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Brazil 2001 Energy Crisis – The Albras Approach

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Abstract

During 2001, Brazil suffered a major energy shortage. The Aluminum Industry was heavily hit and forced to reduce its energy consumption. This paper describes the approach adopted by Albras to deal with the crisis and to get a fast return to normal operation at the beginning of 2002. The results are discussed regarding the low energy input operation and the impact on cell life.

Introduction

Primary aluminium is obtained by electrolysis where electricity is passed through a molten salt bath. During the process of aluminium production there are two main sources of heat in the system. The first source is resistance heating (when the electric current passes through the bath) and the second source is the exothermic back reaction of aluminium.

Thermal balance is very important for aluminium production. This balance will be possible when we have control of the mass and energy balance of the system.

Albras began operation in 1985 with the start up of Pot line 1, which was originally designed to operate at 135 kA. The other lines, which started up in 1986, 1990 and 1991, had been designed to operate at 150 kA. The original production capacity of Albras was 320,000 tons per year. In 2001 all pot lines were running at 160 kA after successful bus bar compensation.

The Albras smelter is composed of four lines, referred to as Pot line 1, 2, 3 and 4. Each pot line is divided in to 2 rooms with 120 pots. This configuration occurred after the most recent expansion that raised the total number of pots from 864 to 960.

All pots use Pechiney technology (AP-13) with prebaked anodes and side-by-side arrangement.

Power rationing in Brazil commenced on the first day of June 2001. At that time 32 of the 96 new pots (from the expansion) had just been started.

The rationing occurred in two different steps as shown in table 1. Power consumption was originally reduced by 17.2 % and then reduced further to a total reduction of 26.3 %.

	Power Demand (MW)		
	Non Peak Demand	Peak Demand	Decrease in %
Before rationing	650	615	0,0
1st step	538	538	17.2
2nd step	479	479	26.3

Table 1

Strategy

Albras had to reduce its power usage by 16.9% (using May 2001 consumption as the reference) at the beginning of power rationing. The rationing rate was later increased to 25% (using as reference the average power consumption from June to September 2000). It is important to note that Albras was increasing its operating amperage during and after the reference periods. As a result, when the government adopted power rationing rates based on past consumption (and not on present consumption), this further increased the power reduction required, creating an even greater challenge to process control.

As it was necessary to reduce the power used in the plant, we had two possible actions:

1. Shutdown pots;
2. Reduce energy input in the pots;

Each of these actions had advantages and limitations as described in table 2.

What	Advantages	Limitations
Reduce energy input in the pots.	Fewer pots to be restarted and minor impact on pots' life.	Thermal balance from the pots.
Shutdown the pots.	Run the pots in appropriate thermal balance.	Elevated number of pots to be restarted. Impact on pots' life of the shutdown pots.

Table 2

Albras' objective during the power rationing period was to shutdown as few pots as possible and beyond that maintain stable thermal balance in the remaining operating pots. As a result, a mix of the actions described in table 2 was adopted. The amperage of the line was reduced and cell resistance was increased but the increase in the resistance was not large enough, however, to guarantee the same power input in the pot.

Line parameters

A lot of simulations were performed to determinate how many pots would be necessary to shutdown and what amperage we would run, trying to maintain thermal stability. From these simulations we knew that we would decrease the amperage from 160 to 150 kA. Beyond that some changes to the line operation were also done before the power rationing :

- Increase in the anode cover (13 to 17 cm) and decrease in the pots resistance (16.8 to 16.1 μΩ); figure 1.

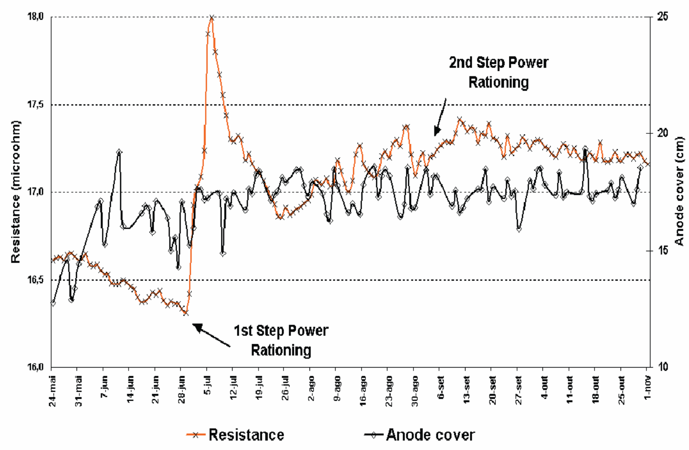


figure 1

- Increase in the bath height (18 to 20 cm); figure 2.

