COMPUTER ALGORITHM TO PREDICT ANODE EFFECT EVENTS

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Abstract

Alumar which is one of Alcoa units, by following a corporate vision, is pursuing ways to reduce greenhouse gas emissions.
Normally, the pot voltage is used to detect the anode effect events every 1 to 10 seconds. With the continuous improvements on the computer performance to handle faster scan data, we are able to read the pot voltage every 100 milliseconds. Our attempt is to use this fast scan data to distinguish the normal and the pre-anode effect voltage period.
An algorithm has been created to detect this behavior, based on the speed of the voltage increase.
With simulation we observed that 60 to 70% of the anode effects are predicted by the new algorithm. The other 40 to 30% are ignored in order to reduce false detections. Only 2 to 10% of the predictions do not really result in anode effects. The accuracy is strongly associated with the noise. The average voltage of prediction is 5.19V where the normal computer detection is 8V.
The predictor was tested during one month in 102 pots indicating that we can predict the anode effect events from 7 to 20 seconds prior to its occurrence. These tests resulted in a reduction of 30% of time above 8 volts and 20% reduction in anode effect/potday.

Introduction

Reduce CO_2 emissions and energy consumption as well as improvements in current efficiency are important keys to the sustainability of aluminum companies around the world.
Financial investments and researches in pot technology have improved the process of aluminum production through decades. These initiatives on pot technology and computer controllers have been reducing the environmental impacts and the cost of aluminum production. For example, computers are able to collect data much faster than 15 years ago. It may allows us to understand more deeply the pot behavior by investigating the patterns of these fast scan information like it was done in this experiment. The anode effect, which is an event that impacts over energy, current efficiency and CO_2 emissions, is detected by the computers when the voltage cell crosses the 8 volts barrier. Once it is detected, this triggers acts to ensure its extinction immediately.

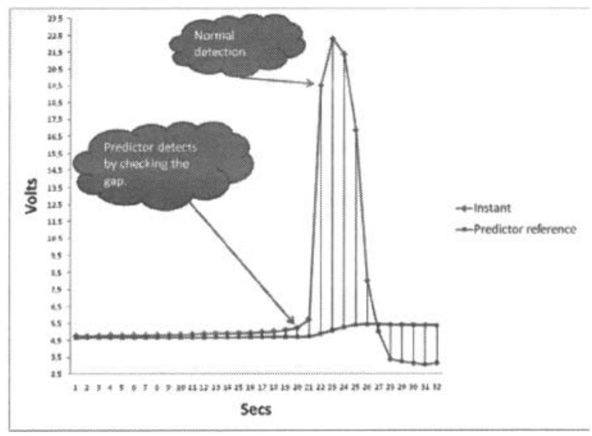

Figure 1 – Two signal volts for detection.

Experimental

The algorithm was created based on field observations of the pot voltmeters during another experiment. It was realized an oscillating pattern in the analogical voltmeter pointer preceding an anode effect event. The fast scan pot voltage was collected for further checking of this behavior and for the algorithm development.
The first trial consisted in one pot and events being forced in order to fine tune the first set of parameters. After the success of this first trial, a group of 10 pots were set during a 15 days period of tests. In this part of the test the computers could only watch and account the number of success versus unsuccessful detections. No action was allowed to be made at that time.
Overall, the algorithm was initially created to compare the fast scan data with the 3 minute information. The gap between these two signals is the main trigger to anticipate the anode effect.
The other very important thing about the predictor is the number of false detections. These false detections are avoided by discarding periods of pot instability or even normal pot operation that would upset the normal signal of voltage.
The result was 137 predictions, 130 resulted in anode effects and 7 were false detected. This 5% error was considered acceptable by the management once the other 95% represents a very good potential of green house gases reduction. The median of time prior to the normal occurrence was 4 seconds sooner and the average voltage was 5.20 V.
The second phase of the test was on a group of 51 pots with the computer watching and reacting to avoid the anode effects.
In order to evaluate the efficiency of the algorithm another group of 51 pots was chosen as a control group. For both groups a period before and after the beginning of the test was defined.

