In Situ Investigation of Current Distribution in the Anode

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Abstract

During the last few decades, there have been several improvements to the Hall-Héroult process to reduce the energy consumption. One of the modifications was the reduction of the anode-to-cathode distance (ACD), which increases the sensitivity of the cell. However, this can cause operational problems due to large variations of the current distribution in the electrolytic bath. To maintain operational stability while minimizing the ACD, a better understanding of the current distribution in the electrolytic bath is required. Considering the aggressive environment, an *in situ* current distribution in the bath remains difficult to obtain. In this paper, a new approach is proposed to allow correlations between the current distribution variations in a specific anode block and the change of surrounding *in situ* pot operational conditions such as alumina dissolution, bubble movement, metal pad deformation, etc. Since the current distribution on a specific horizontal plane in the anode block is linked to the evolution of the electrical resistance between the anode bottom and the cathode, the proposed approach could provide an efficient way to identify design and/or operational problems and take appropriate action.

Keywords: Current distribution in anode block; anode electrical resistance; in situ anode current distribution; in situ pot operational conditions.

1. Introduction

To improve aluminum production while minimizing the production cost, trends are moving towards greater cell amperage, larger anodes (to maintain acceptable current density) and lower anode-cathode distance (ACD). Those changes add further challenges to maintain a uniform current distribution in the cell.

Indeed, larger anodes and lower ACD lead to a low energy input and a small bath volume which can cause non-uniform alumina dissolution along the anodes, leading to a non-uniform current distribution. Also, the use of larger anode block lowers the current pickup rate which leads to a longer period of non-uniform current distribution [1]. Finally, with a lower ACD, the resistance between the anode bottom and the top of the metal pad (interpolar resistance) is reduced. This means that the resistance from the bubble movement and the metal pad distortion represent a higher percentage of the interpolar resistance than in case of large ACD. Then, considering the parallel circuit configuration, the uniformity of the current distribution across the anode panel becomes more sensitive to those local phenomena. The resulting non-uniform current distribution can lead to high magnetohydrodynamic (MHD) instability, thermal balance disturbances and other operational problems such as anode spikes, perfluorocarbon (PFC) production and anode effects.

To improve the uniformity of the current distribution between anodes, the difference in electrical resistances of each electrical path (delimited by the anode stall location and the cathode) has to be minimal. Figure 1 shows the main features leading to variations of the electrical resistance between the anode stall and the cathode block.

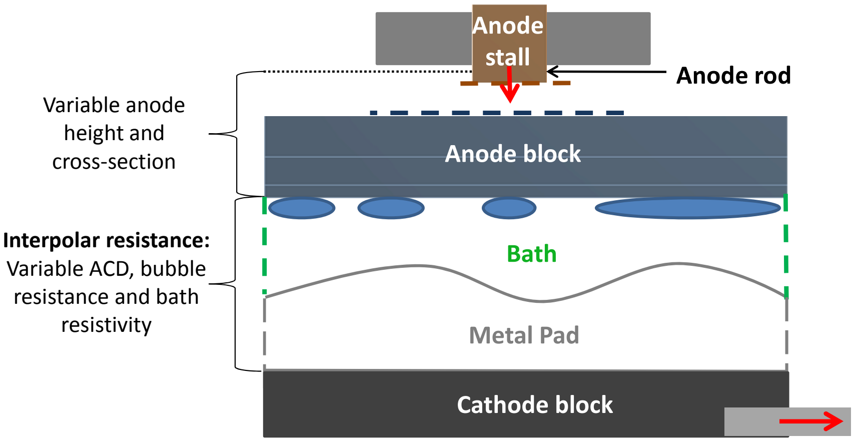

Figure 1. Elements leading to a variation of the electrical resistance.

Since the interpolar resistance variation is directly influenced by the surrounding pot operational conditions (alumina feeding, anode change, anode aging, anode effect, etc.), a better knowledge of the relationship between the *in situ* interpolar resistance variation and the surrounding pot operational conditions may lead to key elements for process optimization.

However, since each event, leading to an interpolar resistance variation, **can have a local impact under the anode bottom**, the anode rod current variation will give only the collective behavior of multiple events. In those cases, it may be difficult to correlate this information with pot operational conditions.

Therefore, **local measurements along the anode bottom would allow correlating the current distribution variation to a local variation of the interpolar resistance.** For instance, as bubble coverage locally increases the resistance and stops the electrolysis leading to higher current densities over the remaining anode bottom surface, the current distribution along the anode bottom would give valuable information about the local electrochemical process.

In this paper, since the current distribution in the anode block is linked to the interpolar resistance distribution (coming from variable ACD, bubble resistance and bath resistivity), an approach is proposed to allow correlating the current density distribution in a specific anode block with the change of *in situ* pot operational conditions.

2. In Situ Measurements

Considering the cell configuration, the aggressive environment and the fluctuations of the local electrical current, the *in situ* current distribution in an anode is difficult to measure.

As shown in Figure 2, the approach consists to use multiple voltage drops along the anode block to be able to interpret the current density distribution along the anode bottom.

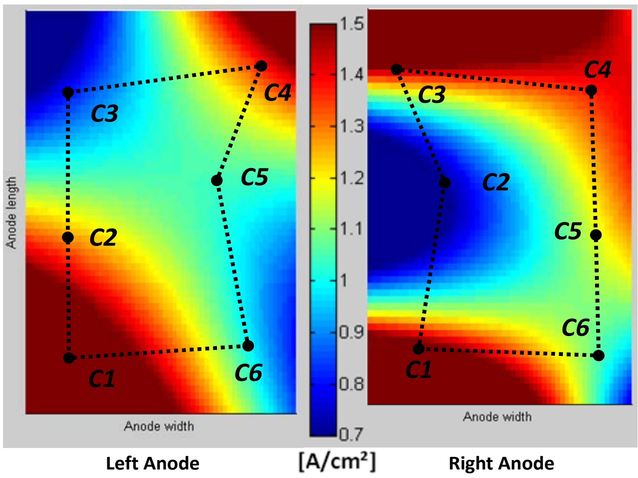

Figure 13. Current density gradient at measurements location.

5. Conclusions

- The approximated function of the anode current density, j(x, y), taken from the anode measurements is able to detect variation of the interpolar resistance distribution;
- The ratio between the calculated current summation according to Equation (2) and the measured anode current allows a better approximation of the resistance between the measurement planes which leads to a more reliable quantification of the anode current densities;
- Higher current density gradient along the measurements leads to larger extrapolation errors of j(x, y).
- A greater number of voltage probes along the measurement planes are needed to get a more accurate (higher polynomial degree) approximated function of j(x, y).

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7. References

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