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ELECTRODE TECHNOLOGY FOR ALUMINUM PRODUCTION

Rodding Operation and Anode Electrical Connections

SESSION CHAIR
Duygu Kocaefe
Université du Québec à Chicoutimi
Chicoutimi, QC, Canada

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IMPROVING ENERGY EFFICIENCY AT ALBRAS: A CASE STUDY IN THE RODDING SHOP

Paulo Douglas S. de Vasconcelos[1], Marcelino Pascal Rodrigues Vasconcellos[1], José Fernando Nunes[2]
[1]Albras Alumínio Brasileiro S/A; [2]Elosolutions

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ABSTRACT

Aluminum industry is very competitive on international level, which is forcing aluminum smelters to reduce their costs. Electrical power accounts for the biggest part of the aluminum production cost; consequently, there is a drive for increasing energy efficiency of the smelters. In 2012, Albras launched an Improvement Program to reduce its production costs. So, more than 1000 suggestions were received from the employees to reduce the cost with fast return to help Albras overcome the crisis. The focus of the rodding shop was on the reduction of the energy consumption of the inductions furnaces and the fans of the baghouses. These together represent 72.8% of energy consumption in the plant. Effort was also concentrated on educating the plant personnel on saving energy. This paper shows how the rodding shop reduced the total energy consumption from 879 MWh/month to 720 MWh/month and the specific energy consumption (per anode) from 75.82 kWh/ton to 67.7 kWh/ton (2010 to 2013).

INTRODUCTION

The electrical energy was subsidized for Albras from the start up in 1985 to 2004. In this period, the engineering department improved the workplace environment and the pouring station capacity by installing electro-intensive baghouses and two induction furnaces of 1 MW in the rodding shop. To support this upgrades, the local substation was repowered from 3 MVA to 6.7 MVA. The electric motors of the baghouse exhausters of 110 kW with sofstart drives controlled the motor start-up but did not control the volumetric air flowrate of the baghouses. Therefore, the dedusting of the workplace was adjusted via the exhauster damper as shown in figure 1.

After 2005, the energy price increased more than five times and the aluminum price (LME) decreased almost by half since 2008. So, Albras has to increase energy efficiency to stay competitive.

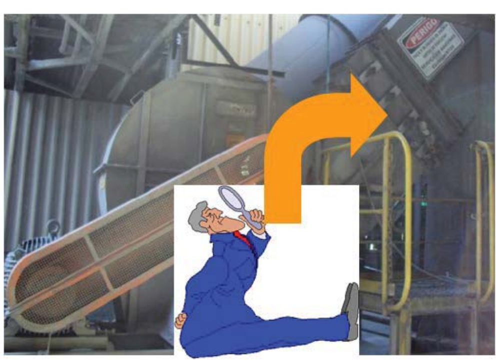

Figure 1 – Exhauster's damper to adjust the volumetric air flowrate of the baghouse.

DESCRIPTION OF THE PROJECT

Until 2004, electric energy accounted for less than 20% of the Albras' production cost, but today it represents almost 50% of the cost. So, it is necessary to change the old ways of thinking and introduce new concepts to eliminate energy and raw material waste.

Even after installing eight huge baghouses in the two rodding shops, demands of operators continued for better workplace without pollution, especially, the pouring station receiving cast iron from the induction furnaces. These issues were related to the conception of the original projects. The pipeline of the baghouse that dedusts the shot blasting machine, autogenous and roller mills became clogged from time to time due to deposition of coarse particles collected at the hood as it can be seen in figure 2.

Figure 2 – Clogged pipeline due to lack of intelligent control of the exhauster's baghouse.

Other problem was the reliability and availability of the induction furnace, which is the state of the art technology. However, at that time, there was a lack of spare parts and personnel trained to repair it quickly in case of failure in addition to the equipment design problems.

CASE STUDY

Characterization of the problem

As explained above, the induction furnace was not very reliable. Extra-hours of work were required to reach the production target. When the induction furnace of 1 MW was available, it was used in full power mode which increased the energy consumption as illustrated in figure 3 (46% of total energy consumption).

