) leading to a higher cell voltage. A low CVD is aimed at saving energy but the opposite can take place. A poorly magnetically compensated cell (old technology) may be significantly upgraded by using copper bars. The electrical current will flow more vertically inside the cathode, impacting on the metal surface contour and the velocity field. The magneto-hydrodynamic (MHD) fields such as metal velocity and current density will interact with the magnetic field in a different manner and the cell may become more stable from an MHD point of view. An improved MHD stability allows operating at lower anode to cathode distance (ACD) and/or at higher line current. This leads to lower specific energy consumption and/or increased production. Last but not least, the improved current density distribution at cathode surface minimizes the electro-erosion of the cathode blocks, leading to a longer cell life.

1.2 Ready-to-Use Cathode

The ready-to-use cathode or RuC® refers to the use of copper bars in the cathode in such a way that there is no need for cast iron sealing of the collector bars. It fully avoids a first pre-heating of the carbon cathode. RuC technology shows all benefits of other copper bars and adds a number of advantages such as allowing a much lower bar height inside the cathode giving the option of either increasing the cell life or using a lower carbon cathode. A lower carbon cathode increases the cell cavity that can help using higher anodes and/or improving the cell thermal insulation on top of the anodes. When using RuC technology no rodding operation and no pre-heating are necessary. The difficult handling of cast iron is suppressed. Copper can be easily recovered at the end of the cell life and the degrees of freedom for the cell lining design are considerably increased.

Figure 2 shows examples of RuC copper bars. The shape and cross-section of the copper bars are determined to optimize the positive effects of the bars and realize a simple connection to the outside aluminium flexes.

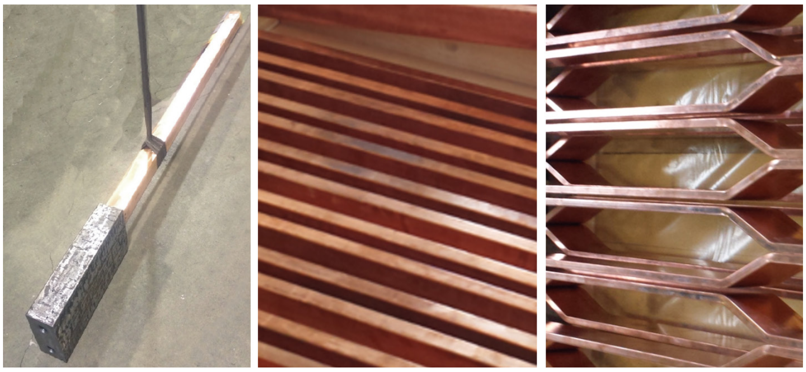

Figure 2. Examples of RuC copper bars.

The validation of the concept has been done with a number of cell technologies and the impact is presented in the next chapters for two specific cell technologies (Technology 1 and Technology 2). Figure 3 shows a set of RuC cathodes, first as model and second real before implementation.

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