Light Metals 2011 *Edited by: Stephen J. Lindsay*
TMS (The Minerals, Metals & Materials Society), 2011

Light Metals 2011

ALUMINUM REDUCTION TECHNOLOGY

Improvement in Cell Equipment and Design

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RETROFIT OF A COMBINED BREAKER FEEDER WITH A CHISEL BATH CONTACT DETECTION SYSTEM TO REDUCE ANODE EFFECT FREQUENCY IN A POTROOM

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Keywords: Chisel bath contact1, Anode effect2, P155 technology3

Abstract

Chisel bath contact detection is a feedback system installed on aluminum reduction cell alumina point feeders to ensure that the crust breaker (or chisel) touches liquid bath. The benefits of chisel bath contact detection on anode effect reduction are well known on ***AP Technology***™ operating with a separate system of breakers and feeders. The present paper describes the technology adaptation for a safe hot change installation of chisel bath contact detection applied to the combined breaker/feeder in a P-155 cell while, at the same time, introducing a longer pneumatic cylinder stroke. Mechanical modifications allowing the reuse of most of the existing breaker/feeder parts as well as the results obtained on four experimental cells during the development phase are presented. The retrofit procedure is also described in the context of a hot change while controlling health, safety and environment (HSE) related aspects.

Introduction

Background

Rio Tinto Alcan is operating three smelters using the P155 technology (Sebree, USA, Grande-Baie and Laterrière, Canada). The three plants represent a total of 1200 cells using a combined breaker and feeder technology[1].

Reducing greenhouse gas (GHG) emissions is part of the Rio Tinto Alcan objectives. To this end in 2006, the Arvida Research & Development Centre was commissioned to find a way to decrease the anode effect frequency (AEF) in P155 cells. The anode effects (AE) are the result of a shortage of alumina in electrolytic cells or when the alumina does not dissolve efficiently in the bath. This predominately generates two gases (CF_4 and C_2F_6), which significantly increase GHG generation due to their high GHG intensity [2].

Operation without chisel-bath contact system

When operating without chisel-bath contact system, the cell is fed with alumina using a simultaneously operated, single cylinder breaker/feeder combination. The breaker breaks the crust and creates a direct opening to the liquid bath and, at the same time, pushes in the alumina dose deposited during the previous crust-breaking operation. The fact that the opening in the crust and alumina feeding are done simultaneously in the same operation with two breaker/feeders is a particular feature of the P155 technology. A single pneumatic cylinder is used in the same operation for both tasks (Figure 1). The cylinder travels the same distance for each crust-breaking operation.

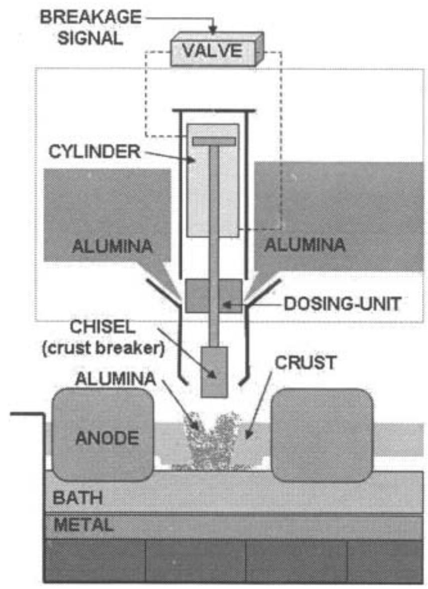

Figure 1: Operation without chisel-bath contact system

Description of problem

During cell operation it may sometimes happen that alumina has difficulty or is not able to reach liquid bath. This phenomenon can take place when the crust is too hard, particularly in the area of the two breaker/feeders. When this happens, the breaker is unable to maintain the opening in the crust. Bath may also accumulate on the chisel of the breaker/feeder. This occurs when the bath level is high (high pumping effect and high bath level fluctuations [3]).

