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HIBERNATING LARGE SODERBERG CELLS

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Abstract

A procedure is proposed to lower the anode in metal pad with the power on pots, in case of prolonged partial shutdowns forced on Soderberg pots. Details are given of changes in voltage, temperature of metal and anode top, bakedome and restart in the case of a large pot left in hibernating state for 7 days. Advantages of adopting this procedure and limitations to its application set by local conditions are discussed.

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HIBERNATING LARGE SODERBERG CELLS

Aluminum smelting plants all over the world have been generally concerned about the loss incurred in the event of shutdowns forced on them due to various reasons, like power outage and labour strike (1). It was felt by us that at least a portion of this loss could be reduced in some instances by putting the anodes down on the metal pad with the power on and leaving the pot in this "hibernating" state.

Experiment

In order to study the effect of "hibernating" on our large Soderberg cells at the Paranam Smelter in Suriname, we actually lowered the anode onto the metal pad, in a cell, which was operating normally at an average level of performance, at the average metal and bath depths. The lowering was done in small steps over 15 minutes and this helped substantially in preventing spillage of bath outside. When the anode was lowered 5 cms (2 inches), the voltage dropped abruptly to 1.8 volts, and the lowering was stopped. However, the voltage continued to drop and reached a value of 1.4 volts within 4 hours.

Temperature measurements of the metal layer in the pot were taken every 4 hours through a steel pipe inserted for the purpose before the anode was lowered. The readings were plotted as shown in Fig. 1. As could be seen there, the temperature fell to 700°C in 2 days at the end of which by raising the anode by about 12.5 mm (half an inch), voltage was brought up to about 3.5 to 4.5 volts. Within 16 hours, the temperature of metal rose to about 900°C. Voltage was put down and adjusted to about 2 volts which seemed to hold the temperature in the desirable range of 750° to 800°C. Voltage changes made in the pot are illustrated in Fig. 2.

Apart from the above voltage adjustments, the first movement of the anode was made 12.5 mm (half an inch) up and down at the end of the first 24 hours after the anode was lowered. Initially, the jack motor stalled by blowing one set of fuses, but later it operated well. No special strain was seen on jacks.

The anode top was blown off daily to minimize accumulation of alumina dust. Current distribution was fairly even except for the fact that the front end was taking slightly more load. The temperature at the anode top surface was measured regularly and plotted as shown in Fig. 3. The anode top paste surface temperature dropped slowly in the first two days and then fast till it reached 134°C after 7 days of the pot in hibernating state. On the other hand, measurements of bakedome taken periodically, as plotted in Fig. 4, showed only a very slight increase in 7 days.

Restart

After 7 days in hibernating state without spike setting, tapping or pasting, bath was dug out from the downstream back end and upstream front end corners till the pool of liquid metal could be seen. The pot was restarted after warming up the metal pad for 2 hours at 4.5 to 5 volts and then pouring in bath and lifting the anode, without going through switchplating and power interruptions. The metal pad was moving and the voltage kept kicking for over 1½ hours. Then the voltage became steady around 30 and liquid bath could be seen on the sides of the anode. After a few minutes, the anode was lowered to get the light out and the voltage dropped to 7.5 volts. Some small chunks of anode were removed from the front end, then the pot operated normally with the normal voltage restored within 32 hours as shown in Fig. 5. Operation of the pot after restart was uneventful as shown also by the bath temperature trends shown in Fig. 6.

Benefits

This procedure is thus proved to be practical for adoption in case of an emergency and has the following advantages:

1. It obviates the necessity for switchplating and their removal for a temporary cut out and thus saves manpower and equipment and reduces delays.

2. In the case of large cells, the power interruptions for the line needed for switchplating and cut in operations are completely eliminated, thus reducing pot days lost and other production losses involved in such an operation.

3. Faster restoration of normal operation. The pot remaining still warm during hibernation, comes to normal voltage several hours earlier.

4. It allows us time to fabricate and install means of bypassing current from a pot in some cases, where the bus is badly damaged, by pot failure, to the extent of preventing the possibility of switchplating.

5. This technique comes in handy to push operating level (number of operating pots) higher in some potlines where the main restriction is due to the concern over firm power available always, considering peak loads and possible breakdowns in the system.

6. Reduction in loss of potlining life. On cutting out a pot and restarting, we expect to lose on an average, approximately 20% of the remaining life of the lining. By adopting the hibernating procedure, we expect to eliminate this loss or at least reduce this loss substantially.