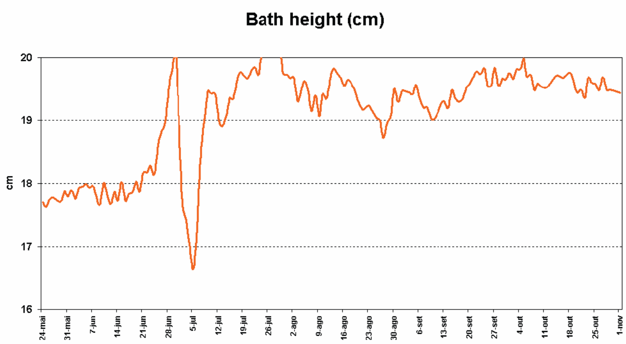


figure 2

- Decrease in the excess aluminium fluoride target in the bath (from 11 to 10%);

Figure 3 contains information on superheat from some Albras' pots. These measurements were made before and during the power rationing. The measurements made during the power rationing were performed after all the changes described in this paper had been implemented.

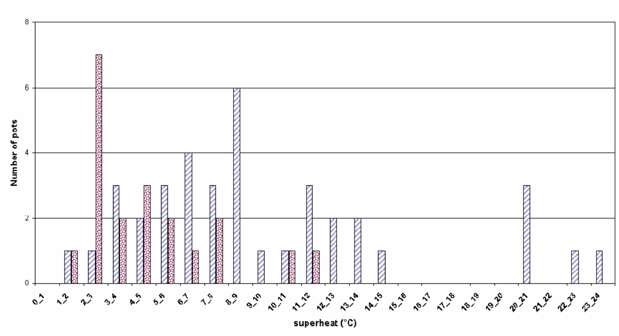


Figure 3

Shutdown

The shutdown commenced on 06/26/2001, which was as close as possible to the start of the power rationing.

Special teams were formed to shutdown the required 93 pots in 5 days.
The largest group of the pots for shutdown were located in pot line 1 (60 pots). As a result, an average of 12 pots needed to be shutdown in Line 1 each day.
The shutdown curve and the decrease in the amperage can be observed in figure 4.

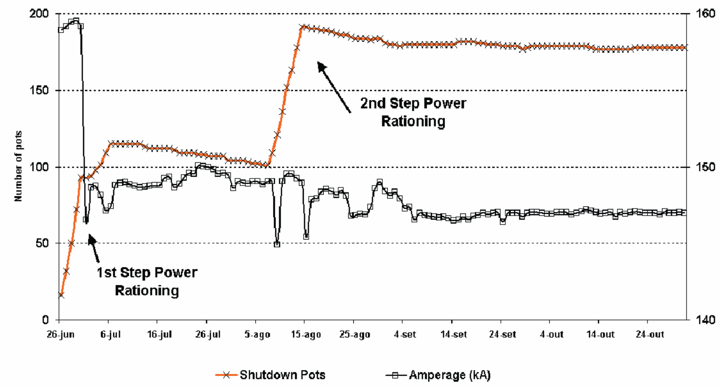
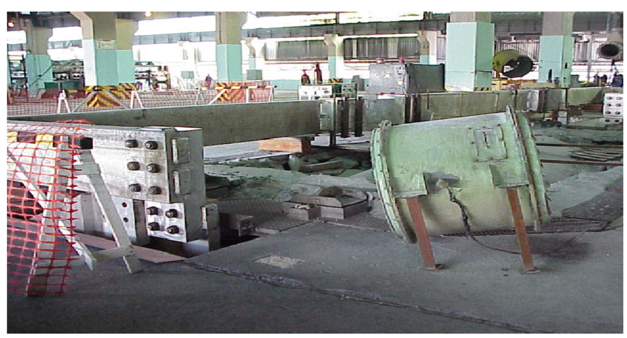


Figure 4

The crossover was the reason why we elected to shutdown so many pots in pot line 1. Using the crossover made possible some energy savings from the bus bar drop and we had more workers during the power rationing and for the beginning of the restart period.
Picture 1 shows the crossover used at Albras during the power rationing.


