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INITIATIVES TO REDUCTION OF ALUMINUM POTLINE ENERGY CONSUMPTION ALCOA POÇOS DE CALDAS/BRAZIL

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Abstract

Energy is one of the most important inputs for aluminum production and is responsible for approximately 40% of the cost of aluminum production (CAP) in Soderberg pots. Facing the 2008/09 global economic downturn, Alcoa Poços de Caldas Plant, Brazil, has focused its efforts on a planned project, counting on its personnel's potential, to reduce the energy consumption. Main initiatives taken along this process were: workshops on energy (thermal balance and energy consumption), STAR Probe measurements (pot control focused on thermal balance), new cathode design, financial model development and changes in automatic pot control. Through this project a reduction of 77mV/pot and 0.30 kWh/kg Al were achieved, the best ever result reached at the plant at the present load level. In financial terms, in 2008/09, US$ 1 million was saved without any extra investment.

Introduction

Alcoa is a world leader in the production and management of primary aluminum, fabricated aluminum, and alumina combined, through its active and growing participation in all major aspects of the industry: technology, mining, refining, smelting, fabricating, and recycling (Alcoa Inc. Website, 2010).

The increasing global competition gives a steady demand to reduce production costs. The electrolytic production of primary aluminum metal in Hall-Heroult cells is highly energy intensive and accounts for nearly 40% of the production cost (Tandon and Prasad, 2005). This means that energy saving should be the driving force to reduce production costs. To ensure Alcoa Poços de Caldas' future as a competitive aluminum producer, the facility has constantly researched for solutions and development that guarantee the minimum energy consumption and maximum benefit.

As the aluminum industry has faced the 2008/09 global economic downturn and any investments were postponed, Alcoa Poços de Caldas has focused its efforts on a planned workforce, involving its personnel's potential to reach the best financial results in a short-term through energy saving, without any extra investment. The objective of this paper is to present the main initiatives to reduce energy consumption at Alcoa Poços de Caldas, Brazil.

Background

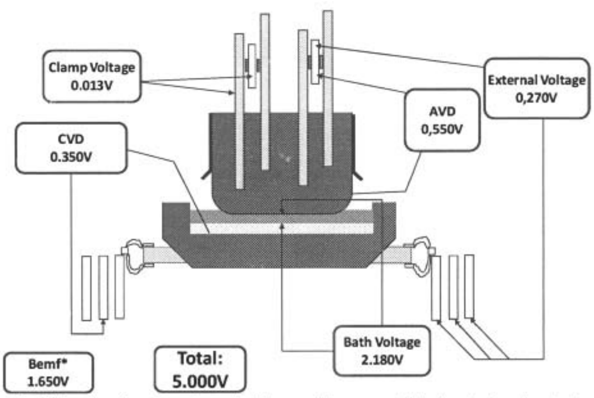
The energy consumption is related to the total energy employed (kWh) to produce a certain amount of molten metal (kg Al), i.e., kWh/kg Al. In other terms, as is derived from Faraday's law, the energy consumption for aluminum electrolysis is:

$$\frac{298.06 * Pot\ Voltage}{Current\ Efficiency\ (\%)}$$

This means that energy consumption reduction can be achieved in either two ways:

1) Reducing total energy use (Voltage/Pot); or,
2) Increasing current efficiency (%).

The "Business Case" of this project was to focus on the first item. Fundamental effort was placed on CVD (Cathode Voltage Drop), AVD (Anode Voltage Drop) and Bath Voltage Drop, according to the voltage drops given in Figure 1.



* Bemf: When the pot line amperage is turned off the pots still have some residual voltage that is usually referred to as the battery effect or Bemf.

Fig. 1 – Break up of total pot voltage (typical).

The largest part of the pot voltage is the voltage drop of about 2.180 V in the molten bath between the carbon anode and the metal pool, which is essentially the cathode. The anode to cathode distance (ACD) is around 5 cm. Reducing ACD, to reduce pot voltage for decreasing energy consumption usually is not adopted in practice because of the danger of losing stability and workability of the cells and consequently the current efficiency. The voltage drop across the ACD depends upon bath resistivity, current density and bubble resistance (Tandon and Prasad, 2005).

The main benefits of reduced voltage per pot are:

- Financial: energy saving;
- Market: different alternatives for use of the surplus energy, including availability to the electricity spot market; increased metal output by means of amperage increase without substantial increase in pot voltage.
- Sustainability: long-term energetic sustainability to the Company;
- Process: reduced bath temperature (since pot stability is maintained); reduced superheat (increase in potlife).

