Review of the SAMI Retrofit Project in QTX Smelter in China

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Abstract

So far in the 21st century, the aluminium industry smelting capacity expanded rapidly in China through greenfield projects using recently developed Chinese high amperage cell technologies. The most recent being the 350-400 kA, 500 kA and 600 kA cells. In particular, the SAMI SY400 (400 kA), SY500 (500 kA), SY600 (600 kA) cell technologies, developed by Shenyang Aluminum & Magnesium Design and Research Institute (SAMI), have been widely used because of excellent MHD design. This period of rapid greenfield expansion has recently slowed down in China. Most realistically, in the near future, smelting capacity expansions will come mostly from brownfield retrofit projects, also named capacity creep projects. There is huge potential for such projects in China in particular, as most cells are designed to operate at relatively low anode current density in which it is easy to creep the capacity. This paper presents the SAMI retrofit project in the Quingtongxia Aluminium Smelter (QTX) in China, one of the few capacity-creep retrofit projects that has already been carried out in China and could be reproduced in other smelters both in China and abroad in similar low current density cell technologies.

Keywords: QTX aluminium smelter, SAMI cell technology retrofit, cell MHD models, cell thermo-electric models, cell key performance indicators.

1. SAMI Retrofit Project in QTX Smelter in China

Even if it is not very common and even less well known, some retrofit projects have been carried out in China recently. The SAMI retrofit project in Qing Tongxia (QTX) smelter is one of them.

In 2004, a GP350 potline containing 288 pots was started in QTX. Figure 1 presents the construction project schedule while Table 1 presents the obtained key performance indicators (KPIs) for that potline. This is a good example of non-optimal design suffering some important deficiencies like high instabilities up to 10 hours after an anode change, excessive ledge toe in the cell corners and reduced current in the corner anodes.

1.1 Magnetic Model

In 2008, SAMI was mandated for a retrofit project on that potline to improve the MHD and lining design. A magnetic model similar to the ones shown in Figure 2 was built to compute the magnetic field in the metal pad. As we can see, SAMI magnetic model is based on ANSYS. The vertical component of the magnetic field (B_z) of the GP350 model is presented in Figure 3. There is a non negligeable gradient of the B_z along the longitudinal direction of the cell. According to Urata [3] such B_z gradients are responsible for MHD bath/metal interface wave producing cell voltage instabilities.

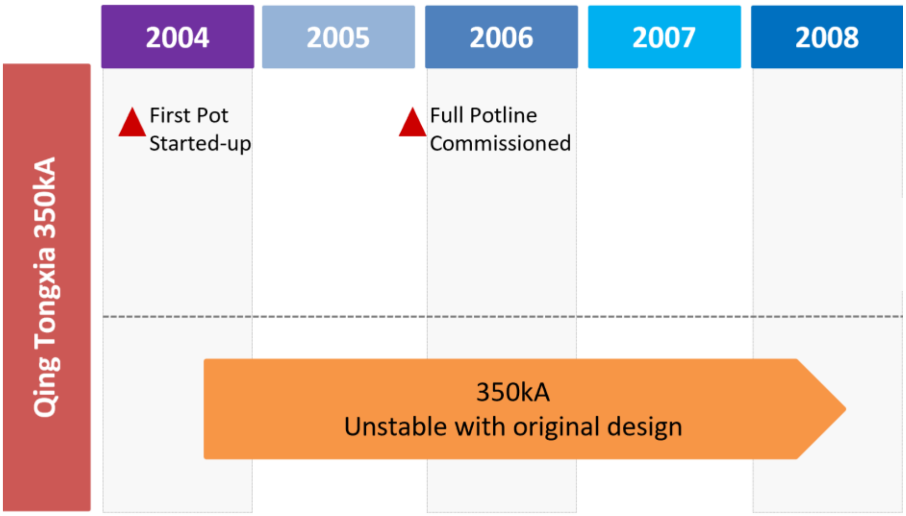

Figure 1. Commissioning schedule of the QTX GP350 potline.

Table 1. KPIs of the original QTX GP350 potline.

