Installation and Commissioning of a Magnetic Compensation Loop and Booster Rectifier Circuit by Means of Reliable and Economically Efficient Bolted Joints

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Abstract

ALCOA's Deschambault Smelter has been operating AP30 cells for more than 25 years, having crept its potline far beyond the original technology nameplate amperage. In order to validate the industrial performance of ALCOA's internally-designed technology upgrade enabling the operation of these pots at even higher amperage, a magnetic compensation loop and a new booster rectifier and circuit were installed in early 2017. Working in a brownfield environment where the magnetic field could exceed 13 mT, the Integrated ALCOA-HATCH Alliance Project Team decided to assemble the 3 km of total equivalent linear length of prefabricated busbars modules without welding, resorting only to bolted connections. While most of the design and installation effort was based on proven methods employed in past successful experiences, a new tightening procedure for the assembly of bolted joints was developed based on the insights gained from both bench testing and numerical analyses. Furthermore, the Project Team developed a new contact resistance testing protocol to validate the quality of each one of its 170 connections in pre-operational verifications without having the busbars energized. This helped to streamline the equipment commissioning, which was successfully completed under budget and on schedule, including a 48 h existing booster shutdown, but no potline outage. Finally, an economic analysis based on Project's total costs showed that the usage of reliable bolted connections can be cost-effective compared to traditional construction strategies using commercially available arc-welding methods subjected to the aforementioned conditions.

Keywords: Aluminum reduction cells, brownfield, busbars, magnetic compensation loop, bolted connections.

1 Introduction

The Alcoa Deschambault smelter was completed in 1992 and is built around a single potline of 264 AP30 cells featuring a booster section. The booster was built with the plant and included prototype cells right from the first start-up. R&D and innovation are part of the Deschambault ongoing operational strategy, and the smelter is home to the Alcoa Center of Excellence (CoE) whose mission includes applied research, pilot testing, training for Alcoans around the world, and technical support to all Alcoa smelters.

The experience gained over more than 25 years of AP30 cells operation allied to ALCOA's CoE technical know-how allowed Alcoa Deschambault smelterto creep its potline far beyond the original technology nameplate amperage. In order to validate the industrial performance of an internally-designed technology upgrade enabling the operation of these pots at even higher amperage, a magnetic compensation loop (MCL) and a new booster rectifier and circuit were installed early 2017. The present article focuses on the design, installation and commissioning of these conductors.

2 New Magnetic Compensation Loop and Booster Circuits

Alcoa Deschambault's test section originally comprised 10 cells and is located in the B room upstream of the smelter's 3/4 passageway. A first retrofit enabled the inclusion of two additional pots (B110 and B111) in the boosted segment of the potline, which was then fed by a 22 kA GE booster rectifier. The positive booster circuit, located on the "outside" (tapping end) and running in a direction opposed to that of the potline, provided partial magnetic compensation to these pots.

By 2015, the existing booster rectifier was getting close to the end of its service life and would have to be either retrofitted or replaced. Magnetohydrodynamics studies performed by CoE indicated that a magnetic compensation loop (MCL) would be required to allow for stable operation of the next pot generation to be field-trialed at higher amperage. Furthermore, to realistically emulate the future magnetic environment to be experienced by the pots once the current of the whole potline has reached the target amperage level, the original booster circuit routing had to be modified.

An option analysis performed by the Integrated ALCOA-HATCH Alliance Project Team indicated that the most viable scenario would be to install a brand-new booster rectifier to feed the test section while repurposing the original 22 kA rectifier to feed the MCL prototype. The new service conditions of the existing rectifier at a significantly lower voltage drop would extend the aging equipment's life span, and therefore reduce the capital expenditure involved in the trials.

2.1 Layout

Aiming to generate a vertical magnetic field bias on the test pots similar to that of a mid-section pot at the target increased amperage, the positive branch of the new booster circuit was relocated to the tap end (TE) of the opposite pot row, crossing under two cells outside of the testing section, namely A121 and B121 – see Figure 1. Due to the limitations of the original booster rectifier, the MCL prototype routing employs 3 turns to meet the process requirements since these conductors had to be installed in the small aisle (duct end, DE) in close proximity to each other.

The total linear length of both circuits is 3 km. As a strategy to reduce the aluminum purchasing costs, the temporary potline startup bridge – which was stored in the 3/4 passageway since the smelter's start-up – was modified and its busbars were used for both the new booster circuit and the MCL prototype.

It is important to stress, however, that bolted connections lead to voltage drops larger than those obtained by welded joints and, therefore, the associated energy costs must be taken into account in order to appropriately calculate the Project's economics.

6 Conclusions

An Integrated ALCOA-HATCH Alliance Project Team successfully installed an equivalent 3 linear km of prefabricated busbars modules without welding, resorting only to bolted connections. While most of the design and installation effort was based on proven methods, a new tightening procedure for the assembly of bolted joints was developed based on the insights gained from both bench testing and numerical analyses.

The addition of the new booster circuit and prototype MCL introduced new electrical risks to the smelter which were managed by employing several mitigation strategies, including the employment of precast concrete culverts to prevent the short-circuiting of different pot-potentials due to molten metal spillage on the new booster positive circuit. This and other potential short-circuit scenarios were taken into account when designing the busbar details and their supports.

A new contact resistance testing protocol was devised to validate the quality of each one of the 170 connections in POV phase. Likewise, the electrical insulation levels of the entire installation was assessed prior to system's startup. This helped to streamline the equipment commissioning, which was successfully completed under budget and on schedule, including a 48 h existing booster shutdown, but no potline outage.

Finally, an economic analysis based on Project's total costs showed that the usage of reliable bolted connections can be cost-effective compared to traditional construction strategies using commercially available arc-welding methods when working on complex brownfield environments subjected to intense magnetic fields.

7 References

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