Picture 1

A similar strategy was used for the second step of the power rationing. The amperage was reduced from 150 to 147 kA and more pots were shutdown. Crossovers were used on pot line 1 and 3. In the end we had shutdown 120 pots in pot line 1 and 60 in pot line 3.

Rationing period

During the first five days following the decrease of the amperage (160 to 150 kA) it was necessary to make very strong actions to balance the lines. Initially we calculated 93 pots to be shutdown, but it became necessary to shutdown 115 to allow extra resistance to be added to the pots.

Figures 5 and 6 show the behavior of some process parameters at the start of the rationing. At that time the line was very unstable and several process parameters were outside of the target ranges.

Fresh alumina was added to the cells to decrease the excess aluminium fluoride in the bath. Fresh alumina additions ceased as soon as the excess aluminium fluoride showed some improvement.

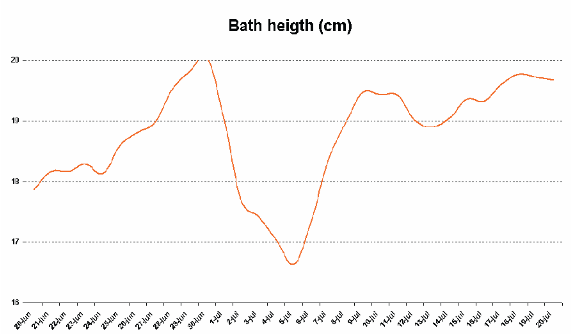


Figure 5

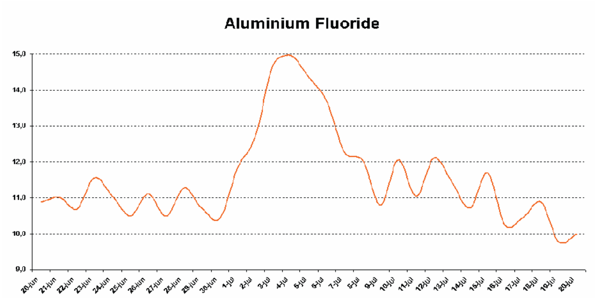


Figure 6

<u>Lines parameters after amperage decrease</u>

Further actions were taken after the amperage decrease. All previous changes were maintained (such as anode cover, bath height etc) and the following new actions made:

- Decrease in the metal pad from 24 to 21cm;

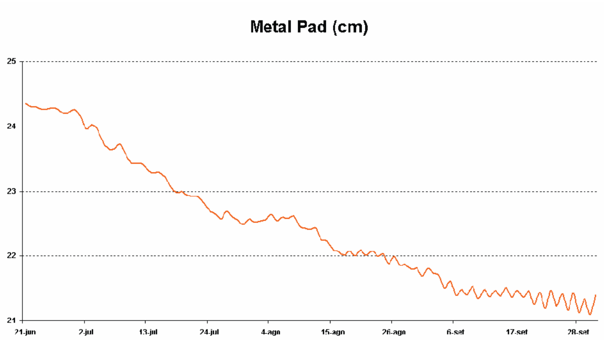


Figure 7

- Decrease in the exhaust rate from 4200 to 3900 Nm^3/h/pot;

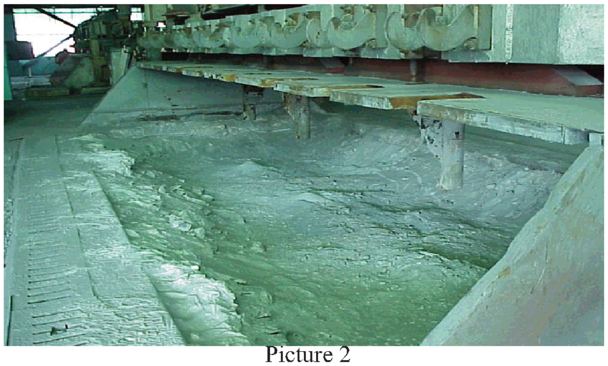
The biggest operational problem faced during the power rationing was the difficulty to tap the pots due to the lower metal pad and the ledge result of the new thermal balance.

