Design and Performance of a Full Copper Collector Bar Pot at EGA

Mustafa Anwar Mustafa[1], Bernard Jonqua[2], Abdalla Alzarooni[3], Fatma Albastaki[4] and Alexander Arkhipov[5]

1. Area Engineer - Reduction Engineering
2. Former Manager Technology Potlining
3. Vice President
4. Former Engineer I – R&D
5. Manager – Modelling, Technology Development & Transfer

Technology Development & Transfer, Midstream
Emirates Global Aluminium (EGA) Jebel Ali, Dubai, United Arab Emirates
Corresponding author: mamustafa@ega.ae

Abstract

Cathode voltage drop (CVD) is an important component of pot voltage. Many initiatives to lower CVD have been implemented in the industry. One of them are copper inserts in the collector bars which have been implemented successfully in many smelters. Recently, this idea has been pushed further by using full copper collector bars that are sealed in the cathode blocks in new, innovative ways without the need for cast iron rodding. This paper describes the design, preheat, start-up and performance of the proprietary and patented full copper collector bar design test pot in Emirates Global Aluminium (EGA). Detailed measurements of several critical parameters were made during all stages of the pot start-up and operation. The CVD in the test pot is approximately half the value of the CVD in regular steel collector bar pots. Plus, the observed value is also much lower than in pots with copper inserts. The performance of full copper collector bar pot is comparable to regular pots, except for the fact that it results in a considerably lower specific energy consumption for the same pot technology. Building on the success of the first pot, several other full copper collector bar pots have been put in operation in different EGA pot technologies.

Keywords: Full copper collector bars in aluminium reduction pot, Cathode voltage drop, Low specific energy consumption, Advanced potlining.

1. Introduction

Cathode voltage drop (CVD) is an important component of pot voltage. Many initiatives to lower CVD have been implemented in the industry. Cathode block grades have migrated from anthracite to graphitic, and then to graphitized, which have progressively lowered the electrical resistivity [1]. Nowadays, predominantly graphitic and graphitized grades of carbon cathode blocks are used because of an additional advantage that the CVD changes little with pot age. Another initiative for CVD reduction is the use of copper inserts in the collector bars that today have been successfully implemented in many smelters. A typical CVD reduction of 60 – 80 mV has been reported with copper inserts [2-4] and the gain obviously depends on the copper insert design, particularly its cross-section and length.

Recently, the concept of decreasing the resistance of collector bars has been developed further and now full copper collector bars have been proposed by EGA [5-7] and others [8-11]. In references [8-11], copper collector bars in test cells have steel terminations outside the potshell in order to limit not only the heat loss through the collector bars but also the collector temperature at the connections to aluminium flexibles. However, this really limits the large potential of a reduction of CVD with full copper collector bars. The main advantage of a full copper design is that there is no cast iron rodding between copper collector bar and cathode carbon block needed. The steel portion at the end of the copper collector bar has been proposed to be eliminated and replaced by reduced cross-section of copper outside the potshell [12], but the implementation of this design in industrial cells has not been published.

EGA has invented its own proprietary full copper collector bar design [5-6] and built a test pot. This is described in this paper together with results from operation of these pots.

The potential benefits of full copper collector bar pots as they are designed by and implemented at EGA, are numerous, ranging from safety to environmental and financial [7]:

- Eliminates requirements for cathode casting operation meaning this is:
  - Safer
  - Requires less manpower
  - A lower energy cost
  - Requiring less materials, and
  - Requiring less space for making the cathode assembly
- Significant energy savings
- Enhanced potlife meaning:
  - Possibility of higher cathode carbon thickness, and
  - Possibility of lowering maximum cathode current density
- Easily recoverable resulting in more valuable scrap sales
- Creates a valuable know-how and the potential for technology transfer.

2. EGA Full Copper Collector Bar Pot Design and Modelling

A major concern with the full copper collector bar is the lower melting point of copper (1080 °C) than of cast iron (1070-1150 °C, depending on composition) and steel (1425-1540 °C). Furthermore, there is a minor concern whether there will be sufficient pressure between the collector bar and the carbon block to make good electrical contact to obtain a low contact resistance. These concerns are addressed by EGA in cathode design, pot preheat, start-up and operation by an innovative design, upgraded pot start-up procedures and detailed measurement follow-up.

2.1 Collector Bar and Cathode Block Design and Installation

Before implementing the new design in a full pot, a crash test was conducted in a D18 pot where 4 conventional cathode assemblies were replaced with the new, innovative full copper design. This pot was planned to be stopped after a few months of operation in order to convert the pot to D18+ technology. This crash test gave the initial indication that the copper can safely survive startup and early operation. Importantly, it also showed very low contact voltage drop between copper collector bar and carbon block. The 4 blocks were autopsied after stopping the pot and found in very good condition. This test gave the greenlight to the first full pot test with EGA's new full copper collector bars design.

The first test pot is D20 Technology Pot 5B269 in EGA Jebel Ali's Potline 5B. It operates under a line amperage from 270 to 275 kA. The most distinguished feature of pot 5B269's design is the use of full copper collector bars that are directly inserted into the cathode block slots without any cast iron. The design of the cathode block and the collector bars is shown in Figures 1 – 3 [5-6]. It can be seen that in the center of the cathode carbon block there is a gap between the collector bars that is filled with ceramic fiber (16 in Figure 1).