The baghouses are also electric energy intensive equipments and their consumption accounts for 26.8% of the energy consumption in the rodding shop.

So, the baghouses and induction furnaces were identified as the main cause of the low energy efficiency in the rodding shop.

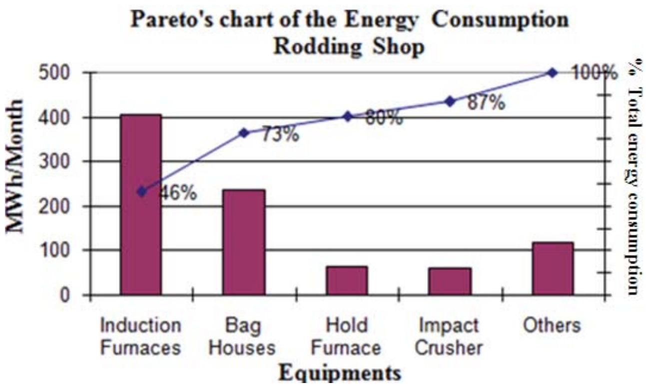

Figure – 3 Energy Consumption (2010).

Analysis of the problem

Following the inspection of the baghouses and induction furnaces, the following problems were identified:

- ✓ Lack of a speed controller (using manual dampers) to start and adjust the volumetric air flowrate and the power demand of the baghouses – figure 1(**project**);
- ✓ Low reliability and availability of the induction furnaces (**maintenance**);
- ✓ Lack of an educational program/campaign to encourage the rational use of electric energy including lighting (management);
- ✓ Lack of confidence of the operation crew who has to operate the plant with only one induction furnace (management).

Solving the operation and maintenance issues:

1) Baghouses – Installation of a speed controller.

Figure 4 shows the power requirement of a baghouse exhauster (FM 223006) versus the volumetric air flowrate. Using the law of similarity for the fans, it is possible to correlate the power requirement and volumetric air flowrate with the output frequency of the speed controller:

- ✓ The volumetric air flowrate (Q) [1] is directly proportional to the frequency (f) or motor speed (n) – equation (1).

$$\frac{Q_2}{Q_1} = \frac{n_2}{n_1} = \frac{f_2}{f_1} \qquad (1)$$

- ✓ Power demanded (P) [1] is proportional to the third power of the frequency or motor speed – equation (2).

$$\frac{P_2}{P_1} = \frac{n_2^3}{n_1^3} = \frac{f_2^3}{f_1^3} \qquad (2)$$

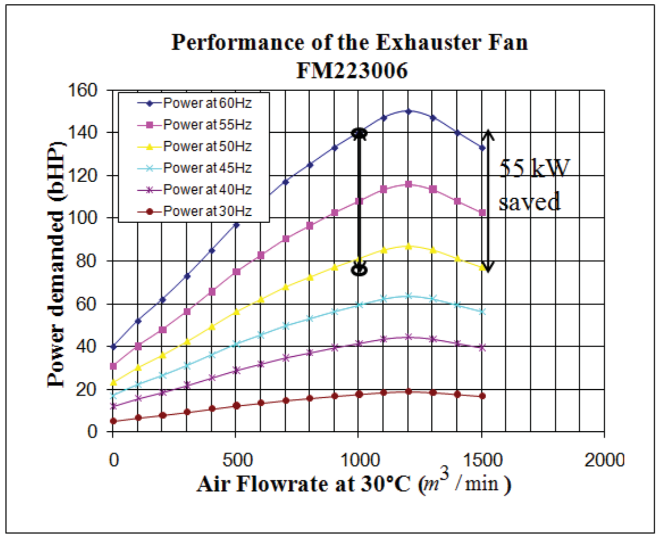

Figure 4 – Exhauster curves controlled by a speed controller – PID controller [2].

The baghouse number FM 223006 was not performing well. The damper had to be totally open to dedust the workplace environment. In addition, frequent shutdowns occurred due to current overload. The pulley and power belt transmission repeatedly required man-power due to frequent need for repair. The maintenance crew identified the problem as the low power of the electric motor (110 kW).

