Protection Against Open Circuit in ALPSYS Pot Control System

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Abstract

To the question "What is the most important feature of a pot process control system in a smelter", many will talk about current efficiency, energy consumption or will talk about how the system helps manage the potline. For us, this is not the best answer. The most important feature of a pot process control system (PCS) is safety. Safety for people who work all day long beside pots (pots generating up to 1 to 2 MW power) and safety for equipment, to ensure continuity of the smelter activity There are many risks in a potline, and the most important risk the process control system has to manage is an open circuit.

Safety features have been an important part of ALPSYS right from the start. 30 years ago, when pre-version of ALPSYS was under development, open circuit protection was already part of the system. Over the years, many improvements have been made to this protection, either by improving the existing protection, or by developing new ideas. Several open circuits or near open circuits happened in plants over past years. All were analyzed to identify the root cause and propose a solution or a mitigation. This article describes different types of open circuit protections encountered in existing plants and discusses the advantages and disadvantages of each type.

Keywords: Safety in potline operation, Pot control system, ALPSYS, Aluminium reduction supervision system, Open circuit protection.

1. Potline Protection

Potline protection against open circuit is not done by the PCS; it is managed by the substation. The substation monitors in real time the potline voltage and the potline current. During an open circuit, the potline voltage increases until the substation reaches its maximum power limit. Then the potline current decreases significantly. An open circuit is then detected when the potline voltage is high, and the potline current is low. Upon detection, the substation immediately cuts the power to the potline to stop the incident. An example is given in Figure 1. This is probably the oldest and the most standard open circuit protection. It is very effective, but it has some disadvantages. Its main weakness is its inability to make the difference between several anode effects (AE) happening simultaneously and an open circuit happening on one pot. At the beginning of the phenomenon, as seen from the substation, both give the same result: Potline voltage increases rapidly, and potline current is maintained at its setpoint as much as possible by substation rectifier regulation.

The potline open circuit protection efficiency is based on the proper adjustment of the protection thresholds. But they require a precise adjustment. If the thresholds are too restrictive, the potline will trip when several AE happen simultaneously. Multiple AE occurs regularly during a difficult restart after a potline shutdown, and a badly adjusted substation protection can repeatedly trip the substation during the restart. If the thresholds are not restrictive enough, an open circuit will be detected too late, when a lot of damage has been done to the pot or the potline circuit, with a very high risk for people around the pot.

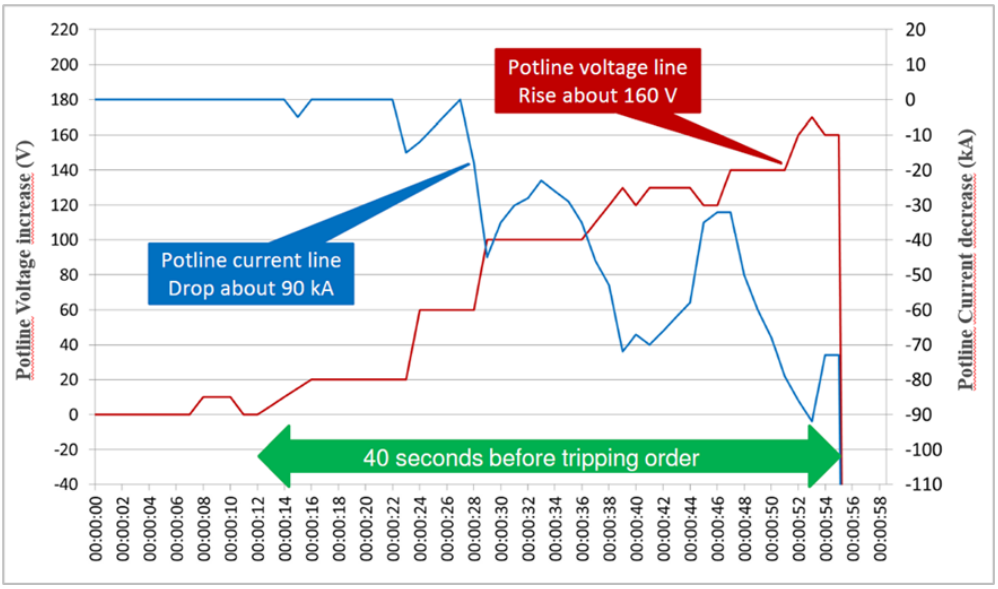

Figure 1. Example of potline current and voltage at the beginning of an open circuit.

Another difficulty of a potline open circuit protection is that it needs to be regularly adjusted to what happens in the potline. Ideally, each time a pot is stopped or is going in preheating, each time the potline resistance setpoint is changed, the protection thresholds should be adjusted to ensure that the protection thresholds are not too high or too low.

Several improvements have been done and are still ongoing to improve the potline protection:

- A new algorithm has been developed in the substation protection system (the so called SURMEC) to adapt automatically the thresholds during a potline start-up [2].
- ALPSYS and the SURMEC are exchanging information so the SURMEC can adjust its protection in real time to what happens in the potline.

Despite these improvements, there are still some limits to what can be done from the substation point of view. It was clearly demonstrated by an open circuit that happened a few years ago with substation thresholds correctly adjusted. From the data recovered from this incident, we were able to get information about the pot voltage during the incident, the pot voltage was:

- Above 30 V for almost 2 minutes,
- Above 60 V for 63 seconds,
- During the incident, despite the substation tripping in less than 2 minutes, the power input to the pot was 16 times the normal power: at this rate, the total energy consumption for one hour is injected in the pot in only 4 minutes.

Whatever the improvements in substation, the results will always be limited from the potline point of view. An even more efficient protection can be achieved by building a protection at pot level. Table 2 shows an example of pot voltage during an open circuit.

2. Pot Protection

There are several categories of risks leading to an open circuit situation, and they need be addressed differently:

- Equipment fault,
- Human mistakes,
- Unexpected pot behavior,
- Pot fault.

as much as possible. As discussed before, potline protection is very effective but may be slow to react because the open circuit pot is "hidden" in a lot of other pots. To improve effectiveness, we need to move this protection to the Potmicro itself.

The problem then can be stated as the following: How can a Potmicro make the difference between an anode effect and an open circuit? Studies have been done on this subject and the preliminary conclusions are that it seems possible to create a detection in each Potmicro, with the objective for the Potmicro to send a shutdown order to the substation upon detection.

The second question is: Is it possible to detect an open circuit before the substation, enough in advance to make a difference? The results of our preliminary studies, when applied to the open circuit case discussed previously, show that the open circuit duration would have been divided by 3, and the total power consumed during the open circuit would have been divided by 4. We can confidently assume that this will result in a significant reduction of the consequences for people and equipment.

Additional work and tests are still necessary to integrate this kind of protection in ALPSYS, but it looks very promising.

3. Conclusions

Contactor feedback or anode beam position feedback is a must. Having a timer switch and no contactor feedback is not enough to prevent open circuits. Each smelter not having it should be looking into installing it.

Depending on pot technology, the maintenance can have a very significant impact on open circuit detection efficiency. For a smelter relying on non-fail-safe protections, a very strict maintenance policy needs to be enforced to maintain the risk at an acceptable level.

Always consider risk that could be created by the mitigation actions (people should not rely on risk protection to do the job). A high level of training to open circuit protections should be maintained for operators in a potline.

Regarding ALPSYS development, several evolutions have been implemented in different smelters and other improvements are under study to develop protections with the objective to greatly reduce the occurrence and the consequences of an open circuit.

4. References

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