The combination of fixed cylinder travel and liquid height means that the chisel goes deeper into the bath and heats up with every crust-breaking operation. This eventually leads to liquid bath sticking to the chisel, accumulating into a solid mass. The mass grows at each crust-breaking operation and in the end keeps the alumina from entering the bath. Moreover, this additional mass increases the risk of mechanical failure and can even significantly reduce component life cycles. It also leads to premature chisel wear.

The problem can be summarized as follows: the breaker/feeders always operate in the same manner, regardless of cell conditions. They always travel the same distance, always stay the same amount of time in the down position, and always apply the same pressure, regardless of crust conditions. Furthermore, these situations raise HSE risks by increasing the number of operator interventions in problem cells. This also increases the occurrence of AEs that are directly linked to increases in GHG emissions.

Causes of anode effects

Anode effects on P155 cells were analyzed and results show that about half of these are caused by the following:

- Liquid heights
- Blocked feed openings
- Frozen bath accumulated on chisel.

All three situations lead to the same findings: alumina shortages in cells and/or inefficient dissolution. The other AEs are link with operation

Choosing a Solution

Following careful analyses of potential solutions, the chisel-bath contact system used in ***AP Technology***™ was decided upon. The main mechanical difference between the two technologies is found in the breaker/feeder system, which is divided into two separate, independent operations in AP Technology™ cells as opposed to P155 technology. A joint partnership was set up between ARDC and ECL, who already have a tried-and-tested technology on the market, to develop an adapted chisel bath contact solution for P-155 combined breaker/feeder.

Why the chisel-bath contact system?

The chisel-bath contact system:

- Ensures that the chisel stays clean as it quickly withdraws from the bath. This eliminates the accumulation of solidified bath on the chisel and, consequently, cuts down on anode effects.
- Increases the potential of opening the feed hole in the crust as the full power of the cylinder can be used when called for. This increases the likelihood of alumina dissolution in the bath, thus reducing the number of AEs.
- Ensures that the chisel pushes alumina into the bath, thus increasing the total amount of alumina that dissolves into the bath and consequently decreasing AEs.

Ultimate objective for the P155 chisel-bath contact system

- Determine the technological modifications and control conditions to decrease the anode effect rate and/or duration for P155 technology.
- Develop and test the chisel-bath contact detection on P155 cells and adapt PBF's P155 with the best knowledge
- Measure the possibility of detecting contact with the bath when using a combined breaker/feeder.

Description of the P155 Chisel-Bath Contact System

Detection is done by measuring the voltage difference between the chisel in the bath and the cathode, as shown in Figure 2. This requires perfect insulation between the components at cell potential and the breaker-feeder.

This new element makes it possible to operate in two separate modes. The "normal operation" mode allows optimising power, air consumption [3], and alumina penetration in the bath. The other mode, "alarm mode", occurs when the voltage difference measured by the system is too low. At this moment, the cylinder pushes down over a longer period, allowing it to reach full power and push down on the crust for a longer time to increase the chances of crust-breaking and enable alumina injection.

Another situation could occur if a voltage difference is measured even before the breaker has started to move. This is declared a permanent contact situation, and the breaker-feeder operates as if it was in the "alarm mode".

A control system is needed to define which mode the breakers are in, and how each breaker-feeder should react. In short, the crust-breaking signal of the cell is sent to the control system, which activates the command to the breaker-feeders. The information from the crust-breaking operation is sent back to the system, which will creates an alarm if necessary.

Normal operation

A crust-breaking signal is sent to the breaker-feeder, which travels down towards the bath. The chisel comes down and pushes the alumina into the bath. When the chisel comes into contact with the bath, the voltage difference is measured, which generates the lift command to the cylinder. During this sequence, the dosing unit comes down and deposites new alumina near the hole. This operation occurs more quickly than the standard cell operation, leading to air consumption savings [3].

Alarm mode

A crust-breaking signal is sent to the first breaker-feeder, which travels down towards the bath. The chisel comes down and pushes the alumina towards the bath. If the chisel does not come into contact with the bath or if the voltage difference is too low, the cylinder continues to travel down to build up maximum pressure over a long time period. During this sequence, the dosing unit comes down and deposites new alumina near the hole comes back up and sends an alarm to signal the situation.