Parameter	Before Optimization
Potline amperage, kA	350
Current efficiency, %	90.5
Gross anode consumption, kg/t Al	557
Anode effect frequency / pot-day	0.085
Noise, mV	23
Excess AlF_3, %	5.5
Bath temperature, °C	964
Metal level, cm	27-30

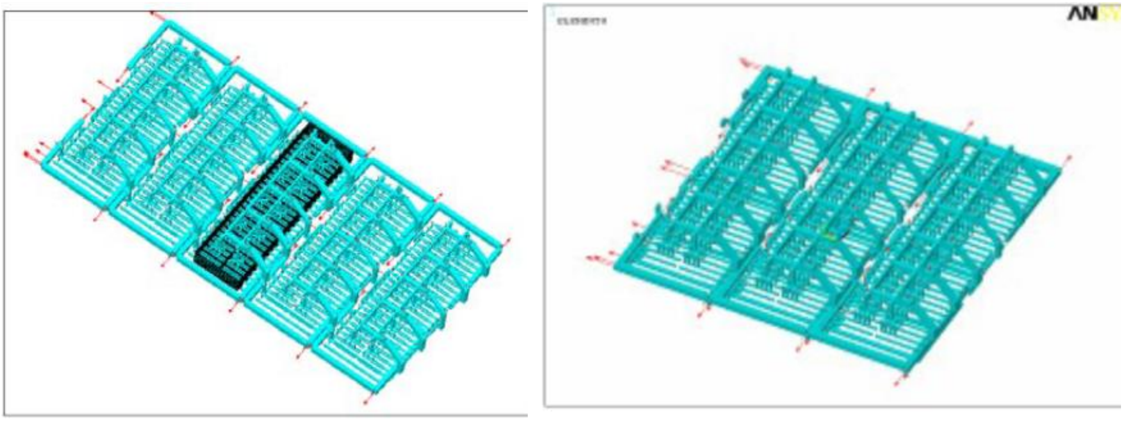

Figure 2. Left: SAMI's SY300 magnetic model, Figure 4 in [1], Right: SAMI's SY350 magnetic model, Figure 8 in [2].

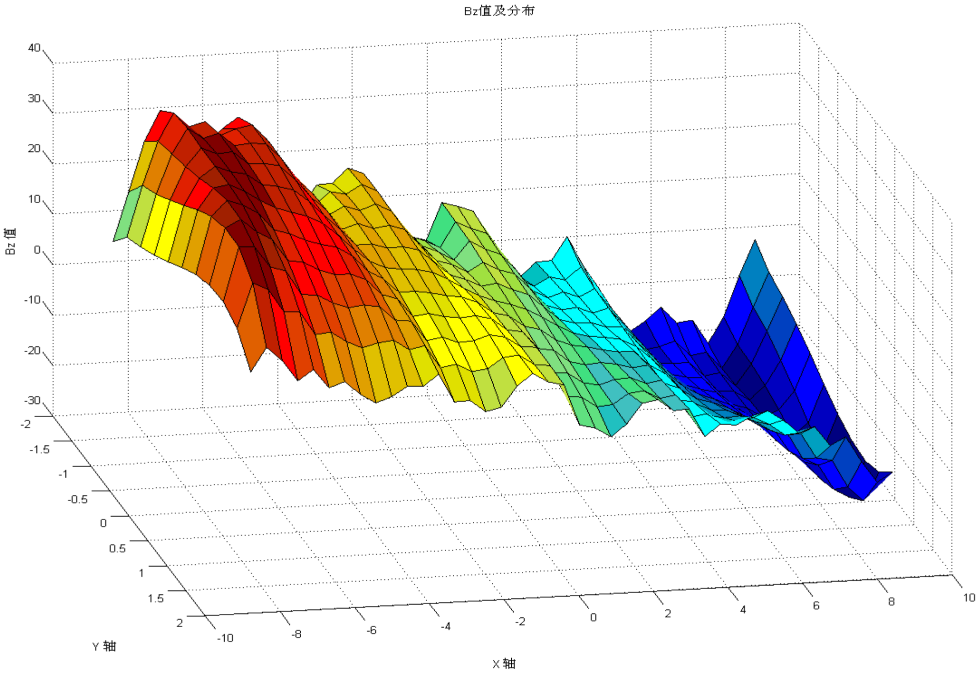

Figure 3. B_z model result for the GP350 of original design (X and Y in meters and B_z in gauss).

