Millivolt Anodes - New Technology Opportunities for Better Pot Control

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Abstract

Uniform anode current distribution is the basis of stable pot operation and better efficiency. The most common method to control the anode current distribution is to measure voltage drop between two points on each anode rod, the so-called anode millivolt (mV) drop, with a fork. The trend to increase cell size makes global sensing of the cell behavior not sufficiently powerful. Various localized cell phenomena may affect operation and may induce interesting signal pattern characteristics on a probed anode. In order to make this measurement more reliable, rapid and automatic, Maestria Solutions, in collaboration with Rio Tinto Aluminium, has developed Millivolt Anodes (mVa) tool, including a lightweight fork, automatic recording of the anode mV, pre-programmed sequence of measurements and automatic modern data transfer to the computer. This tool has been in use in several smelters, some of them have been using the previous generation of the tool for over 25 years. In this paper, new technology opportunities mainly based on real time analysis, data transfer and integration will be discussed. Actual results of the new versions of these tools will be shown.

Keywords: Anode current distribution measurement; Millivolt Anodes (mVa); anode setting.

1. In Search of Current Efficiency

Current Efficiency (CE) is an important cell parameter that measures which fraction of the electric current results in aluminum production. Proper use of anode signal can be a great process control tool for improving it.

The industrial cell is a complex system where all parameters are closely interrelated. Incremental improvements can be made by managing marginal contributing factors when you can identify their probable origin.

Recently, a considerable interest has been noted in the literature in detection of local cell conditions based on individual anode current measurements [1], which fits well with the global trend of Data Mining, the statistical analysis of large pools of data to find hidden correlations so called Big Data [2]. We vision a great potential of such applications in aluminium smelters considering it is getting easier each year to collect and process a lot of data. We will concentrate on one path of application we know works well and can be implemented without major investment from operators.

Uniform anode current distribution is basic for stable pot operation and best efficiency. Obviously, the smelter staff needs to monitor it by some means. The most common method to monitor the anode current distribution is to measure the voltage drop between two points on each anode rod with a fork, the so-called anode millivolt (mV) drop. We can easily postulate that all the aluminium smelters do this measurement on a more or less regular schedule, but not all reach the maximum possible payback by doing it.

The trend to increase cell size or to increase the amperage of older cell designs makes global sensing of only one measurement element for the whole cell, not sufficiently powerful to really understand the various variations happening inside the cell. Moreover, another trend is amperage creeping of an existing smelter, which is one of the most cost efficient ways to increase the specific production, and is really a success story for many aluminum smelters when well done. One way to increase amperage is to reduce the anode-cathode distance (ACD). So, close monitoring of each anode becomes more and more critical; no need to detail how the current efficiency is very sensitive to ACD variation, especially when it gets very low where instability and drift can make the goal of increasing CE very hard to reach.

Thereby, typical problems following amperage increases are the loss of current efficiency (CE), increased frequency of anode problems, increased anode effect frequency, and increased cathode wear resulting in shorter cell lives. It is well documented that many abnormalities encountered in cell operation are often preceded by some patterns occurring in the current distribution.

Many various local cell phenomena may affect operation and may induce interesting signal pattern characteristics on a probed anode. Diagnosis and correction of operating cell event history help to build a knowledge base that can be put in relation with the anode signal measurement, looking for anode kicking, anode spike, anode setting accuracy, bubble and MHD noise, etc…

Maestria Solutions has developed Millivolt Anodes (mVa) tool; including a lightweight fork, automatic recording of the anode mV, pre-programmed sequence of measurements and automatic modern data transfer to the computer. This tool has been in use in several smelters, in some cases for over 25 years. This tool can be easily integrated at low cost into actual operation team doing the work on the aluminium cells. In diagnostic mode, the tool does a part of the job done by an on-line continuous current monitoring which needs to be installed on each anode of all cells, at a very high installation, maintenance and operation costs.

Uniform anode current distribution is the basis of stable pot operation and best pot performances. Some people consider that 80 % of the cell operation problems are caused by anodes. Even though this can be viewed as an exaggeration for some, it is well known that the anodes are a primary source of potential problems in real operation. Therefore, it is logical to monitor closely the anode behavior in order to detect and correct any irregularity early.