Installation of the new system on test cells

Four cells in the same potroom were modified for installation of the new chisel-bath contact system. The new breakers were, in fact, standard P155 breakers that were reused and adapted to fit the chisel-bath contact system. Most of the standard breaker-feeder components were therefore recovered. The new breaker-feeders were installed on an operational cell, with tight control of HSE risks. It has been shown that breaker replacements can be completed in less than 45 minutes, as the result of using a quick fastening system. The replacements can be made on several cells at a time, according to potroom lifting equipment availability.

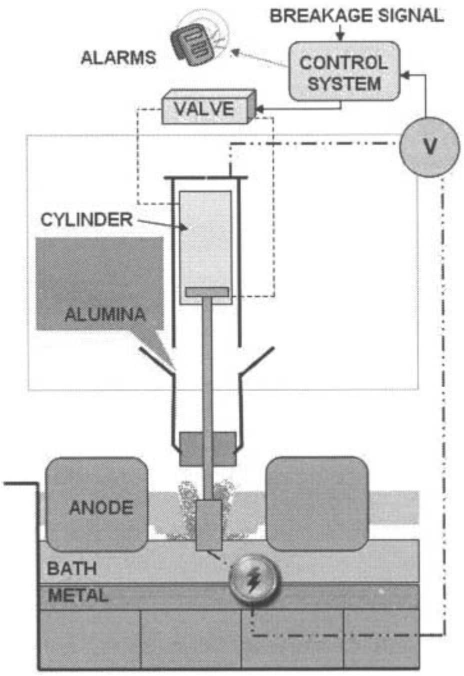

Figure 2: P155 chisel-bath contact system

Details of hot change works:

- Cell preparation before hot change:
  - EHS review with team performing risks analysis
  - Adaptation of control system
  - Installation of new electrical connections
  - Prepare all equipments and tool needed
- On the hot change day:
  - Cell preparation just before hot change
    - Put cell in overfeed mode to avoid AE during the modification
  - Stop one crust-breaker and keep in operation the second one
  - Remove the stopped breaker
  - Install adapted head with quick connection
  - Install new crust-breaker with chisel bath contact
  - Do the same with the second breaker feeder
  - EHS observation with feedback to the team

Operational Results

On December 1st, 2009, four test cells were operating and were representative of the overall plant cell age. A minimum of four control cells were chosen for each test cell.

Anode effect frequency

The anode effect frequency is the number of anode effects occurring per cell per day. The results for the December 2009 to June 2010 seven-month period show a 56 % decrease in AEF with 0.11 AE/cell/day, compared 0.25 AE/cell/day for the control cell group. Figure 3 shows the monthly results from December 2009 to June 2010. The test cell results are always lower than their control groups.

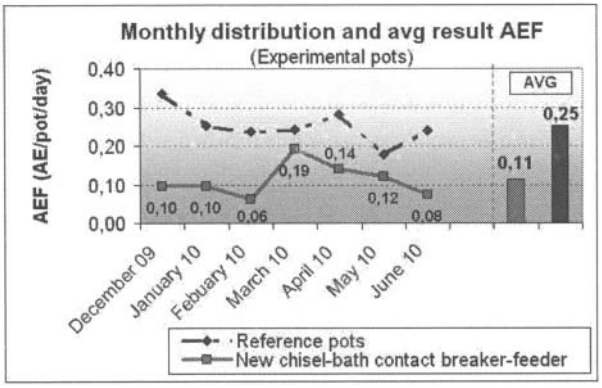

Figure 3: Graph of anode effect frequency during test period

Anode effect duration

The new system does not affect the AE automatic extinction period, which remains much the same with or without the system. There was no effect on the AE suppression reaction time or extinction speed.

Chisel-bath detection percentage

The percentage of successful contacts is a significant measurement for system performance. It represents the number of times the chisel successfully touched the bath following the crust-breaking signal. In other words, it is the number of times the system was able to measure a voltage difference for each breaker. The higher the contact percentage, the more trustworthy is the data received by the system.