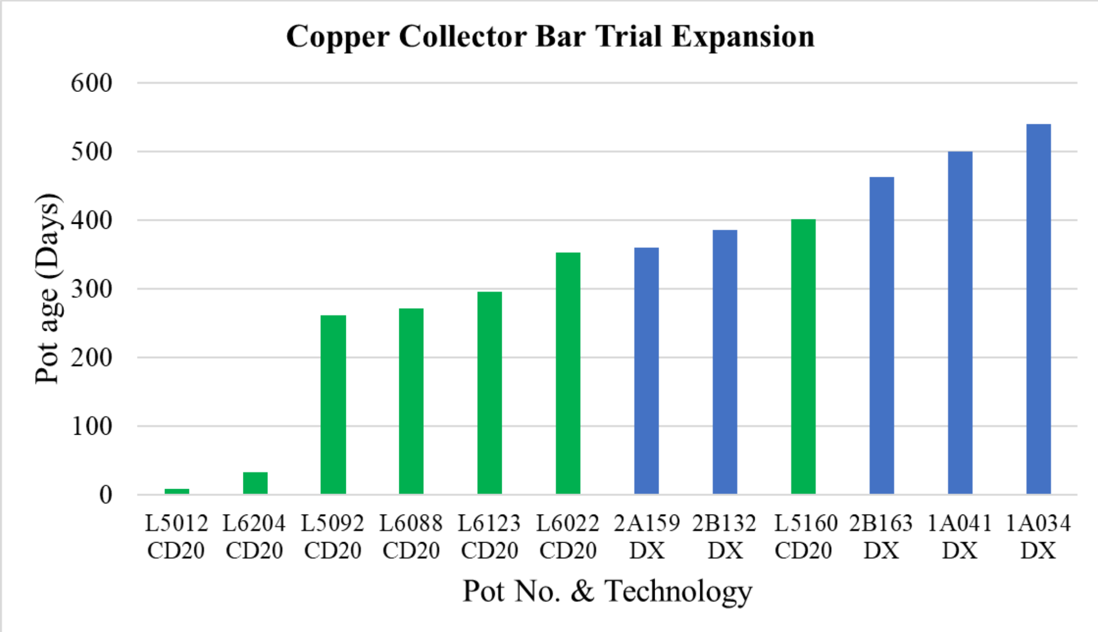

Figure 18. Copper collector bar trial expansion pot age on 22 October 2021.

6. Conclusions

EGA has built and tested a proprietary pot design with full copper collector bars. Due to very low cathode voltage drop (CVD) the pot operates with substantially lower voltage drop and consumes approximately 0.5 kWh/kg Al less energy than the control pots with standard steel collector bars. Copper collector bars and cathode blocks perform well so far, which is witnessed by uniform current distribution in collector bars together with low and uniform collector bar temperatures, and low copper concentrations in the metal. Based on autopsy the cathode surface at the age of 1002 days was in exceptionally good condition showing little erosion and practically no cathode heaving. The trials have been extended to other EGA pot technologies and they show good potential for lowering specific energy consumption, which is the primary objective of these trials.

7. Acknowledgment

We would like to thank the various teams involved who contributed in these successful initial trials: Pot repair and potlining process control teams, Potline Operations and technical teams. We would also like to thank Dr. Vinko Potocnik for his input in reviewing this work.

8. References

1. Loig Rivoaland, Development of a new type of cathode for aluminium electrolysis, *Proceedings of 34th International ICSOBA Conference*, 3 – 6 October 2016, Québec, Canada, Paper AL28, *Travaux* 45, 757-765.
2. Marwan Bastaki et al., DUBAL cell voltage drop initiatives towards low energy high amperage cells, *Light Metals*, 2014, 451-455.
3. René von Kaenel, Jacques Antille, Louis Bugnion, Impact of copper inserts in collector bars, *Light Metals* 2015, 807-812.
4. Amit Jha et al., Copper insert collector bar for energy reduction in 360 kA smelter, *Light Metals* 2019, 565-572.
5. Bernard Jonqua, Abdalla Zarouni, Cathode block for electrolytic cell suitable for the Hall-Héroult process, WO2016/157021 A1, International Publication Date 6 October 2016.

6. Bernard Jonqua, Mustafa Mustafa, Cathode assembly with metallic collector bar for electrolytic cell suitable for the Hall-Héroult process, UK Patent Application GB, 2558936 A, Publication Date 25.07.2018, (Also WO/2018/134754, Publication Date 26.07.2018).
7. Mustafa Anwar Mustafa, Copper collector bar development at EGA, Gulf Aluminium Council (GAC) Seminar, Virtual, 16 February 2021.
8. Louis Bugnion et al., Copper as a key element in the collector bars of aluminium smelter cells, International Aluminium Journal, 1-2 2018, 70-74.
9. René von Kaenel et al., The use of copper in cathodes of aluminium reduction cells, *Proceedings of 35th International ICSOBA Conference*, Hamburg, Germany, 2 – 5 October 2017, Paper AL11, *Travaux* 46, 879-889.
10. Markus Pfeffer, Oscar Vera Garcia, Louis Bugnion, and Laure von Kaenel, Ready-to-use cathodes for the Hall-Héroult process, Light Metals 2020, 1291-1298.
11. Markus Pfeffer et al., A novel cathode design using copper collector bars for high amperage technologies, *Proceedings of 39th International ICSOBA Conference*, Virtual, 22-24 November 2021, Paper AL17, *Travaux* 50
12. Markus Pfeffer and Rene Von Kaenel, Cathode current collector/connector for a Hall-Héroult cell, patent WO2018/019888 A1, International Publication Date 01 February 2018.
13. Alexander Arkhipov et al., Cell electrical preheating practices at DUBAL, *Light Metals* 2014, 445-449.
14. Ali Al Zarouni et al., DX+, an optimized version of DX Technology, *Light Metals* 2012, 697-702.