Upgrade to Narrower and Deeper Slots in Anodes: Improving Efficiency and Mechanical Behavior

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Abstract

Business case for slotted anodes need not to be made anymore. Slots help reduce thermal stresses in the anodes lowering risk of cracking. They are an effective way to allow continuously formed gas escaping from underneath the anodes and thus reducing electrical cell resistance while improving pot stability. Slots also result in bringing down electrical power consumption during aluminium production. Depth of slots ensure that benefits last throughout the entire life of the anodes and finally slots with reduced width reduce the amount of carbon removed from anodes and extend anodes cycle time.

Anode quality is a key variable in an aluminium smelter overall efficiency and production costs. Smelters already using cut or molded slots in anodes can improve the benefits by increasing depth and reducing width of slots using Anode Slot Cutting Machine (ASCM) climb milling technology instead of conventional slot cutting. A climb milling technology upgrade allows for deeper and narrower slots (up to 450 mm deep and 9.5 mm wide). It can be more demanding on the control of anode movement across the cutting blades. For this reason, a climb milling upgrade includes changes to the hydraulic and electrical control systems but does not require increase in power. In addition, more fine dust is generated which in most cases requires an upgrade to the existing dust management system.

The new generation of ASCM systems with climb milling technology offers the ability to cut deeper and narrower slots in various geometries including optional interrupted slots. The spinoff of this is the ability to also upgrade existing systems. In addition, any upgrade of an ASCM can include the addition of a high degree of self-diagnostics, predictive maintenance and remote monitoring to detect alarm/abnormal conditions. This will allow operators to keep a close eye on equipment performance and predict blade and other failures before they occur. All this to reduce OPEX expense, increase uptime and to reduce blade consumption and associated costs.

Keywords: Climb milling technology upgrade, Energy efficiency of the electrolysis process, Anode handling Industry 4.0, Conventional anode slot cutting, Anode resistivity measurement.

1. Introduction

High cost of energy and volatile metals prices are driving primary producers of aluminium to optimize their processes to stay competitive and profitable in a very tight market.

Since 2003, Anode size have increased considerably. Anode slotting got introduced within the Primary producers' process when they started using larger anodes. With a larger carbon block, larger surface, greater resistance to release gases from the electrolysis translating into energy losses and lower performances. At the beginning anodes were about 130 cm (L) × 65 cm (W) × 55 cm (H). Nowadays, it is common to work with anode size of roughly 165 cm (L) × 100 cm (W) × 60 cm (H). Although, in 2018 a significant increase of anode production costs brought primary aluminium producers to the analysis of what can be done to minimize the impact [1]. For the ones already practicing anode slot cutting, the challenge was thrown at equipment designers to reduce the width of the slots and make them deeper for a better life cycle.

2. Brief History of Slotted Anodes

Figure 1 shows the evolution of anode slots from the traditional unslotted – caricatured as primitive, to mold-formed, and saw-cut – caricatured as intelligent.

- In the 1980s, ever increasing amperage and corresponding increasing anode size was causing anode cracking due to thermal shock as well as anode effect (perfluorocarbon gasses trapped underneath the anode) which reduced cell efficiency.
- Through the 1990s trials were done at aluminium smelters to overcome this problem. Examples of these trials were: In 1994, Aluminium Alouette underwent a trial to replace the twin AP30 anode with a single double wide block [2]. The cell current efficiency dropped by 3.6 % and the deterioration was attributed to CO_2 gas bubbles twice the normal size. In 1993, Hydro Aluminium also performed tests which entailed splitting of the anodes in two. This had the opposite effect on cell noise and current efficiency.
- Slots were first introduced to solve anode cracking issues and it was only later discovered that the slots had additional benefits.
- In 1998 both Rio Tinto [2] and Alcoa [3] started using slotted anodes on a production scale.
- In the early 2000s, slot sawing was at the beginning of industrial use and since then, slot sawing has been continually refined and accepted by many technical authorities as best practice for manufacturing anodes for aluminium production.