Shutdown pots protection

There were great concerns about the lining of the shutdown pots. It was necessary to protect the lining to avoid, or at least minimize, air attack.

Prior to the power rationing, several types of restarts were tried and based on this work the pots were shutdown with some bath left in them. The amount of bath that was left was enough to protect the cathode blocks during cooling while also being little enough to allow easy cleaning of the pot for the restart period.

Picture 2 shows a typical cathode block situation after shutdown.



Picture 2

It should be noted that even after leaving some bath in the pot to protect the lining, oxidation still occurred (as can be seen in Picture 3).

Picture 3

Restart

During power rationing all shutdown pots were checked and decisions were made whether pots would be relined or restarted. For those pots selected for restart, some required patching and others not. The kind of restart (with or without pre heating) was also determined for each cell.

The curve of restart pots at Albras can be seen in figure 8.

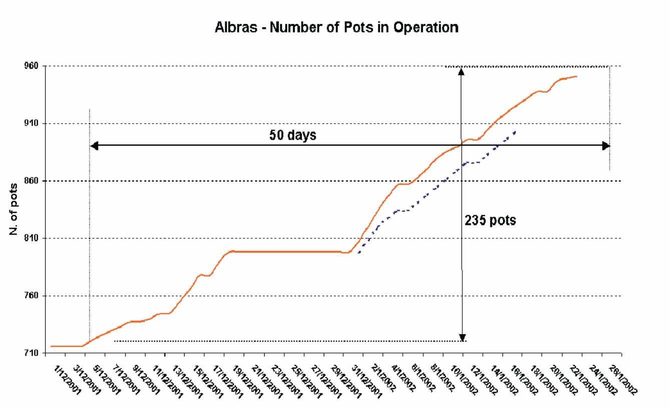


Figure 8

On average, 7.2 pots were restarted each day (if we consider only the days when at least one cell was restarted). In the middle of December cell restarts had to be halted due to power constraints. Cell restarts commenced again in January.

After all, we had 235 pots to be restarted. The objective was to restart these as fast as possible. Several kinds of restart were used to give more flexibility.

Types of restart used at Albras:

1. Cold restart - Addition of hot bath without preheating using hot butts;
2. Hot restart – using a preheating device and/or shunt.

Prior to the power rationing we restarted some cells as a test. One of the concerns raised from this work was the time and logistics involved during the restart period. Efforts were made to decrease the use of hot butts during the restart. This, however, proved to be a problem for the pots because of the number of cracks in the new (cold) anodes. The solution to this problem was the use of cold restart for some pots and a pre heating restart for others.

The cathode block conditions of some pots that were restarted can be seen in the pictures 4 and 5.

Picture 4

Picture 5

The pots were cleaned and then prepared for the restart, as seen in pictures 6 and 7. This cleaning had to be done sometime before the restart due to the large number of pots being restarted. Immediately following the cleaning, plastic sheet was placed over the cathode and sidewalls for protection, as seen in pictures 7, 8 and 9.

Picture 6

Picture 7

Picture 8

Picture 9

Results

The actions taken were effective to improve the control of the pots during the rationing and the restart. We faced some operational difficulties such as transition joint failure, high burn off rate, anode problems (cracks) and hot pots. It is obvious that those difficulties were related to the large number of pots that needed to be restarted and the required high rate of restarts.

We are confident that the actions taken, which include:

1. Delaying the shutdown of the pots;
2. Using the crossover;
3. Protecting the cathode block during cooling down of the pot (with bath) and after cleaning (using plastic);
4. Restarting the pots as fast as possible;

were responsible for the good results obtained during 2001.

This was a very difficulty year for the Albras' team. During this period, however, the skill and strength of the team to win challenges was obvious. This teamwork made possible all of the actions described in the paper.

Acknowledgements

I would like to thank Albras for the opportunity to work with such a team. I would also like to thank all of the people involved during the power rationing at Albras.

References

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