Innovation of Prebaked Anode Design to Enhance Productivity

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Abstract

Prebaked anode consumption depends not on physical-chemical properties of the anode as it is, but also by its shape and dimensions. Previously to reduce non-electrolytic consumption of carbon material the upper part of the anode in RUSAL Company had a 100 mm high “lip”. The main shortcoming of this shape is increased burn off rate at the end of the anode cycle, dusting, exposure of stubs to the bath, reduced effective area of the anode, and disturbance of current distribution in the anode carbon. To eliminate these shortcomings optimum anode configuration was mathematically modeled and tested in experimental areas: the lip was diminished, the stub hole was made deeper and the height and width of the anode were increased. Anodes with this configuration showed improved efficiency. Anodes with modified design were used in all potlines with prebaked anodes. Changes in the shape helped reduce anode consumption by 5 – 7.5 kg/t Al and electric energy consumption by 85 to 290 kWh/t Al (depending on the cell type).

Keywords: Prebaked anode, anode shape, butts, anode consumption, anode reactivity.

1. Introduction

It is common knowledge that the main contributors to consumption of prebaked anodes are their physical-chemical properties, cell design and electrolysis variables. Figure 1 shows classical diagram of anode consumption from the paper by Werner Fisher [1], it also gives an equation that helps evaluate contribution of each component of anode net consumption.

$$NC = C + \frac{334}{CE} + 1.2\left(T - 960\right) - 1.7CRR + 9.3AP + 8TC - 1.5ARR \qquad (1)$$

where:
- NC Net carbon consumption, kg C/t Al
- C Cell factor (270 – 310 defined empirically)
- CE Current efficiency, %
- T Bath temperature, °C
- CRR CO_2 reactivity, %
- AP Air permeability, nPm
- TC Thermal conductivity, W/mK
- ARR Air reactivity, %.

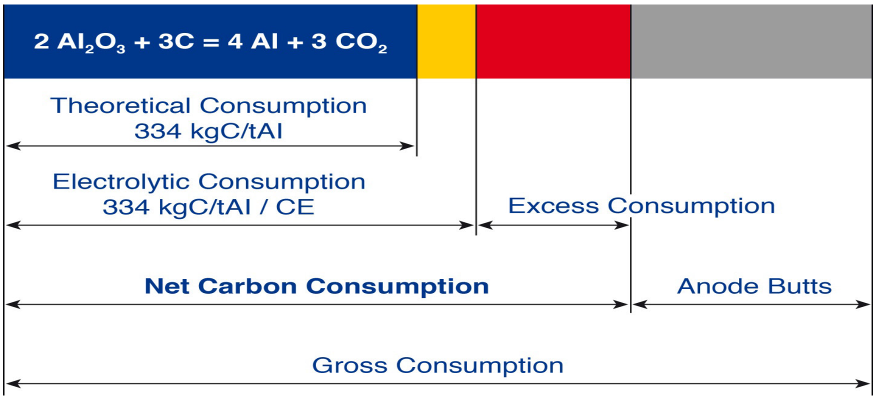

Figure 1. Anode consumption diagram [1].

The anode consumption is largely affected by its shape, configuration of its top, height, length, width and their ratio, stub hole depth, the shape of its faces, height, width and location of slots.

Anode production and the purchased anode cost have a big effect on the cost of aluminum production. Their share varies with companies from 12 to 14 %. Therefore, every producer is searching for its optimum anode shape matching the cell design and meeting commercial requirements when purchasing anode blocks elsewhere: As a minimum, this involves shape and size unitized for different cell types and balance between the minimum of the mass and cycle length.

Anode shapes used in the world are numerous, some of them are shown in Figure 2.

Figure 2. Prebaked anodes of various forms [2].

This article describes causes and results of this conversion a new anode shape.

2. Motivation for Anode Shape Modification

Until 2015, as it was thought at that time in RUSAL plants, to reduce non-productive consumption of carbon material, the section on the upper part of the anode was decreased by a 100 mm high “lip” (Figure 3).

For industrial tests we chose “D” type anode – this is the shape of the new optimized anode with chamfered edges (Figure 12). Industrial tests were carried out in three smelters: Sayanogorsk, Krasnoyarsk and Irkutsk, on different cell types. Performance of the anodes was evaluated for three months. The tests showed that the butts are of regular geometric shape, no burn off at the end and side parts of the butt were observed, reduction of prebaked anode consumption was from 4 to 22 kg/t Al, this makes possible to reduce costs on the average by 6.5 $/ t Al . Test results made possible to recommend implementation of the anode.

Figure 12. New optimized anode with chamfered edges.

6. Conclusions

Comprehensive work on mathematical modeling and industrial tests made possible to choose and assess performance of the prebaked anode of new design. Optimization of geometric dimensions of the anode, depth of the stub hole and shape of faces made possible to improve efficiency of aluminum production:

- Reduce prebaked anode consumption by 5 - 7.5 kgC/t Al and electric energy consumption by 85 to 290 kWh/t Al (depending on the cell type),
- Improve quality of produced prebaked anodes: CRR up to 92.2 %, ARR up to 81.3 %.

7. References

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