Figure 5 – Portable velocity and pressure meter with Pitot tube.

The volumetric air flowrate of this baghouse (FM 223006) was measured as 1000 m^3/min using a Pitot tube shown in figure 5. So, the power demand was obtained using the equations (1) and (2) and the Microsoft Excel, and shown in figure 4 for the frequency range from 30 Hz to 60 Hz [3]. The manufacturer of the fan supplied the calibration curve of the exhauster (FM 223006) at 60 Hz.

After the installation of the speed controller in the baghouse, the maintenance problem was eliminated, the workplace ambience was improved, and the air velocity inside the pipelines was increased. Consequently, clogging problem in pipelines, shown in figure 2, was solved. In addition, the power demand was cut by half which resulted in saving of 55 kW. As shown in figure 4, the electric motor was running at 60 Hz (upper circle in figure 4) before the installation of the speed controller and it is running at 48 Hz after the installation of a PID controller with set point adjusted to 50% of the motor nominal power rate (110 kW).

2) Induction furnaces – Improving the manufacturer's design

Albras installed a state of the art induction furnace (figure 6) of 1 MW in 2003 controlled by a programmable logic controller (PLC), net profibus optically linked with the PLC. This equipment had problems due to the start-up in the NAMC card that controls the metal fusion process – see figure 7.

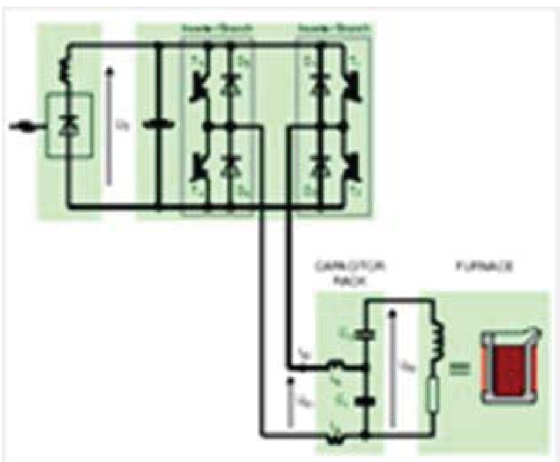

Figure 6 – Induction furnace circuit using IGBT (Insulated gate bipolar transistor) as a power switch [4].

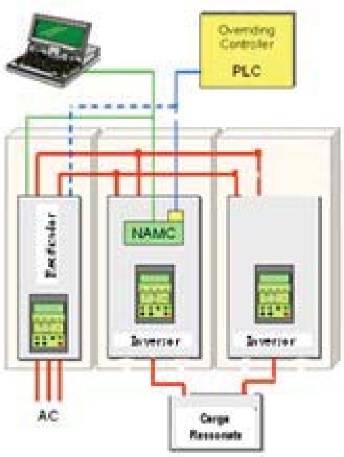

Figure 7 – Induction furnace's peripherals – NAMC card [4].

The NAMC card had memory problems frequently which stopped the fusion process and increased the power consumption of the rodding shop.

In 2010, Albras established a partnership with a Brazilian company to solve the constant problem encountered with the NAMC card. After the study, it was concluded that the problem was related with the electromagnetic noise, because the card was installed close to the inverter's output cupper busbar as can be seen in figure 8. Furthermore, oscilloscope measurements showed the circulation of Eddy current inside the panel due to a lack of an electric earthing. The capacitors of the card were replaced to improve the stability during electrical transients, and a stable power supply was installed– see figure 9.

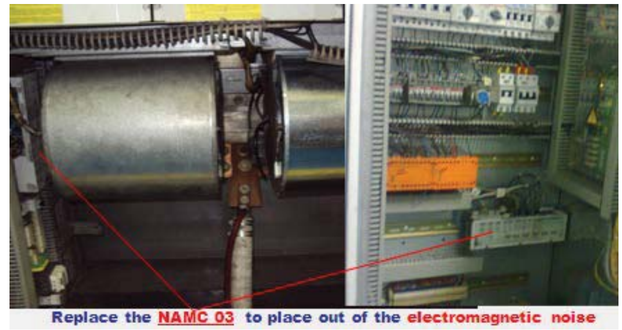

Figure 8 – NAMC card installation.

