Anode Centre Modifications to Accommodate Potroom Amperage Increase – A Review and Practical Experience

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Abstract

As anode consumption is proportional to aluminium production, an increase of amperage for more aluminium production requires an increase in anode production. This increase can be in the number of anodes, anode size or anode density. This usually means substantial modifications in the anode centre. There are large numbers of possible modifications to increase carbon anode production. Each modification arrives with its advantages and disadvantages. This paper presents most modifications that can be made in an anode centre to increase anode production, with an overview of consequences on equipment, process and inventory. This review paper is motivated by the first author's experience of over 25 years with the modifications in an anode centre, made to accommodate amperage increases.

Keywords: Aluminum electrolysis, Carbon anodes, Anode center modifications for increased production, Anode size increase.

1. Introduction

There are two main directions in potline operation, depending on economical conditions and objectives: maximum metal production, and minimum power consumption. The former is profitable in regions with abundant power and low energy cost, the latter in regions with high energy cost and limited power. In general, high metal productivity pots operate with high anode current density and low anode-cathode distance (ACD), and low energy consumption pots with low anode current density and high ACD; in the same technology, the two modes of operation are also possible, each at different amperage [1].

In this paper we focus on smelters that are maximizing metal production, and we explore the consequences of increasing the metal production on the anode production.

Metal production increase in an existing smelter can be achieved by:

1) Increasing amperage in existing pots: This involves pot operation strategy changes, and pot design changes to compensate for increased heat generation in the pots [2].
2) Adding pots to existing potlines [3]. The number of added pots is usually limited by available space and maximum rectifier voltage.
3) Adding one or more potlines to an existing plant (greenfield expansion) [4, 5].

From these three methods, the first one, amperage increase in existing potlines, is the most profitable because capital cost is minimal as long as existing spare capacities of potrooms, anode plant and casthouse facilities are used. Amperage increase potential for smelter productivity increase in existing smelters was recognized in the 1990s [6–7]. Some smelters started to increase amperage at the very startup of a potline [4].

Whatever method used, anode centre has to follow, because higher metal production requires more carbon anodes since net carbon consumption per tonne of aluminum stays essentially the same. Table 1 gives an example of carbon anode production needs for amperage increase from 360 kA to 410 kA [8]. Production of carbon anodes is a manufacturing process quite different from aluminium electrolysis. Implications of producing more carbon for aluminium pots can become very challenging when anode centre operation is pushed to the maximum of its capacity. Table 2 gives some challenges that, among many more, will be discussed in detail in this paper.

Table 1. Required anode production increase for amperage increase from 360 kA to 410 kA [8].

Anode requirement	Unit	Now	Future	
Amperage	kA	360	410	
Aluminium production	t/y	600 000	680 000	
Baked anodes required	t/y	335 000	380 000	
Baked anode weight	kg	980	1070	
Baked anode length	mm	1550	1650	
Baked anode height	mm	625	650	
Anode current density	A/cm^2	0.893	0.956	
Green paste production	t/y	375 000	420 000	
Green anode weight	kg	1030	1120	
Green mill throughput	t/h	2 × 33	2 × 36	
Specific mixing energy	kWh/t	8.5	7.8	
Anode baking furnace		6	6 fires	7 fires
Production per fire per year	t	55 800	66 300	54 300
Tonnes per section	t	188	180	180
Fire cycle time	h	29.5	24.9	29
Total heat-up time	h	177	149	174

Table 2. Anode production increase: some challenges [8].

Green anode production bottlenecks	Baking furnace
• Ball mill production capacity • Preheating of dry aggregate • Insufficient specific mixing energy • Paste cooler capacity • Vibroformer availability and process control • Mold must be changed for longer anodes • Vacuum compaction to increase anode density • Green anode cooling capacity • More butts: butt storage, cooling, cleaning, crushing, cast iron stripping • Rodding: Faster rodding cycle, more cast iron to be melted, conveyor speed, higher/longer anodes – check clearances	• With 6 fires, total heat up time 149 h is not enough • Increased waste gas volume increases pressure drop in the flues, which leads to a lack of oxygen in the fire zone (soot) Solution: • Add one fire • Increase flue height (check clearance for crane) • Investment required: Extension of the furnace building, refractory, firing equipment, anode transport, handling and slotting equipment, crane capacity and adjustments for anode handling

Table 3c. Volatile volume if 100 % is H_2.

Molecular weight of H_2 (g/mol).	Volume* of H_2 per mol (L)	Weight volatiles, from Table 1a (g)	Volume* of H_2 (L)	Volume* of H_2 (m^3)
2	22.4	54 500	610 400	610.4

** Under normal temperature and pressure conditions, 0 °C and 101 325 Pa*

5. Conclusions

To allow potrooms to produce more aluminium, either by current increase, additional pots or potlines, anode centre should increase its production by either production of more anode blocks, bigger anode blocks or/and denser anode blocks.

This requires additional raw materials and may require more production time or faster production rate. This may also ask for modifying existing equipment to produce, convey, store, bake, rod more, bigger or/and denser anodes and clean and strip more or/and bigger butt.

This requires careful assessment of existing plant equipment to see if it is fit to handle new requirements. If not, it has to be determined if it can be modified to fit new requirement. If not, it may be necessary to replace it with new equipment designed to fill the new requirement.

This process is rarely simple. It requires time, expertise and adequate funding, especially if the anode plant was not originally designed to be upgraded.

6. References

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