7. Power is the only significant requirement of a hibernating pot. In our case, it needs approximately 40% of the normal power input of an operating pot. It postpones the date for total shutdown of the Smelter in case of labour strike, etc., and allows an orderly way of doing it when necessary. This procedure thus improves the readiness of potlines to face wild cat strikes and intermediate length power curtailments. There is a strong possibility that we can face power curtailments of less than 24 hours, with substantially reduced losses.

Limitations

1. This experiment has proved that our large Soderberg pot could be kept in hibernating state for 7 days without significant damage. There is every indication that a pot can be kept in this condition without problems for a longer period, if required. However, doubts have been raised whether prolonged hibernating condition could induce anode problems, and further experimentation is needed to find out the effect on anode after a longer period of hibernation.

2. Suppose the cost of new lining including cost of bath materials and start-up associated is "a". When a new pot is cut out for restart we lose $\frac{20a}{100}$, assuming loss of lining life to be 20%. This will be less when the pot that is cut out is older.

   If the average lining life to be expected is 5 years, the cost of lost lining life will be approximately $\frac{a}{5}$ in the first year, $\frac{4a}{25}$ in the second year, $\frac{3a}{25}$ in the third year and $\frac{2a}{25}$ in the fourth year and $\frac{a}{25}$ in the fifth year.

   Let us assume that the voltage requirement of an operating pot is 5.0 volts, that of a hibernating pot is 2.0 volts and the bus losses for a pot cut out between two operating pots is 0.33 volt. Based on this, the additional voltage requirement of a hibernating pot is 1.67 volts after deducting the inevitable voltage losses when a pot is cut out. That means, in order to put a pot in a hibernating state instead of cutting it out, the additional requirement will be the equivalent of power needed to operate 0.33 pot.

   When we put a pot in hibernation, the voltage requirement is reduced by 3.0 volts, the equivalent of power needed to operate 0.60 pot.

Therefore, in order to put one pot on hibernating state, instead of cutting it out, when we use all available power, we will need to put an additional $\frac{0.33}{0.60}$ or 0.55 pot in hibernation.

Thus, 0.55 additional pot days will be lost if we are to keep one pot in hibernation for a day rather than to take it completely out of service, when power availability is limited.

Let us assume that the net profit from production per pot day is "b", and that the loss of lining life can be eliminated if the pot is not cut out, but instead, is put on hibernation. The maximum number of days a pot can be kept so economically is $\frac{a}{5 \times 0.55\ b}$ if the pot is new, decreasing to $\frac{a}{25 \times 0.55\ b}$ if the pot is in its fifth year of lining age.

The above is a simple calculation taking only some of the most important factors into account. In the case of our pot in Suriname, we feel the economic limit lies between 3 and 7 days depending on the age of the pot or average age of linings in the potline. While in some cases it may not be economical to let a pot hibernate, in certain cases the best course will be to hibernate, as in a situation with acute labor shortage. The decision depends on the abovementioned factors, market conditions and situations obtained then. This technique gives us one more option to choose from, in many cases.

References

1. Pearson, T.G., The Chemical Background of the Aluminium Industry, The Royal Institute of Chemistry, Lectures, Monographs & Reports, No. 3, 1955, p. 41.