The general concept for individual anode current measurements is to regularly monitor the values and trends of the data sets and to deduce various local cell conditions by matching patterns for known process behaviors, where the proper statistical analysis helps to guide the corrective actions. Starting with Statistical Process Control (SPC) method, the data can be scrutinized in many ways; and by using some smart ways to highlight specific pattern occurring in the data set, it becomes a great diagnostic tool.

A good operation to be monitored closely is the anode setting, well known as disturbing the cell operation for several hours after setting, if not several days. The anodes are set to a certain target height with respect to the old anode butt for proper operation of the cell. Anode setting accuracy in typical operational condition is influenced by many factors. Even in the best situation, it is quite common to have some margin of error in the actual height adjustment. Operators have typically found the following pattern:

- Anode set too low has the following consequences:
    - High current flow in this anode,
    - Prone to cracking carbon, causing bad connection in cast iron-carbon contact,
    - Early instability as metal waves increase, higher noise,
    - Computer adds resistance modifiers,
    - Detrimental to current efficiency, reduces aluminium production.
- Anode set too high has the following consequences:

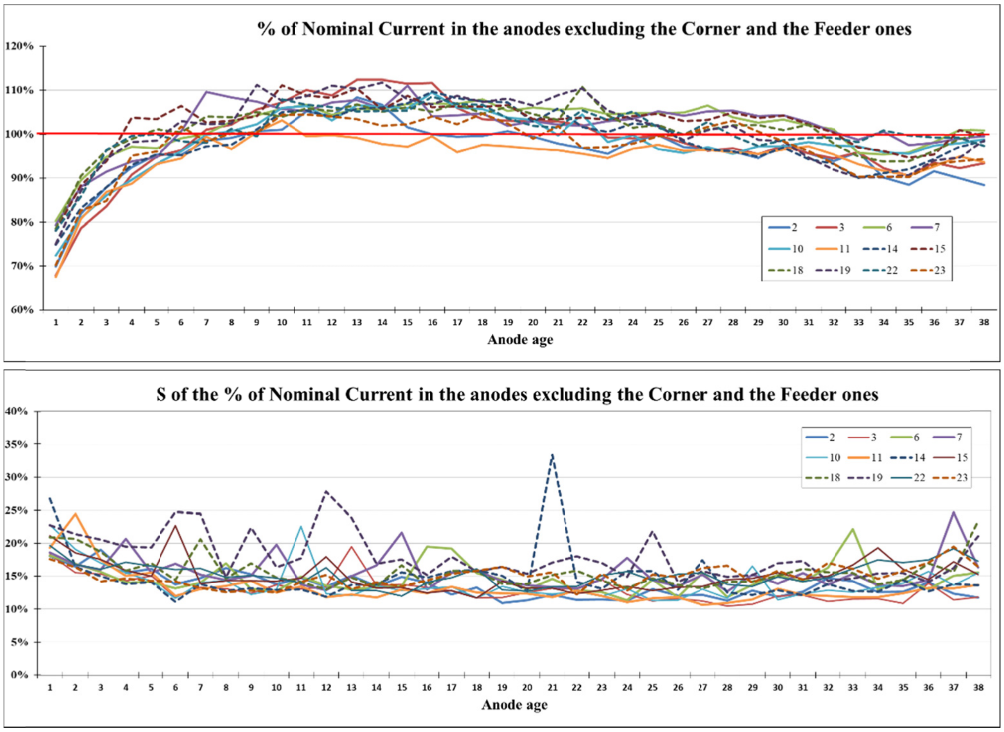

Figure 9. Average and SD of the Nominal current during the life of the anodes excluding the Corner and the Feeder ones. Anode age is in 12-h shifts.

3. Conclusions

In the aluminium smelting process, knowledge related to diagnosis and correction of operation abnormalities is based on rules of the art, but primary source of information is based on actual data of the operation, a real demonstration of the statement: Measure to Control - Benchmark to Improve. Stable anode current distribution is known to be of primary importance and one of the first elements of good cell operation. Applying an easy tool and an easy method for anode current distribution measurements, mVa of Maestria Solutions, will help pot operation staff in day to day follow-up of the cell behaviour and in determination of required actions for optimum pot performance. Some smelters have found great success with the tool and the method for many years. Without having to put a lot of instrumentation in potlines, with mVa tool it is possible to make very good short term diagnostics for anode current outliers and longer term diagnostics, such as potline drift from optimal anode current distribution parameters.

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5. References

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