1.2 Thermo-Electric Model

SAMI thermo-electric models for the calculation of the cell voltage drop and heat losses are based on ANSYS as shown in Figure 4. Following the thermo-electric model development, SAMI performed a series of on-site measurements to calibrate/validate their thermo-electric model. Figure 5 shows typical measurements for the SY400 cell technology. These validated models were used for thermo-electric analysis of the original and retrofitted QTX cells presented in this paper.

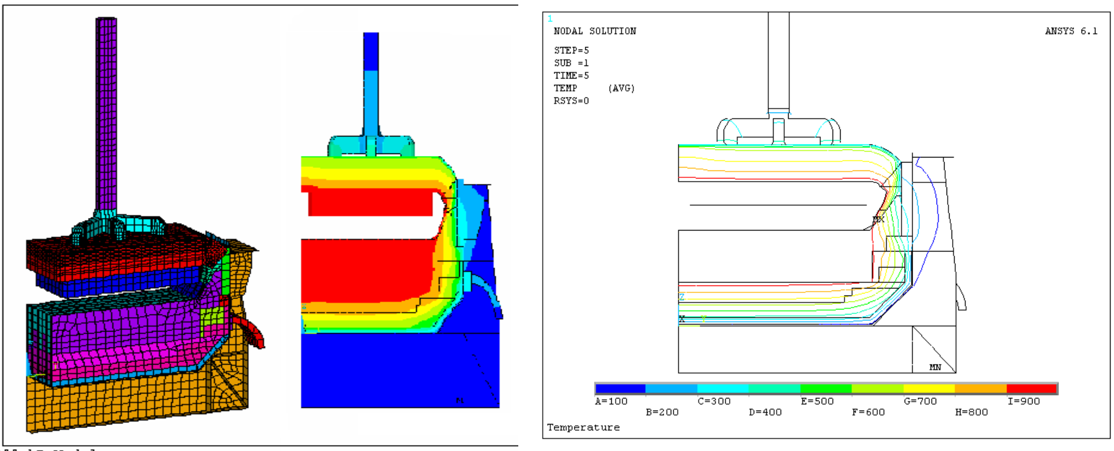

Figure 4. Left: SAMI's SY300 thermo-electric model, Figure 6 in [1]. Right: SAMI's SY350 thermo-electric model, Figure 9 in [2].

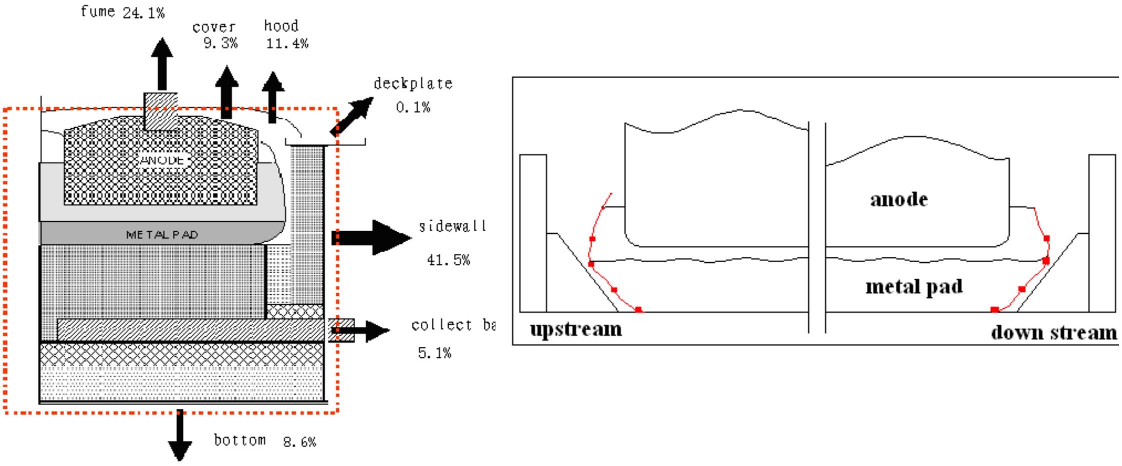

Figure 5. Left: SAMI's SY400 cell heat balance measurements, Figure 12 in [2]. Right: SAMI's SY4000 ledge profile measurements, Figure 13 in [2].

