Potline Open Circuit Auto-Adaptive Protection

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Abstract

An open circuit event in a potline is always a catastrophic danger, resulting in a high power arcing which feeds itself until the current is cut, degenerating into blast destroying all that is in its vicinity. The consequence can be as bad as freezing the potline. Reducing the risk consists in preventing the occurrence by following the basic rules and best practices during potline operation and maintenance. It consists also in reducing the consequences. Triggering line current tripping by quickly detecting the event is more effective than pushing an emergency-stop or calling the power plant. The protection system settings must be fine-tuned according to the operating conditions of the potline (number of running pots and associated status – normal operation, preheating, starting, ongoing anode effect – number of stopped pots, potline status and set point) and to the conditions of the power contract if any: load shedding, frequency-dependent load adjustment, generating high magnitude of the current variation. At least this last condition requires the settings to be changed frequently and on real-time basis. The theoretical and practical aspects of the open circuit are presented as well as the new auto adaptive protection developed and deployed in Rio Tinto aluminium smelters.

Keywords: potline open circuit, open circuit protection, auto-adaptive open circuit protection.

1. Introduction

Figure 1 shows the potline circuit. It includes the rectifying units, pots and busbars. As soon as the live potline circuit accidentally begins to open an arc appears in the air gap.

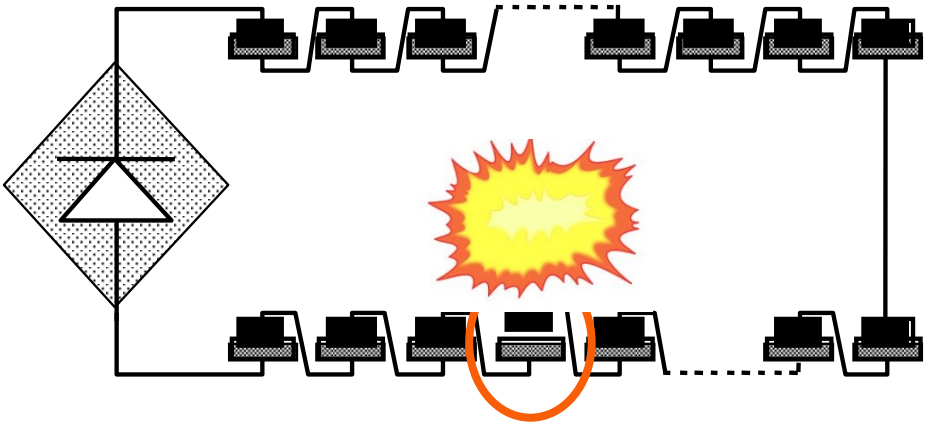

Figure 1. Potline circuit scheme showing the presence of an open circuit.

Figure 2 shows the characteristics of a direct current (DC) arc. Air is ionized by pioneer electrons and the resulting plasma allows the current to flow. The expansion of the plasma gas

creates a pressure. The heat and intense light at the point of the arc is called arc flash. Conductive vapors help sustain the arc. The plasma gas is typically directed outward. The power of the arc depends on the current but depends also on the arcing voltage. The arcing voltage has a fixed part, about a few tens of volts, which can be assimilated to a back electromotive force. But, the higher is the arc length, the higher is the arcing voltage, about 80 volts per centimeter. So the arc is extremely powerful. The temperature of the plasma gas is extremely high also: about 15 000 °C at the origin and still 3 000 to 5 000 °C at working distance.

