Pot Control Systems and Safety - Lessons Learned from Real Potline Incidents

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Abstract

In aluminium smelters, safety training is one of the first and foremost trainings delivered to the reduction staff. It generally covers risks associated with pot line operational activities and risks related to electricity. The standard operating procedures and risk analysis normally covers the risks associated in performing the operations. However, the risks associated with use of the pot control systems are not exhaustively covered.

In the recent past, several of our customer smelters worldwide using ALPSYS have reported significant incidents related, closely or remotely, to pot process control and/or their process control system. Those incidents were critical or potentially critical incidents resulting in very sick pots, pot open circuits and, at times, damages to the pot equipment.

Each incident has been thoroughly analysed to identify root causes and mitigation actions were put in place. In some cases, the pot control system (PCS) has been modified to integrate the mitigation actions. In most cases, the incident could have been avoided, or its consequences greatly reduced, with a proper action from the plant staff. In rare cases, the incident was the direct result of a wrong action.

In this paper, several real cases are presented and discussed, and the lessons learned from those incidents are explained. These lessons learned are relevant for potlines controlled by any kind of control system, not only for potlines controlled by ALPSYS.

Keywords: Pot Control System (PCS), ALPSYS, Safety incidents, Potline open circuit, Sick pots.

1. ALPSYS Pot Control System for Safety

ALPSYS is the AP Technology™ solution developed and owned by Rio Tinto Aluminium Pechiney. This pot control system (PCS in short), in addition to control of the pots and of the pot line, has monitoring tools that not only monitors the pot process status, but also the safety of the pots and of the pot line. The protection system primarily employs three actions – detection, declaration, and a treatment wherever possible.
Many kinds of detections can be done by PCS. Some of the detection systems employed in ALPSYS are:

- Pot voltage monitoring
- Amperage monitoring
- Open circuit protection through the sub-station
- Anode beam movement monitoring – Electrical cabinet monitoring
- Anode beam movement monitoring – Process monitoring
- Pot and potline alarms management

However, a PCS capacity to detect faults are limited. It is limited by what the PCS can measure or by what it can detect. Some typical situations that it cannot detect include:

- An anode beam too high or too low (when pots are not equipped with beam position measurement sensors or limit switches).
- Anode heeling or when anodes movements are physically blocked (when there are no sensors present on the motor mechanisms).
- Faults in the pot control electrical cabinet, depending on its design (some protections are not available in all smelters [1]).

When a fault is detected, the PCS will try to treat the issue. In cases where the pot control system can action, the system triggers direct actions. It can also trigger actions through external interfaces:

- Upon detecting an anode movement fault, the PCS stops the power to the anode motorization to stop any movement.
- If a trend to open circuit is detected, the PCS can send a potline shutdown request to the substation.

But the PCS capacity to treat an issue is also limited by the existing equipment:

- Typically, when an open circuit is detected, the PCS is not able to identify the cause (clad failure, pot tap out, excessive anode movement, etc.). It then cannot do anything to treat the issue as an unsuitable treatment could make the situation worse.

These limits, if not well known and understood, can lead operators to take a wrong action when faced with a difficult situation. It can then worsen the situation instead of improving it. In the worst cases, it can turn an under-control situation to an out-of-control incident.

2. Case Studies

Over the last 10 years, several of our customer smelters worldwide using ALPSYS reported significant incidents related, closely or remotely, to pot process control and/or their process control system. Those incidents were critical or potentially critical incidents: open circuits, damage to pot equipment or very sick pots. The intent of this paper is to share some of the critical incidents that have happened in the pot. The real events are explained to understand:

- The incident
- The consequence and the cause
- What could have been done to avoid the incident occurrence?
- Improvements made to the ALPSYS pot control system.
- What smelters could do to prevent such an incident?

2.1 Incident 1 - Open Circuit on a Pot

2.1.1 The Incident

Smelter A experienced an open circuit creating arcing on the pot, which eventually caused liquid bath overflow and damages to the pot. Fortunately, there were no injuries to the personnel. The pot was stopped, and the resulting restart was difficult due to a high number of anode effects. This resulted in a total of 2 successive line shutdowns of approximately 90 minutes.

2.1.2 The Causes

An investigation following the incident concluded that the resulted open circuit was due to excessive reduction of anode immersion in liquid bath. In other words, it was due to too many up movements of the anodes given by the pot control system. It was also confirmed that no fault was

2.5.4 Lessons Learned

Several important lessons are to be learned from these incidents.

When tapping metal, the operator should always monitor the pot closely because the metal tapping logic can stop unexpectedly at any time. In this case an alarm will be triggered. The operator should then immediately discontinue the metal tapping before checking the alarm. By doing the opposite (checking the alarm before stopping metal tapping), the operator may react too late and there could be possible damages to the pot.

An incident can also happen even if no alarm is triggered. The operator should watch the pot resistance to ensure that it is maintained close to the target. If not, metal tapping should be stopped immediately before investigating the issue.

It is always recommended for smelters to incorporate active exchanges between the pot control systems and the PTAs to integrate the safety interlock for metal tapping.

3. Conclusions

ALPSYS has always been an evolving technology keeping up pace with the real-world needs, prioritizing safety over and above all, ensuring safe operational systems and maximizing efficiency of operations. A very strong hardware and software design, coupled with a robust testing methodology has always been the backbone of ALPSYS. In addition, an active research and continuous exchanges with the users have led to several improvements to be developed and deployed. Several other improvements are also under research and development with a prime objective to safely operate the pot line and minimize the occurrences of an abnormal situation effectively.

However, relying solely on the pot control system to handle all sorts of abnormal situations would introduce additional risks. A pot control system is designed to detect and act on most known scenarios and conditions that arise during a pot and/or pot line operation but there are certain limitations to what the system could deliver in each case. These are determined by the capability of the detection system, the user settings, and the thresholds. Following a fault detection, if a corrective action triggered by a pot control system is overridden by a human action, all or most of the inherent security controls may be bypassed and at times this could worsen the situation, if not properly handled. This emphasizes the need of a strong knowledge of how a pot control system works and what must be done when the automatic systems are overridden.

Independent of the pot technology, a periodical maintenance of all the equipment associated to the pot control system ensures the risks to be minimized and maintained at an acceptable level. Smelters with limited safety protection systems should consider upgrading their protection systems to integrate the latest developments.

A rigorous and periodical training for pot line personnel on all routine/non-routine scenarios, and pot control systems is key to ensure a high level of competent work force that can understand the different situations and handle any abnormal situation that may arise.

4. References

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