Project Approach

In 2007, pot energy consumption at the Poços de Caldas plant presented numbers that positioned the plant in disadvantage within Alcoa Soderberg Technology System. Thus, in 2008/09, a systematized approach based on Alcoa's personnel potential focused on energy reduction was initiated. What most supported this work was the synchronism between operational and process teams.

The first step was an "Energy Consumption Workshop". This initiative counted on representative of the Global Alcoa Technology Team (LTT). Through the action plan, several additional initiatives catalyzed reduction of energy consumption and can be divided into 4 major topics:

1) Anode Voltage Drop (AVD);
2) Cathode Voltage Drop (CVD);
3) Bath Voltage Drop;
4) Other Initiatives.

1) Anode Voltage Drop

Changes in stub pulling reference and tolerance for stub set in range were implemented to reduce zero height towards the target, since the real results were consistently higher (Fig. 2).

Actions taken:

- Stub in range limits squeezed from 300mm to 200mm;
- Tolerance of stub setting reference was changed from 0-300mm than target to ±100mm near the target.

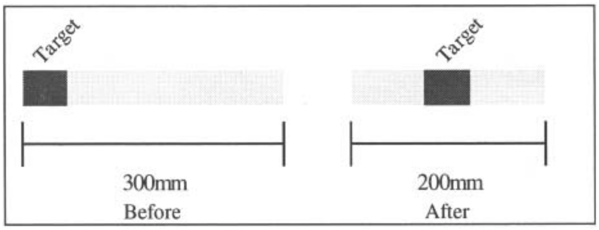


Fig. 2 – Illustrative sketch of changes in stub setting reference.

Theses changes resulted anode voltage drop of 5mV.

2) Cathode Voltage Drop

In this area, the main development was a new cathode design. This project, by itself, reduced cathode voltage drop by 47mV/pot (Fig. 3).

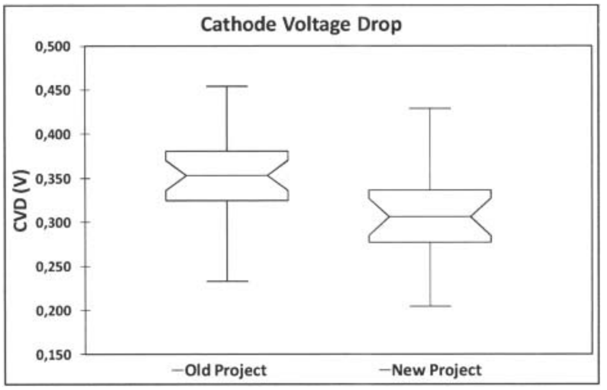


Fig. 3 – Cathode Voltage Drop.

3) Bath Voltage Drop

Main projects developed on this voltage drop were:

- Superheat Workshop: aiming at better knowledge concerning the variables that compose the cell heat balance: voltage, bath chemistry and liquid levels control. From this point on, pot doctors started pot control taking into account superheat numbers. Calculated Superheat and STAR Probe (equipment developed by Alcoa Technical Center employed to measure superheat, temperature, alumina and bath ratio) were widely used and trends daily charted.

- Reduction of Bridge Moves: fine-tuning of the anode bridge move time and step for lowers and raises resulted in a 40%-decrease of anode bridge moves. Thus, pot stability was significantly improved making it easier to make voltage management. Moreover, such a change reduced bridge move travels by over 50% in pots out of control, bringing them into control faster (50% less time).

- Limit for Noisy Pot: for computer control purpose, limits for noisy and quiet pots (extra resistance addition), were increased by 2 units. This adjustment diminished in 90% the total extra resistance for temporary instability control. Trial pots ran for over three months under these new parameters and it wasn't observed any significant current efficiency loss.

4) Other Initiatives

- Financial Model: Calibration and application of a financial model developed by LTT. Basic premises of the model are energy price and LME (London Metal Exchange). Based on these principles the model was utilized as a guideline for the most profitable direction: Current efficiency vs. Voltage per pot (Fig. 4).

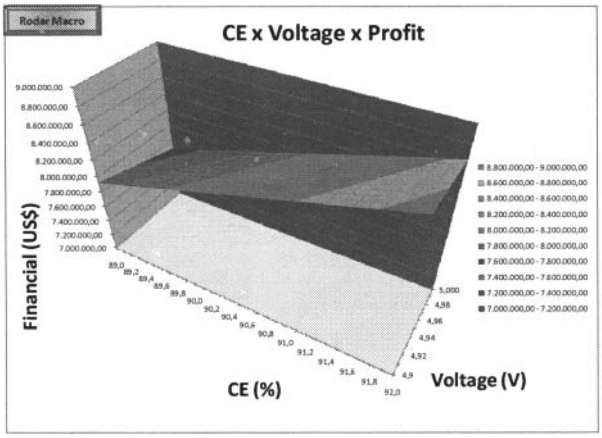


Fig. 4 – Surface graph from the financial model.

