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Restart of 300kA Potlines after 5 Hours Power Failure

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Abstract

A Chinese reduction plant has an installed capacity of 140 kt of metal per year and employs 180 pots with line current of 300kA. In May, 2008, power failure happened. The situation lasted 5 hours. The bath temperatures fell to 900°C below. Power was switched on after recovering the power system. At the initial stage of restart the anode effect frequency was high. The voltage and amperage of lines fluctuated severely, which caused higher anode effects. Rectiformer failure would have occurred in such a situation. We finally solved the problems and led the lines to the normal status. The paper discusses the strategies adopted; restart operations and the technological parameter normalization during restart.

Introduction

The Hall-Heroult process for the production of aluminum based on the electrolysis of alumina dissolved in cryolite, using carbon anodes and cathodes, was introduced in 1886 and is still the most important process for the production of the metal. The process has a strict requirement for power system. For a potline with current input of 160 kA and over, it is difficult to drive the cells to normal status if some kinds of power failures occur. These failures include power blackout or power limit. If blackout duration is longer than 3 hours or limit duration longer than 4 hours at input current not satisfying the thermal requirement, some serious problems will happen during the restart of the potlines and lead to cells shutdown if wrong strategy for restart is carried out.[1]

Comparing with the start-up of a new cell, the different features of a cell being restarted include the following [2]:

- the cathode base is more rigid;
- there is more metal in the cell during early operation;
- there will be more sludge/muck in the cells because of collapse of crust and bath during start-up.

The consequence of these differences is that the probability of forming cracks in the cathode blocks increases significantly. Liquid aluminum can penetrate into the cathode block more readily in restarted cells. Thus the metal purity will go down more rapidly in the future operation. The pot life will be short due to cathode deterioration.

A Chinese reduction plant has an installed capacity of 140 kt of metal per year and employs 180 pots with line current of 300kA. In May, 2008, power failure happened suddenly. The situation lasted 5 hours. The bath temperatures fell to 900°C below and electrolyte almost solidified.

This type of situation was never faced by us. According to some literatures [3], some shutdowns were planned unlike the emergency on hand at this smelter. Planned shutdown involve tapping of the metal and bath to the maximum extent possible, reducing anode changing schedule and other related activities, prior to switching off the lines.

Preliminary work

Fortunately, the plant has an emergency power plant, which can supply power for automation system and lighting system. After blackout accidentally, the operations are largely manual with very little automation.
Some preliminary works were carried out:

- Maintenance of cranes, electric panels, alumina feeding system, anode adjusting system and automation system;
- Arrangements for adequate quantities of pot isolation materials like shunt plates, clamps and accessories were also made;
- Raw materials like cryolite, aluminum fluoride;
- Communication check between potrooms and automation station.
- 100 piece of anode blocks

During the blackout, the strategy adopted includes following aspects:

- Profile control of frozen shell/sludge
- Bath temperature control and monitor
- Anode control

Profile control of frozen shell. After power failure, sludge (cryolite and alumina crystals) formed gradually with decreasing bath temperature and precipitated at the bottom of the cell. The sludge solidification may bring on the poor profile of the frozen ledge. For the sake of forming good profile of the frozen ledge, some operations were carried out:

- Switch automatic mode to manual mode in order to avoid immoderately feeding after recovering the power failure.
- Adjust anode-cathode distance gradually in order to avoid poor profile formed underneath the anodes which may bring on short circuit between anodes and cathodes.

Bath temperature control and monitor. After power failure, all operations were terminated. The bath temperatures were measured hourly. All cover plates were put on the pots, and fire holes were sealed with cryolite and crushed bath; anodes were covered with crushed bath and alumina at higher thickness; alumina was manually removed from alumina hopper; dry scrubbing system was stopped. As a result, the bath temperatures decreased slowly as expected, see figure 1 and table 1.

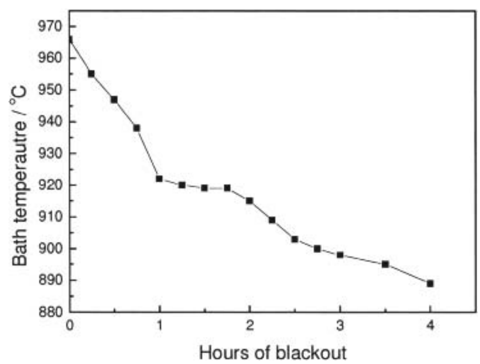

Fig. 1. Bath temperature evolution after power failure.

Table 1. Bath temperatures for some pots

	112#	113#	115#	118#
1h	958	962	951	954
2h	939	935	930	930
3h	912	918	921	914
4h	895	901	885	905

Anode control. The anodes were put down at a rate of 2 cm/h if bath temperatures were higher than 930 °C. In the case of 930 °C below, the anodes were moved downward at a rate of 3 cm/h till contacted with the liquid metal.

Restart Operations

After recovering the power failure, the pot lines were switched on. Initially, anode effects occurred for the most of the cells, and some cells were in the status of short circuit. The line voltage built up reached up to 840 V, and the amperage was very low, less than 120 kA. The pot lines were running at a very poor status and continued to deteriorate.

To overcome this, some strategy were carried out:

- Killed anode effects as soon as possible;
- Stop feeding alumina;
- Stop anode changing operation and metal tapping

Meanwhile, anodes were leveled slowly, and cell voltages were kept at 5 to 6 V. Cryolite was gradually added to increase the bath level. Once electrolyte started melting and bath level was built up to some extent, the voltage was slowly raised to about 10V and this increased thermal input to the pots and thereby helping in melting of cryolite and bath.

After restart operation, bath temperatures gradually reached up to normal level, mainly in the range of 950-965 °C.

Extra cell voltage during the early operating period. During the initial stage of normalization, the voltage was set at 4.3V over. This extra voltage is associated with the heat-up, melting of bath and is necessary for removal of sludge.

Anodes current distribution. Seen from table 2, the initial anodes current distribution was very poor, with number of pots on more than 30V. In some of the pots, arcing and voltage fluctuation were observed. Some anodes were not conducting the current. It was very difficult to push the amperage beyond 120kA. After restart, the situation of anodes current distribution was improved (see table 3). However, most pots were not normalized.

Table 2. Anodes current distribution during restart

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
2.6	**1.5**	**0.8**	3.9	**7.6**	**11**	3.2	3.7	**2.3**	**2.3**
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
3.6	2.9	3.1	5.8	**10.2**	**8**	5.3	**2.1**	**0.3**	**1.9**

Table 3. Anodes current distribution after restart.

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
2.4	3.8	3.7	3.8	3.2	4.2	2.8	4.0	4.2	4.5
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
3.8	4.0	3.3	4.4	**1.7**	3.8	3.7	3.6	3.6	2.6

Side ledge. During restart, the average temperatures of steel shell were never over 400°C (see table 4). It indicated that the side ledge was not damaged.

Table 4. The average temperatures of steel shell before and after restart. /°C

	Tap End	Duct End	Downstream	Upstream
Before Restart	376	367	332	334
After Restart	380	350	330	341

Operating parameters. 15 days later, the cell voltage was controlled at 4.13-4.15V with average cathode voltage drop of 330mV. Anode effect frequency was around 0.2. The metal purity was greater than 99.7%, which indicated that the forming cracks in the cathode blocks were not occurred significantly. After 15 months, the average current efficiency was about 92.5%. The lines come to normal operating levels.

Summary

This was the first experience of restarting lines with current input of 300kA after 5 hours blackout. It is important that the aluminum industry should operate on steady power. Such accident and restart require lot of efforts and have long term impact. However, such restarts enrich our knowledge.

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