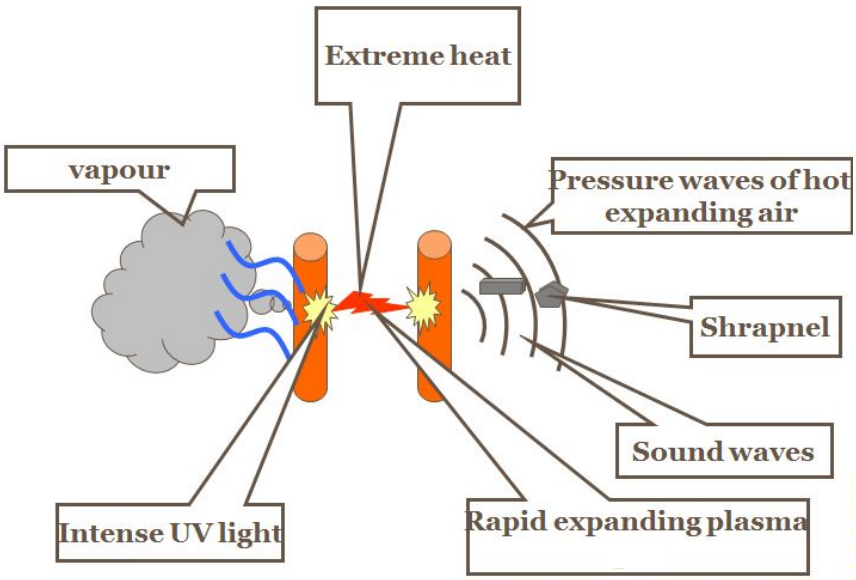

Figure 2. The typical characteristics of a DC arc.

From a safety perspective, such incidents result in very serious situations. In case of manned operation in the vicinity of the incident, the operator can suffer serious burns, damaged eyesight, escalating in some cases to serious injuries or death. The arc blast causes liquid aluminium and pieces to be ejected, equipment to explode. Equipment can be destroyed requiring expensive replacement and repair and causing extensive downtime. If the damaged busbar circuit cannot be repaired and the DC amperage cannot be restored quickly enough, the entire potline can freeze.

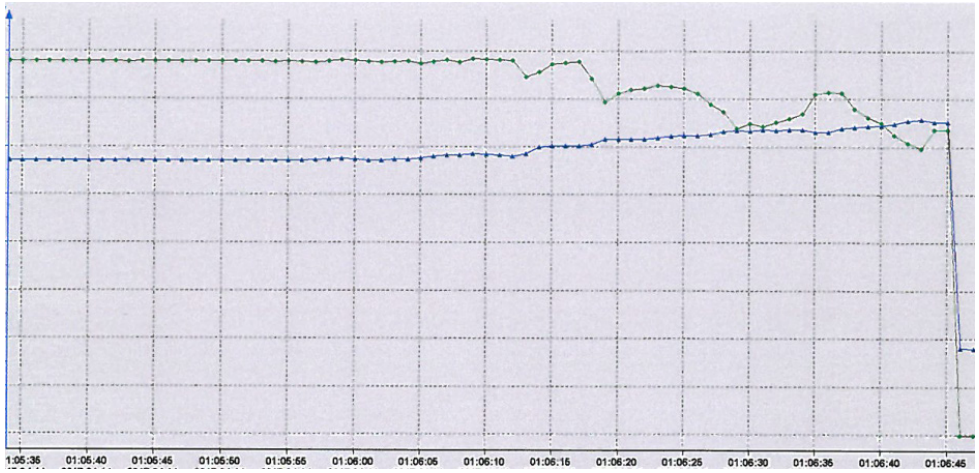

Figure 3. An example of the electrical characteristic of a beginning of open circuit. Green line is potline amperage, blue line is potline voltage.

4. Conclusions

An electric arc is generated whenever the potline circuit is accidently opened: It cannot extinguish itself unless the conversion substation is tripped. The phenomenon is always dangerous. It can often evolve into a destructive event that may jeopardize the DC amperage supply to the potline for a long duration in case of severe damage of a busbar cross-section for example.

AP Technology™ teams have developed a set of operational best practices to prevent this kind of situation from happening. Moreover, the Rio Tinto has developed a potline open circuit protection in order to detect any open circuit trend as early as possible. The potline open circuit protection is the last barrier against electrical arcing in the potline circuit.

The growth of dispersed and renewable generators requires potline open circuit protection systems to become adaptive, as it is the case for the power grid protection systems. High variations of potline current result from unplanned load shedding and high-frequency power modulation. The unpredictability, the magnitude and the frequency of those variations force the protection systems to be adaptive.

AP Technology™ teams developed an evolution in its protection system so that all the impacting factors, including variations of the potline current, are now taken into account in real time by this new auto-adaptive protection system, which has been now commissioned after qualification tests.

5. References

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