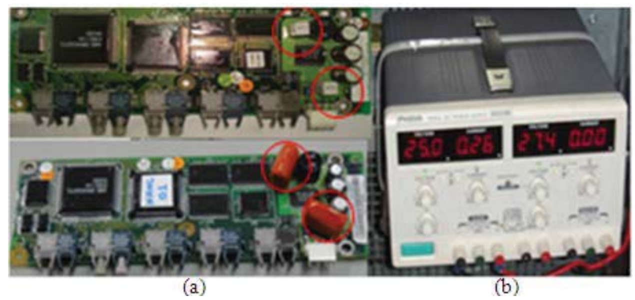

Figure 9 – (a) Replace the NAMC card capacitors, (b) New stable power supply.

Immediately after the modifications of the equipment, the NAMC card performance was improved which consequently reduced the shutdown time of the induction furnace and the waste. This modification also improved the metal fusion process and the energy efficiency.

With these actions, the availability of the induction furnace was increased. However, the reliability of the equipment is still needed to be improved so that only one induction furnace becomes sufficient, consequently, the power consumption of the rodding shop can be decreased. To achieve this objective, a partnership with the same Brazilian company was reinforced and an annual overhaul maintenance plan, both preventive and predictive, was established with the intent of decreasing the undesirable shutdowns.

In the first overhaul, potential source of problems was found to be a faulty connection in the card that measures the voltage feedback of master rectifier as can be seen in figure 10.

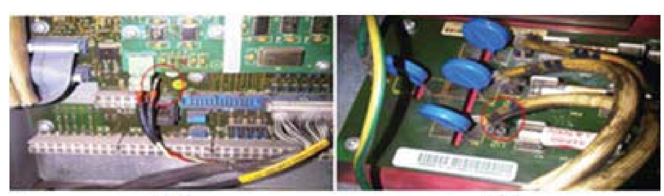

Figure 10 – (a) Disconnected cable in the voltage feedback card, (b) Bad contact in the surge voltage card of the rectifier.

Results and Discussion

Figure 11 indicates the increased reliability of the induction furnace after the improvement of the NAMC card and the new maintenance strategy. According to this strategy, the main goal is to educate the technicians and operators so that they are conscious of the fact that they must do their best to eliminate the waste of raw material and electrical energy for Albras to stay competitive.

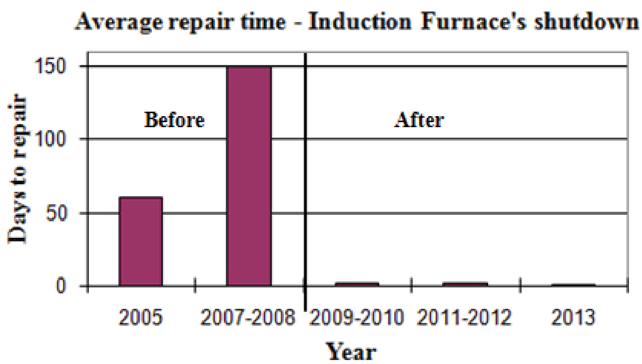

Figure 11 – Shutdown in the Albras' induction furnace.

Figure 12 shows the increase in the availability of the rodding shop since 2005. This indicates the increase in the efficiency of the process due to decreased waste of energy and manpower.