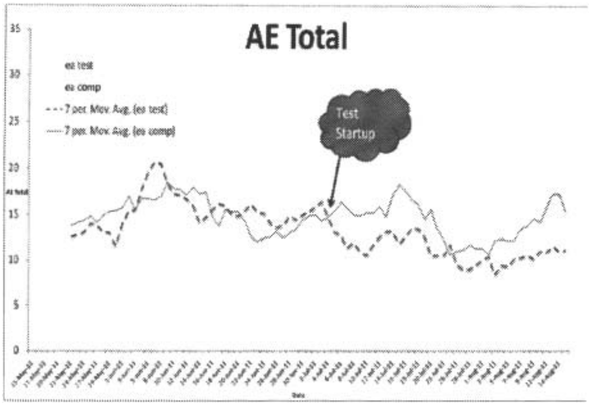

Figure 2 – 7 day moving average test versus control group.

After 46 days of evaluation, a scorecard was graded with the average of the main outputs of the tests – A/PD; AE time above 8 volts/ PD.

	Unit	Gain	% Improvement
AE/PD	total/PD	-0.033	25%
AE_Time>8V/PD	min/PD	-0.058	34%

Figure 3 – Scorecard of gain

An ANOVA was also run against the values collected during the period.
The individual average for AE/PD (anode effect/ potday) showed significant improvement in the test group from before (Antes - Teste) to after (Depois - Teste) with 95% CI, pointed by ANOVA using Tukeys method.

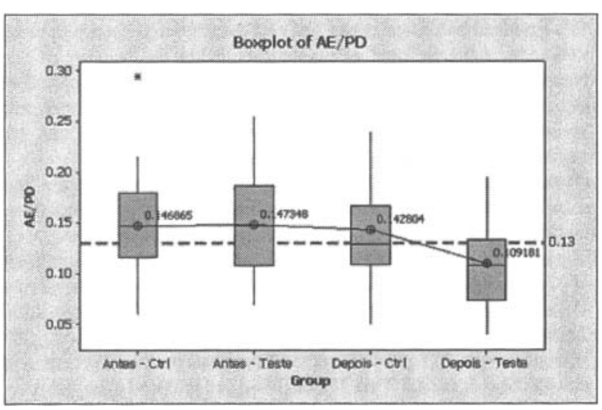

Figure 4 – 51 pots AE/PD Boxplot.

The individual average for AE Time Above 8 Volts/PD had also improved from before (Antes Teste) to after (Depois - Teste), although below 95% CI. - P=0.058.

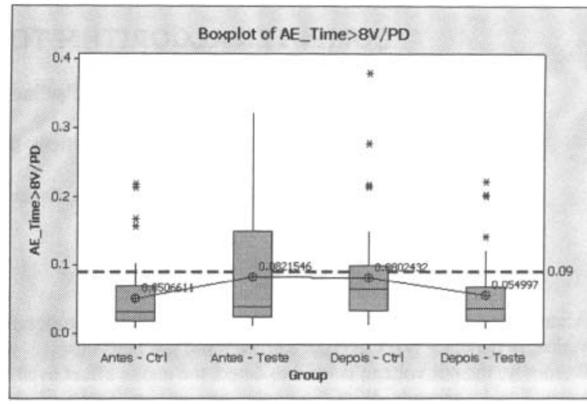

Figure 5 – 51 pots AE Time Above 8 Volts/PD Boxplot.

During the period of tests, other variables were also watched, like current efficiency indicators. There was no significant variance in these indicators.

Conclusions and Recommendations

A simple solution, based on field observations and taking advantage of technology already available gave us enthusiasm to walk in the direction of creating an algorithm that is showing good results over energy consumption and green house gases reduction. We believe that the evolution of this logic associated with more observations, different signals evaluations, artificial intelligence as well as other mathematics calculations could give us better results. The next step is to split new groups of tests in order to fine tune the parameters of the current algorithm and improve the accuracy as well as the time before the anode effect occurrence.
Based on the statistical and scorecard analysis it was recommended the use of the Anode Effect Predictor for all the pots in the plant.

Acknowledgements

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References

[1] – Xiquan Q., Shuijie, L., Shaoxian M., Jihong, M., Dequan W. "Discussion oF Alumina Feeding Control Strategies" **Light Metals**, 2008

[2] – Chase R., Gibson R., Marks J. "PFC Emission Performance for the Global Primary Aluminum Industry" **Light Metals**, 2005

[3] – Batista, E. et al. "Design of Experiment to Minimize Fluoride and Particulate Emissions at ALUMAR", **Light Metals**, 2011