It is theoretically possible to achieve 100% of successful contacts per day. However, operating conditions sometimes make it difficult to measure the contacts with the bath. For example, if a chisel comes into contact with an anode, it is processed as a permanent contact by the system and, consequently, is considered an unsuccessful crust-breaking. The same applies when a hole is blocked. Therefore, when the contact rate is suddenly lower for a breaker, it is a reliable indication that there is an issue with the cell. In future applications this signal can be used to send a message for the operator to take action quickly.

The results show an average of 97% for the four cells, from December 2009 to June 2010.

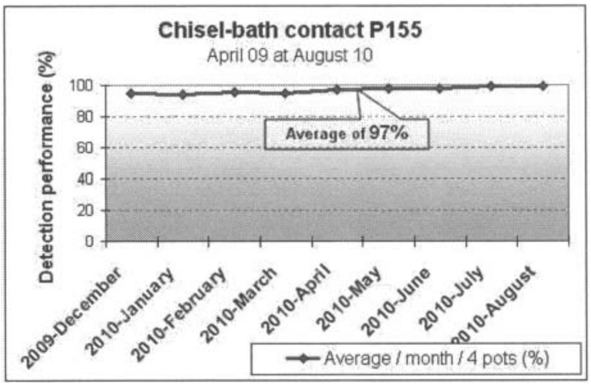

Figure 4: Graph of chisel-bath detection percentage

AE reduction due to breaker-feeders

A new Pareto analysis was conducted to compare the AEs of cells with chisel-bath contact systems to those of 2006. The new results for anode effect causes shows that the chisel-bath contact system had a major impact on the distribution of AE causes. The breaker-feeders are no longer the major cause.

Figure 5 shows that the percentage of AEs due to breaker-feeders went from 59% in 2006 to 15% in 2010. This is a near 75% improvement, which leads to the conclusion that the chisel-bath contact system had a positive effect on AE reduction.

Cause related to B/F	2006 EA (%)	2010 EA (%)
Blocked holes	31%	8%
Liquid level	16%	7%
Crust on chisel	12%	0%

Figure 5: AE reduction percentages relative to breaker-feeders

Alarms and Operators

Based on the information sent back to the control system, two types of alarms are activated. These alarms could allow operators to take immediate action on the cell and be proactive on AEs, particularly multiple AEs. Note that during the testing period, the operators were not asked to respond to alarms since only the impact of the chisel-bath contact was measured. Hypothetically therefore, the AEF could have been decreased even further with operator intervention.

The two alarm types are:

- Blocked holes
  - Alarm activated when no voltage difference is measured for a complete crust-breaking operation.
- Permanent detection
  - Alarm activated when a voltage difference is measured before crust-breaking is initiated.

A trouble shooting procedure was established to quickly target the cause of the problem and the corrective action required. This makes it possible to distinguish between process and mechanical issues.

Conclusions

A Chisel-Bath system was successfully developed for P155 technology. Our principal conclusions are:

- Voltage differences between the cathode and chisel can be measured efficiently with a P155 combined breaker-feeder.
- The new chisel-bath contact breaker feeder can be installed on operating cells while controlling the HSE risks.
- The breakers are, standard P155 breakers reused and adapted for the chisel-bath contact system. Most of the standard breaker-feeder parts were hence recovered.
- Standard cells can be converted to the chisel-bath contact system in less than 45 minutes.
- Several cells could be modified at the same time.
- Results for the December 2009 to June 2010 test run show a 56% decrease in AEF, compared to the control group, down to 0.11 AE/cell/day.
- With regards the duration of the anode effects, the new system made no difference.
- The average percentage of successful contacts was 97%, from December 2009 to August 2010. This is a measure of system efficiency and proves the trustworthy of the data gathered by the system.
- The Pareto analysis shows that the chisel-bath contact system had a major impact on AE causes. The breaker-feeders are no longer the major cause of AEs as these dropped by 75%.

With all these positive results, further AEF reductions can be expected with proactive action by the operators in addition to the chisel-bath contact system.

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