- Energy Management: since this was a project with no technological investment, its structuring depended a lot on the staff creativity and innovation. Hence, all the ideas were supported by the ABS (Alcoa Business System) Methodology, mainly some stability tools, as follows:

  - Daily Management System (DMS) focused on resistance target:
    - Visual boards;
    - Resistance targets (periodically reduced);
    - Daily meetings focused on reduction of energy consumption.

  - Practical Problem Solving:
    - Voltage breakdown study (comparison with the Alcoa Benchmark: Avilés);
    - Establishment of an action plan to reduce the voltage drop.

  - Kaizen/Standardized Work: it was carried out a Kaizen for Spike Pulling Activity, which minimized deviations in this activity. A new procedure was developed for clamp voltage drop correction, where the operators adjust clamp drop as soon as they pull a set of spikes.

  - Process Management: focus on continuous improvement through the integrated actuation of teams of Resistance Control, Liquid Levels Control and Bath Chemistry with the mission of put under control and capable variables that affect directly energy consumption. Main developments were:

    - Quarterly, Cp and Cpk (process capability indexes which measure how close a process is running to its specification limits, relative to the natural variability of the process) are calculated for the most critical variables for energy (voltage, stability, AVD, CVD, External Voltage Drop and Clamp Drop), including control charts.

    - Implantation of a new noise metric (MHD Noise), that has shown better correlation with magnetic stability, given that SPPN (peak-to-peak noise) has strong influence of bubble noise. Statistical analysis showed an optimum point for current efficiency.

    - Change in bath correction table, improving bath level in range from 88% in 2007 to 94% in 2009.

    - Implantation of fortnightly report of external losses.

  - Process Training: three trainings applied for tapping and stubbing operators and pot tenders:

    - Resistance Control Fundamentals;

    - Resistance Control and Graphs;

    - Basic Electrolysis Fundamentals.

These actions are part of a large Process Management System and are considered truly important to keep a long-term improved performance in energy efficiency.

Results

The entire project was based on Process Management Tools and, therefore, it was not invested any money in it. As a result, in 2009 the best result ever was registered for the Alcoa Poços de Caldas Plant since 2001 (from 2001 on, the load increase exceeded 120kA).

Voltage per pot was gradually reduced 77mV in 2009 (Reference: 2007). Figure 5 shows the voltage per pot evolution over 3 years.

In 2009 the energy efficiency achieved was 0.30kWh/kg Al below the result recorded in 2007. The energy reduction provided a total profit of US$ 1 million.

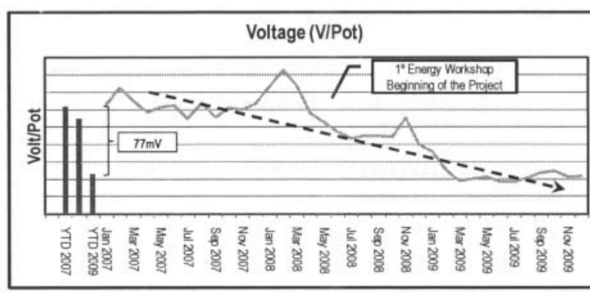


Fig. 5 – Voltage per pot evolution.

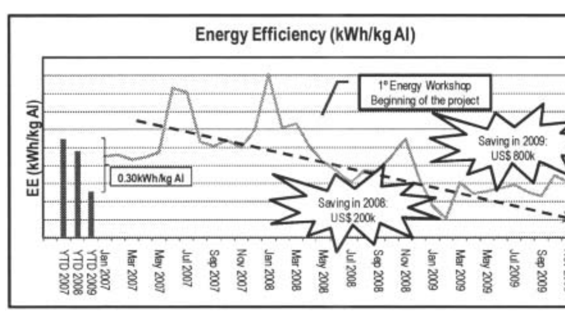


Fig. 6 – Energy efficiency evolution.

Conclusion

Given the world economic crisis, this project implementation has shown the many opportunities smelters can pursue in their own capabilities and personnel's potential. Through a well-organized and integrated Process Management System, by using the correct tools, the energy efficiency improved by 0.30kWh/kg Al, reaching the best results in recent times. Such initiative provided the company with a saving of US$ 1 million and the benefits of this energy reduction are many (sustainability, market, financial and process)

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