2. Results of the Retrofit Study

To improve the QTX cell stability, it was decided to add two compensation loops, one inside the potline and one outside. Figure 6 shows the sketch of the two compensation loops carrying 60 kA in the inner loop and 30 kA in the outer loop. This balances well the magnetic field from pot conductors and from the neighboring row. Figure 7 shows the resulting improved B_z. This improvement was implemented in the first stage of the project. Figures 8 and 9 show the measured vertical component of the magnetic field before and after the addition of the compensation loop for the upstream and downstream side, respectively.

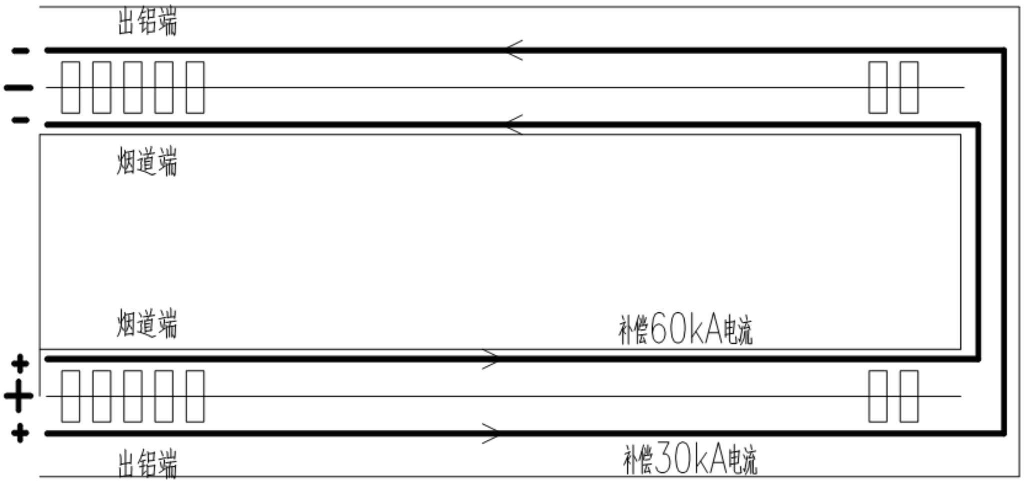

Figure 6. The two compensation loops added to the QTX GP350 kA potline.