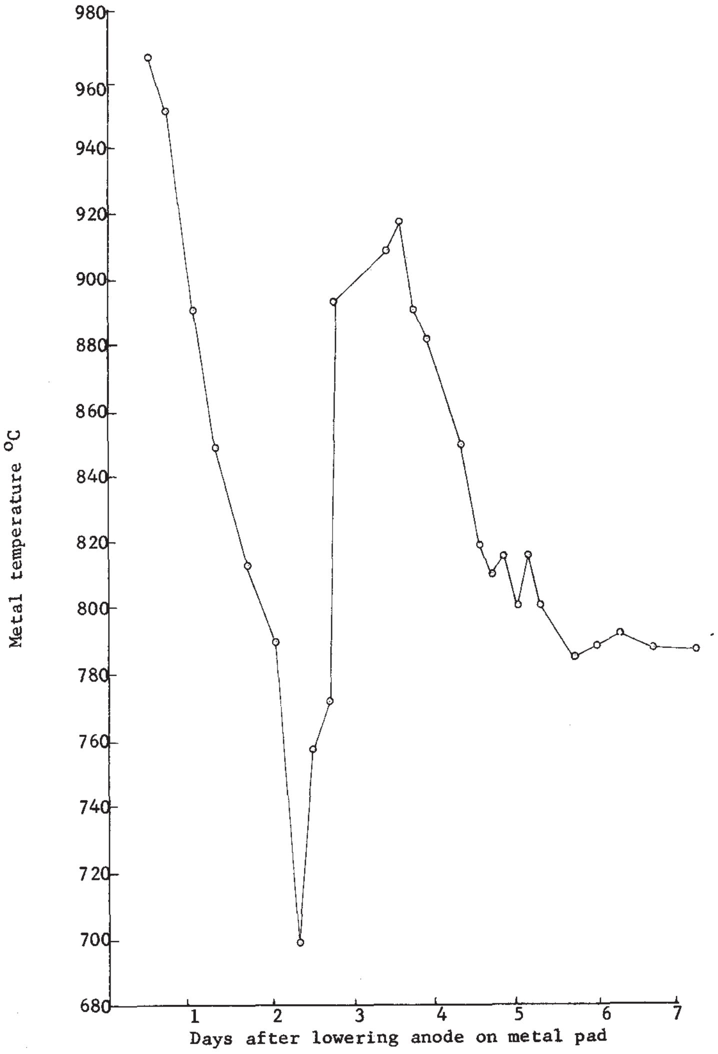

Fig. 1. Metal temperature trends during hibernation.

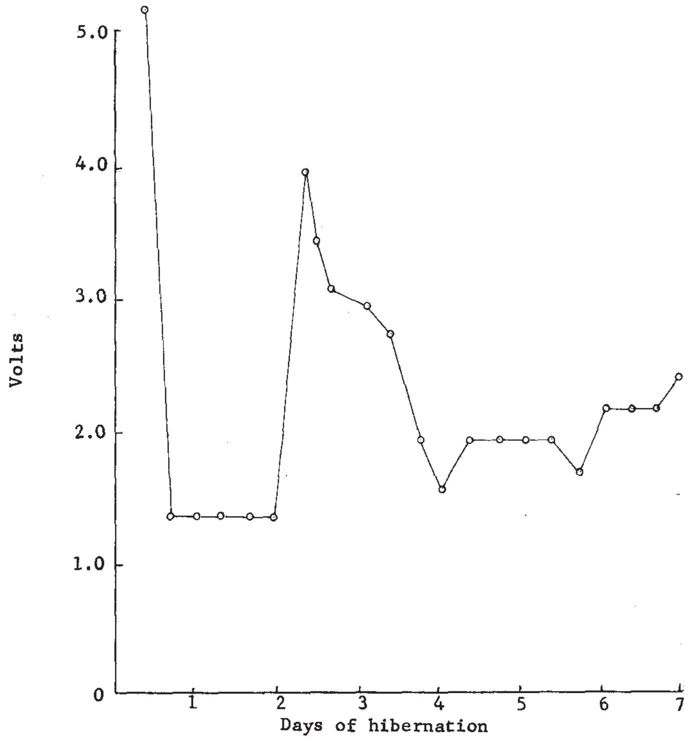

Fig. 2. Pot voltage changes during hibernation.

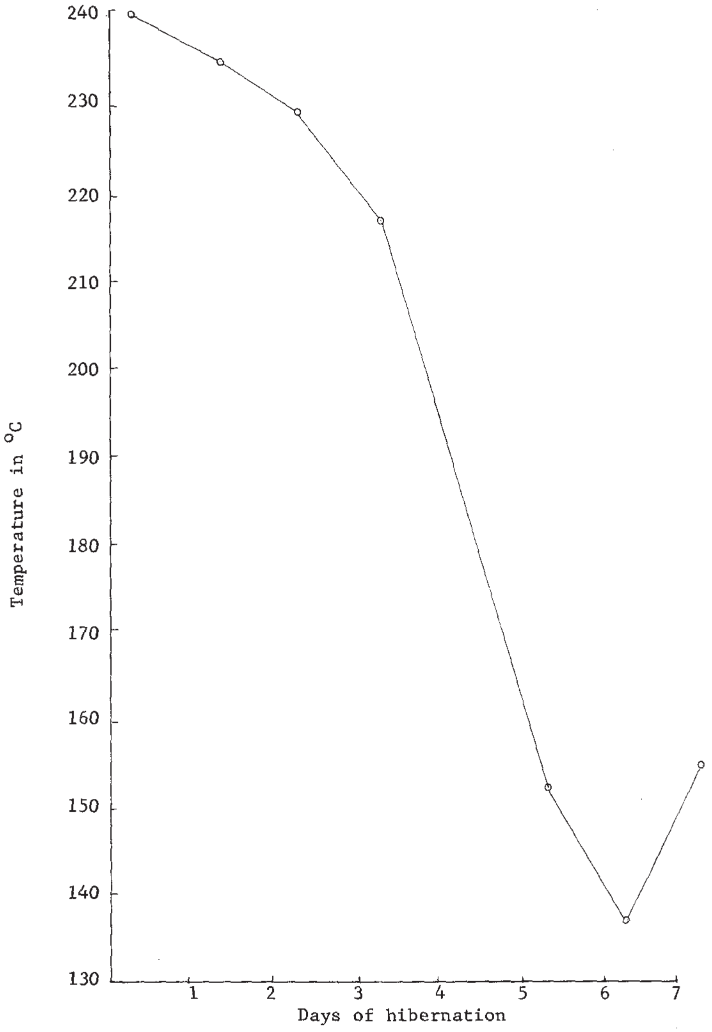

Fig. 3. Anode top paste temperature trends.