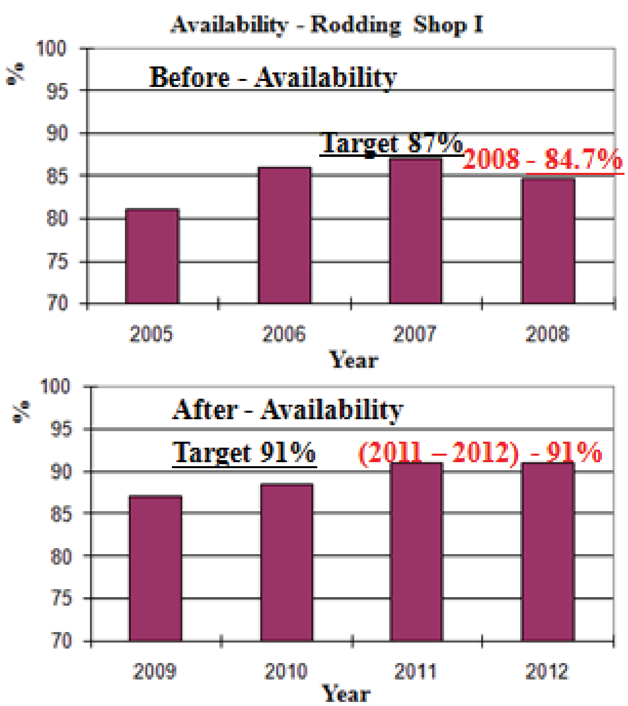

Figure 12 – Evolution of Albras' rodding shop furnace availability.

The energy consumption decreased from 879 MWh/month in 2010 to around 725 MWh/month in 2013 as it is illustrated in figure 13. This shows that a suitable solution was found for the problems of the induction furnaces and the baghouses by installing the speed controllers in five baghouses with 110kW motors as it was explained in the previous section (figure 4).

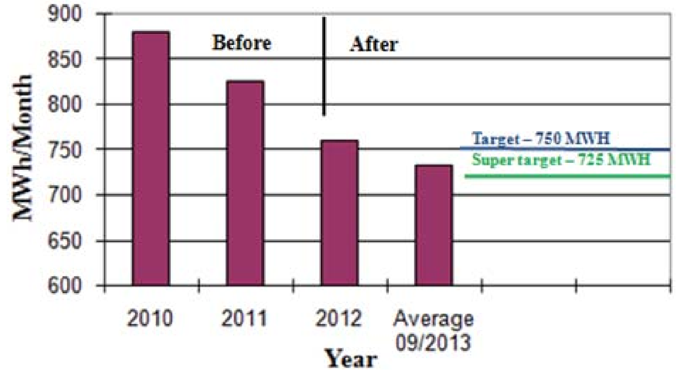

Figure 13 – Electrical Energy consumption in the Albras' rodding shop between 2010 and 2013.

Figure 14 correlates the specific energy consumption with the productivity of the process, thus, shows the improvement in the energy efficiency. This is mostly due to the improvement of Albras' rodding shop which resulted in reduction of specific energy (per anode) from 75.8 kWh/ton in 2010 to around 67.5 kWh/ton in 2013.

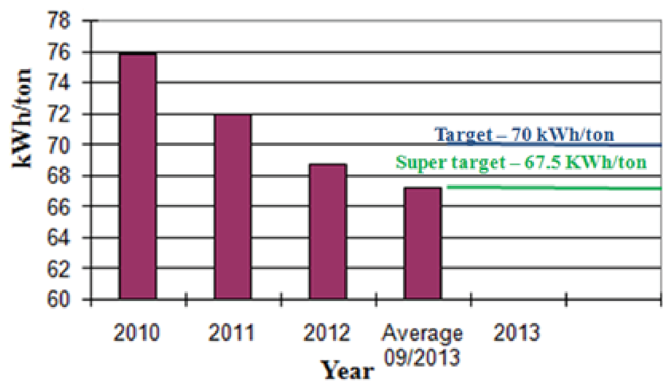

Figure 14 – Specific Electric Energy consumption (per anode) in the Albras' rodding shop between 2010 and 2013.

CONCLUSIONS

The induction furnace has a direct impact on the rodding shop reliability and availability;

Availability of the rodding shop increased from 84.7% (2010) to 91% (2012);

The installation of speed controller is a key factor to control the motor's start-up and the volumetric air flowrate of the baghouses. This optimizes the energy efficiency and reduces the workplace pollution;

The education and training of the teams are very important to perpetuate the results and keep saving energy even in lighting;

The partnership established with an external company has been very useful for Albras.

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