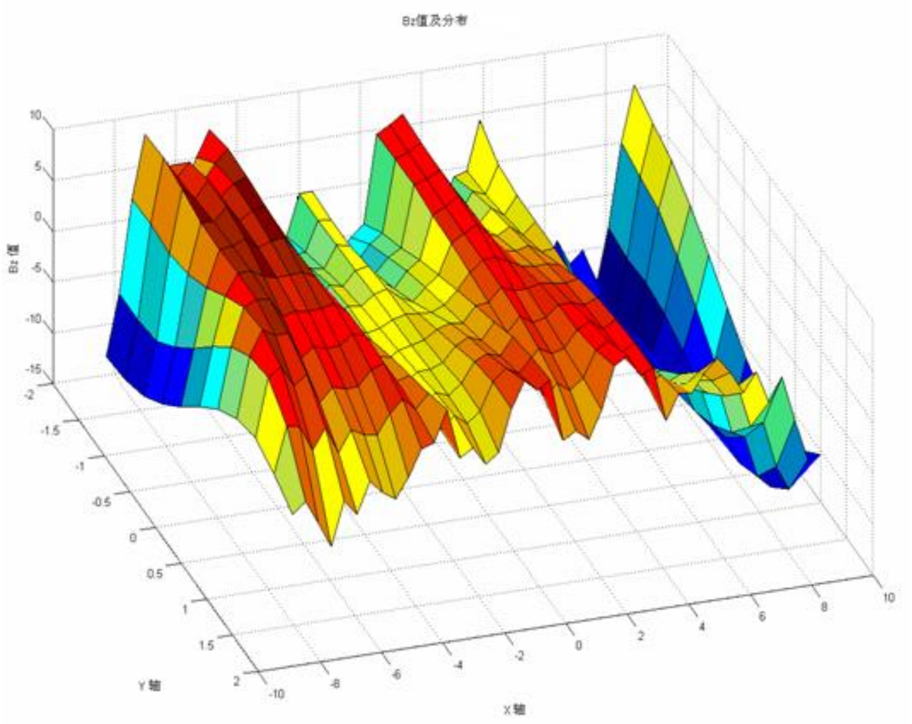

Figure 7. Improved B_z predicted by SAMI's magnetic model.

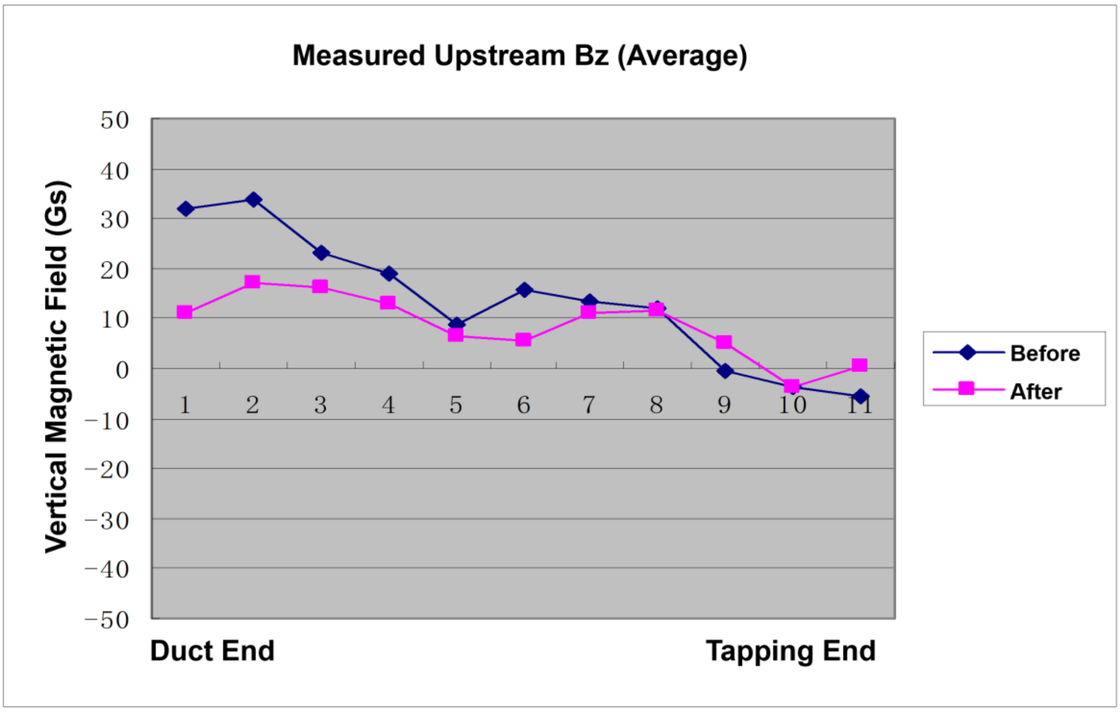

Figure 8. Measured upstream B_z in a QTX GP350 cell before and after addition of the compensation loop.