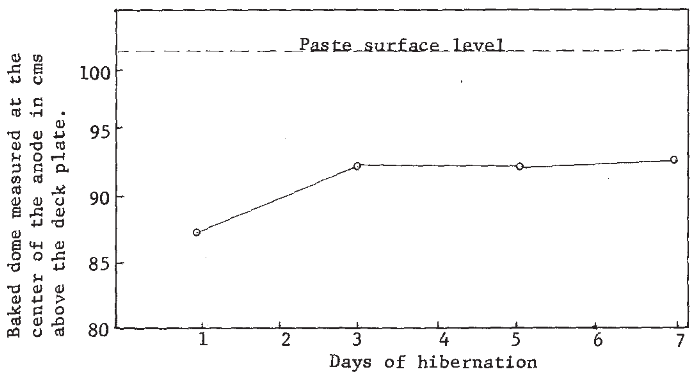

Fig. 4. Bake dome trends during hibernation.

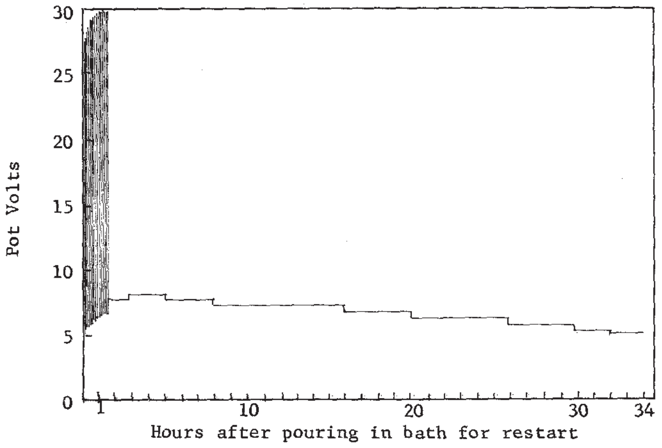

Fig. 5. Pot voltage trends after restart

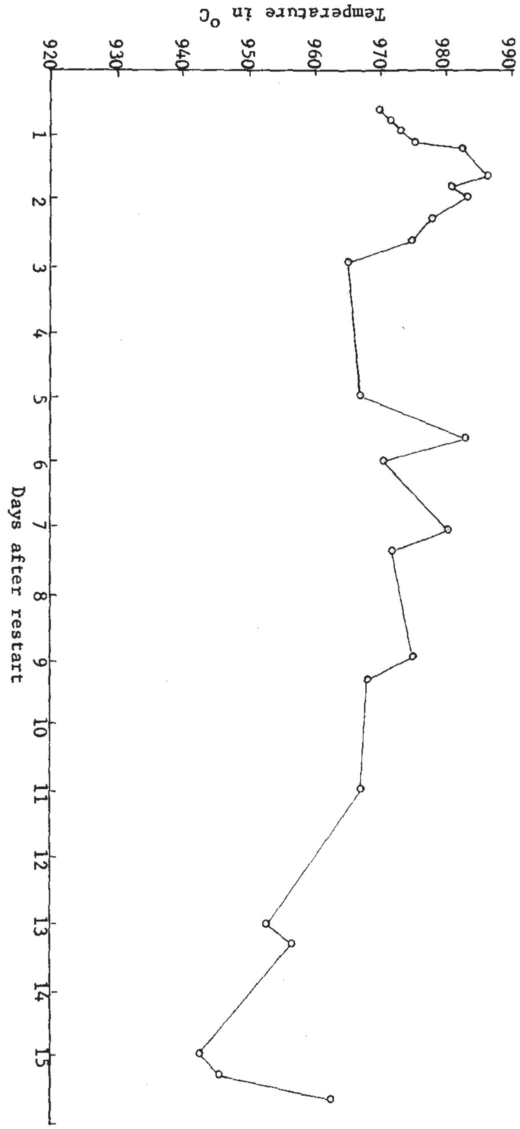

Fig. 6. Bath temperature trend after restart.