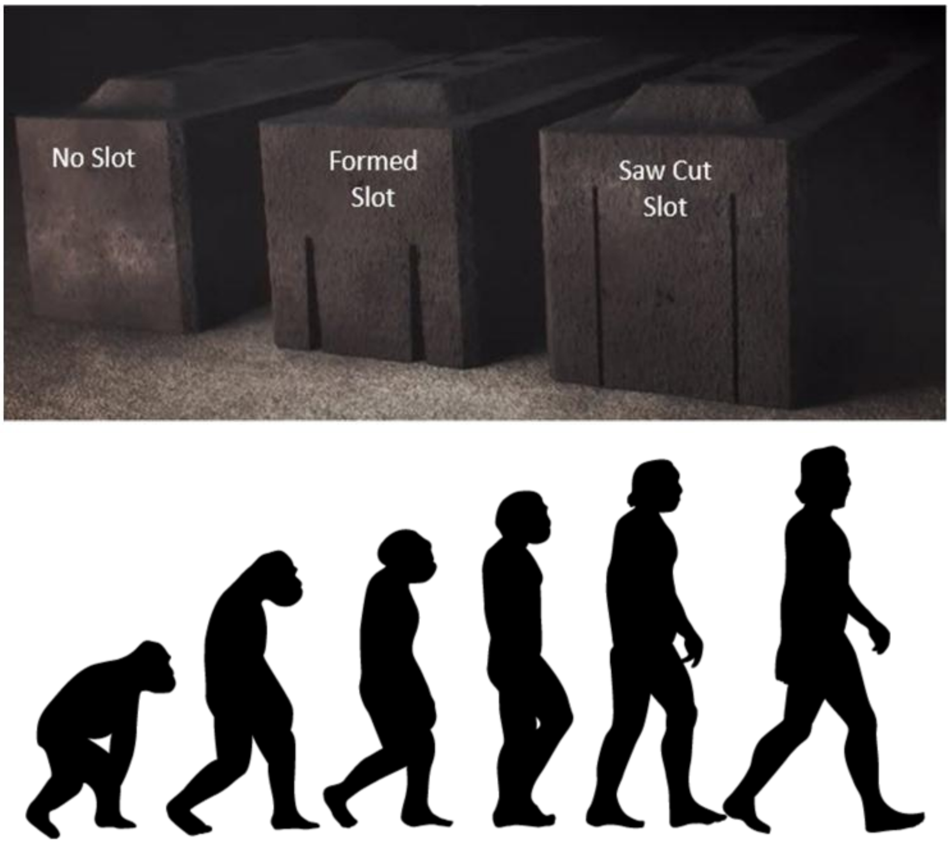

Figure 1. Evolution of the prebake anode slots [4].

with alerts and machine utilisation tracking. In addition, remote monitoring and vision technology will be available to enhance the ability to keep a close eye on the ASCM performance and to predict main machine component including blade failure before it occurs. These enhancements target increased uptime and reduced blade consumption and associated operational and maintenance costs.

7. Conclusions

From this paper we can draw up the following conclusions regarding the upgrade of an anode slot cutting operation to deeper and narrower slots:

- The deepening and narrowing of the slots is an industry trend in the quest of optimization of productivity, financial and environmental performance of the aluminium production.
- The practice of sawing the slots in lieu of forming the slots in the anodes allows for the deepest possible slots.
- In order to have the narrowest possible slots, the climb cutting method is preferred over the simpler conventional cutting method.
- Climb cutting is a more challenging method of cutting in the harsh application but the method and technology are now well proven in the industry.
- The conversion of an existing conventional cutting operation can be converted to a climb milling operation which will allow an existing smelter to reach state of the art slot cutting practice while also having an attractive business case for doing so.
- In the process of an upgrade from conventional cutting to climb cutting, further machine enhancements including Industry 4.0 technologies can be incorporated to reduce OPEX costs and increase uptime and productivity of the slot cutting operation, which can optimise machine performance and provide ample maintenance features for predictive fault finding.

8. References

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