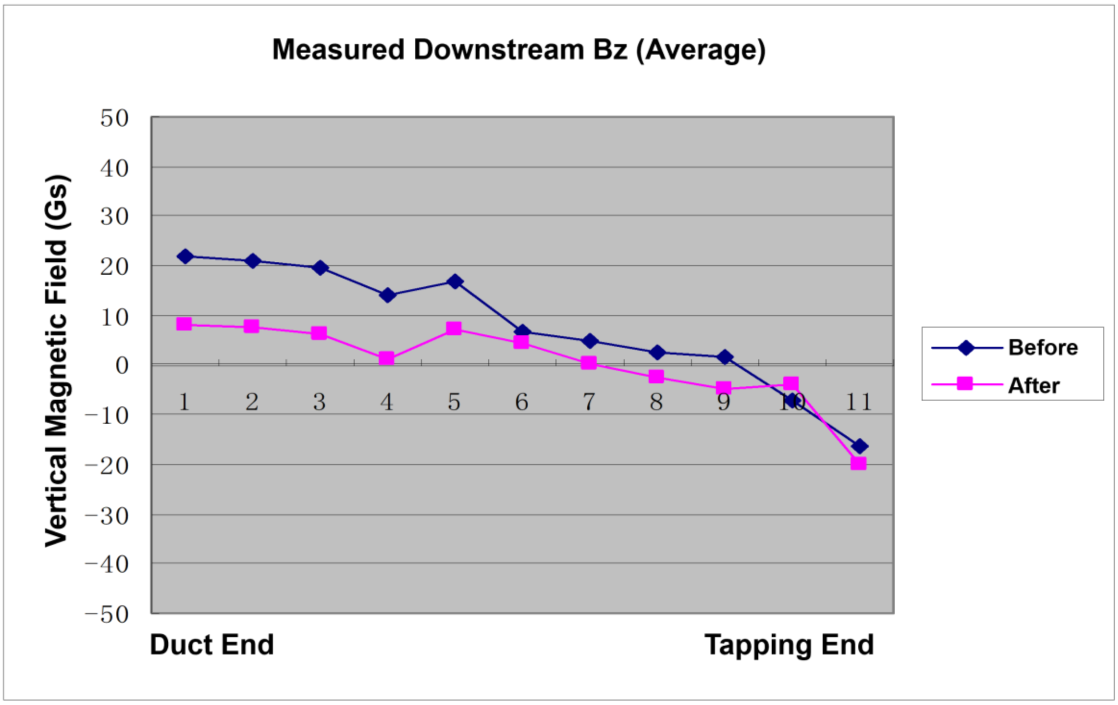

Figure 9. Measured downstream B_z in a QTX GP350 cell before and after addition of the compensation loop.

Later, it was also decided to improve the cell lining design, to improve the cell heat balance and to reduce the horizontal current in the metal pad (J_y). This reduction is done by the introduction of SAMI proprietary HCRT cathode technology. Figure 10 shows that the calculated horizontal current density is reduced by 30 % in the HCRT cathode technology.

