Nordural’s world-first Crowbar system

For maximum potline reliability during power distortions

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The Century Aluminum smelter at Grundartangi Iceland, Norðurál, started to operate their first potline PL 1 in 1998 and added potline PL 2 in 2006. The annual production of primary aluminium has been gradually increased from 60,000 tonnes to today’s 317,000 tonnes. PL 1 operates at 222 kA and 750 VDC, powered by four diode rectifiers. PL 2 operates at 222 kA and 1500 VDC, powered with four Thyristor rectifiers. The system has swing Thyristor rectifiers that can connect to either potline, to ensure N-1 operational capability.

Norðurál is connected to the Icelandic transmission grid, and it receives the energy via two 220 kV overhead lines. The smelter uses approx. 28% of total power production in the country. The three major heavy industries use about 75% of total power production.

Because the transmission system is an island system, and because of the remote location of Norðurál and the environmental conditions over the wintertime (November to March), power distortions are frequent. There are numerous incidents each month, leading to power interruptions that influence the production operation with power loss and potline trip.

Each time the potline lost power, this caused the power system to become unstable, losing larger load at the same time as the distortion was in the system. This led to over frequency and to further disturbances in the grid. Following such events, it would take 60 to 90 minutes to get the power back on the system, and to get the plant and the potline back to full power.

In 2013 Norðurál installed the world’s first ‘Crowbar’ system on their PL 2 to prevent the power distortions from affecting operation and causing production interruptions. Since then the system has operated number of times, allowing stable operation and production during power distortions.

Description of the Crowbar system

The function of the Crowbar is to act as a freewheeling system, so as to give a path for the potline current to run down to zero in the event of a grid network under-voltage. This
will allow the thyristor rectifiers to move to inverter mode, and so to ensure that the current in the rectifiers commutates to the Crowbar. This eliminates the danger of the potline current running down to zero in only one rectifier. As soon as the network voltage is restored, the thyristor rectifiers station will go back to the previous current level. The diagram below shows the flow of the potline current during the Crowbar operation.

**Norðurál Crowbar function design:** If the network voltage dips below 60%, the rectifier controls will move to the inverter limit. The control system will then also block the on-load tap changer from lowering taps to the next tap, so keeping the voltage level steady. After the voltage has been restored for two cycles, the current regulator will be released and allowed to move the firing angle out of inverter limit. The status of the Crowbar operation will be communicated from the rectifier control panel to the common trip panel, and also to the master control system.

**Crowbar performance simulation:** To confirm that the voltage has dropped by 15% before the Crowbar will be engaged, the network voltage must be measured, and reference level continuously changed as the network voltage changes. The floating level detection was tested with different filter values to delay the floating of the reference signal. In all cases the detection level was set to 85% and the reset level 5% higher. The rectifiers were simulated as if running at nominal current, with line voltage of 100%, when the 2-phase volt dip was activated for 70 ms. ABB’s simulation results are shown in Fig. 4.

**Crowbar distortion simulation:** To design the Crowbar, it was required to build up a model of the power supply grid and then to simulate the possible power distortions. The ABB model was set up from measurements taken at Norðurál’s grid. Single phase as well as three phase distortions had to be simulated.

**Crowbar construction and assembly:** The Crowbar frame is built up with aluminium channels and supports. Heat sinks with diodes are placed on the frame and are supported with insulators. The full assembly is protected with temperature sensors and is connected to the potline busbar system with motorised DC disconnect switches.

**Grid voltage measurement during a power**
distortion: Already during the commissioning duration, Norðurál experienced some power distortions which were recorded, and they showed that the Crowbar was operating as per the design and simulation values.

Control system reaction during the crowbar operation: Fig. 9 shows the control reaction when the smelter feeding network experienced a power distortion.

Norðurál Potline 2 stayed in operation: With the Crowbar in operation, the plant managed to ride through the power distortion, and the potline current recovered to full operation level within less than 1 minute.

Summary

Winter conditions have previously often affected the operation of the potlines at Norðurál’s Grundartangi smelter, disturbing the production with power loss and potline trips.

With the installation of the PL 2 Crowbar system at the Grundartangi smelter, most of the power outages of the potline have been minimized resulting in more stable potroom operation. With increased production of the smelter over the years, around 18% above the nameplate capacity, this stability was needed to help in the capacity creep of the plant.

Today the PL2 Thyristor rectifiers do act in almost the same way as the PL1 diode rectifiers during a power distortion, and have managed to ride through the power distortion without causing unstable operation of the potlines.

Authors

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