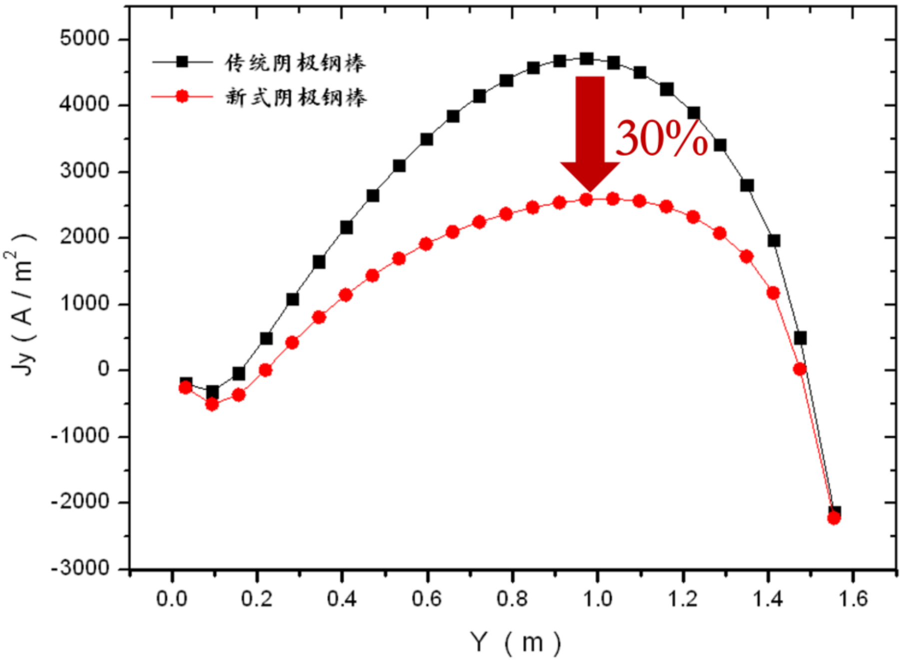

Figure 10. Calculated J_y improvement in the metal pad by SAMI's HCRT technology.

3. Implementation of the Retrofitted Design and New KPIs

Figure 11 shows the implementation schedule of the retrofitted design. SAMI got the retrofit mandate in 2008. The two compensation loops were installed in 2010. The new lining design was implemented in late 2011 and in early 2012. The potline amperage was increased to 370 kA. Table 2 gives the KPIs obtained during the transition period while Table 3 gives the KPIs after the full conversion to the retrofitted SY370 Technology. The amperage increased from 350 to 370 kA while the cell energy consumption was decreased from 14.0 to 13.2 kWh/kg Al. From the reported cell voltage and cell energy consumption in Table 3, the SY370 current efficiency is 90.8 %, the current efficiency after installation of the compensation loops is 93.0 %, while the original GP350 current efficiency was 90.8 %.

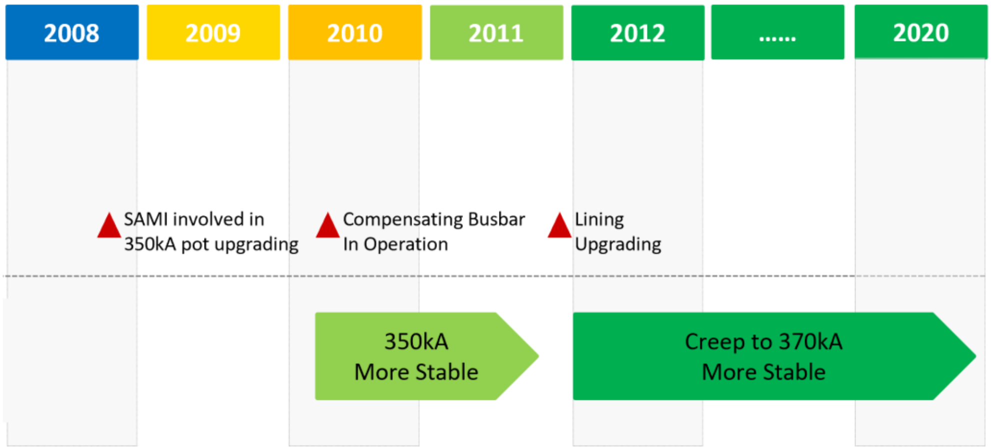

Figure 11. Implementation schedule of the new SY370 retrofitted design

Table 2. KPIs of the QTX GP350 potline after addition of the two compensation loops.

Parameter	**Before Optimization**	**After Optimization**
Potline amperage, kA	350	350
Current efficiency, %	90.5	93.0
Gross anode consumption kg/t Al	557	505
Anode effect frequency /pot-day	0.085	0.028
Noise, mV	23	15
Excess AlF3, %	5.5	7.9
Bath temperature, °C	964	952
Metal level, cm	27-30	20-21

Table 3. KPI evolution from original GP350 to the final retrofitted SY370 Technology.

Pot Technology	**Average Pot Voltage (V)**	**Potline Amperage (kA)**	**DC Power Consumption (kWh/t al)**
Original Technology in 2009	4.269	350	14015
Original pot after SAMI compensation busbar had been put into operation	4.11	350	13172
Relined pot with SAMI energy saving technology	3.95	370	12970

4. Conclusions

The QTX smelter retrofit project illustrates SAMI's expertise to carry out successful retrofit projects. There are a great number of smelters inside and outside China that could benefit from this expertise.

5. References

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