Scaling Potline Amperage Due to Rectifier Maintenance in DX Technology Line 8

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https://doi.org/10.71659/icsoba2024-al006

Abstract

Emirates Global Aluminium (EGA) proprietary DX technology in Jebel Ali Line 8 has seen continuous amperage increase from 340 kA at start-up in 2008 to 440 kA today. Line 8 of 44 cells is at the end of Line 6 operating at 260 kA, therefore, at 440 kA, 180 kA has to be supplied by four Line 8 booster rectifiers, 45 kA per rectifier, at nameplate capacity. The booster rectifier station was designed in N-1 configuration with four rectifiers, three in operation and the fourth one on standby for maintenance, to keep line current constant. However, with large amperage increase from 340 kA to 440 kA since the start-up in 2008, when the amperage reached 400 kA 1n 2014, all four booster rectifiers have been used in routine operation. Consequently, during annual maintenance, taking 7 days per rectifier, and 28 days for four rectifiers, the potline operated at 35 to 45 kA below the normal amperage with the three booster rectifiers. This required changes in many cell operation and cell control parameters.

This paper describes the strategies and practices for rapid amperage decrease by 35-45 kA at the start of maintenance, and rapid increase to normal amperage at the end of maintenance. Now, the amperage is decreased in increase at the end of maintenance has been shortened from fourteen days to just two days in 2-3 steps, thus restoring normal metal output rapidly.

Keywords: Aluminium electrolysis potline, Rectifier maintenance, N-1 rectifier operation, Potline operation at reduced amperage.

1. Introduction

Emirates Global Aluminium (EGA) operates its proprietary DX technology in Jebel Ali Potline 8 (PL8) and Al Taweelah Potlines 1 and 2. PL 8 is operating at 440 kA today, after continuous amperage increase from its humble beginning at 340 kA. The amperage increase required continuous improvement and modifications.

PL8 gets power from two sources: Potline 6 and PL8 booster rectifier transformer (RT). The configuration is given in Table 1:

Table 1. Rectifier configurations for Potline 8.

Potline	Rectifiers	Each rectifier operating current (kA)	Line operating current (kA)
Main Line 6	5+1 (SBRT)	53	260
Booster Line 8	4	45	180
Total Line 8 (Sum)	10		440

The annual RT maintenance schedule involves taking each booster RT offline for one week to do maintenance, and smooth operation in this interval. This maintenance schedule impacts Line 8 set operating current. Line 6 has “N-1” configuration due to the availability of Swing Booster RT (SBRT), ensuring no impact on amperage, when any RT is taken off for maintenance. Line 8 operates in “N” configuration, requiring a de-load of 45 kA in booster line during RT maintenance, impacting the amperage supplied to Line 8. In practice the amperage reduction was less than 45 kA because some more than usual amperage was supplied by the remaining three rectifiers.

Historically, the duration of amperage reduction and ramp-up was high. In this project, the objective was to reduce the metal loss during this transition period without compromising the cell performance. The result is shown In Table 2.

Table 2. Amperage reduction and amperage increase time for rectifier maintenance.

Amperage reduction	Amperage lowering time (days)	Amperage raising time (days)
Up to and including 2020	10	18
In and after 2021	2	2
Net gain	8	16

This paper presents the impact of 35 to 45 kA amperage reduction for RT maintenance and increase at the end of RT maintenance in PL8, and how the reduction team achieved the lower transition period.

1.1 Baseline Performance (Historical Background)

During RT maintenance, potline amperage is reduced by 35 kA and it leads to approximately 50-60 kW lower internal heat. This is partially compensated by increasing the ACD and by reducing the heat loss.

Two main challenges during this process are:

1. Maintain target bath height - While increasing ACD the cell demands considerable amount of liquid bath, which has to be tapped at the end of maintenance when restoring the normal ACD.
2. Maintain thermal balance - Operation practice and key parameter to be changed to minimise the heat loss.

1.2 Earlier Approach for RT Maintenance (Before and in 2020):

Prior to 2021, the amperage reduction and increase were done at a slow rate as shown in Figure-1. This typically took 10 to 20 days to reduce, and 10 to 20 days to increase the amperage during RT maintenance (Figure 1). This includes:

- Lowering amperage in small steps by 3 kA/day and raising it at 1–2 kA/day.
- The adjustment of Base Resistance Set Point (BRSP) in steps to manage liquid bath adjustment, required because of ACD increase at the start, and ACD decrease at the end of maintenance. This also impacts the heat balance.

Heat balance was calculated in terms of internal heat (Q_{in}) as in [2]. Internal heat is net heat in the cell, which is the difference between generated heat and absorbed heat by chemical reactions and auxiliary processes. In thermal balance, the internal heat is equal to heat loss. The distribution of the heat loss from the cell surfaces is calculated using mathematical models [3]. Figure 3 shows potline amperage and BRSP. Table 3 gives the average data for the period of 30 days before the

RT maintenance, during the maintenance and 30 days after the maintenance in 2020. The ACD, calculated according to Haupin [4], was increased for more heat generation, but with the objective of easier bath height management, the ACD increase was not sufficient to keep internal heat constant. Also, energy availability in the rectifiers was limited.

From Table 3, we can see that the internal heat is by 50 kW lower during low amperage. This was partially compensated by increasing anode cover height by 8 cm; this compensated approximately 45 kW. However, the effect of this change took effect slowly. Figures 2 and 3 show the reaction of bath temperature and excess AlF_3, respectively. Bath temperature dropped by 20 °C, the bath was freezing, and as consequence, excess AlF_3 increased from 8.5 % to 13.5 %. The opposite happened after the end of RT maintenance. In spite of this unbalance, there were no major disturbances in the cell operation, such as anode change problems when the cell was freezing.

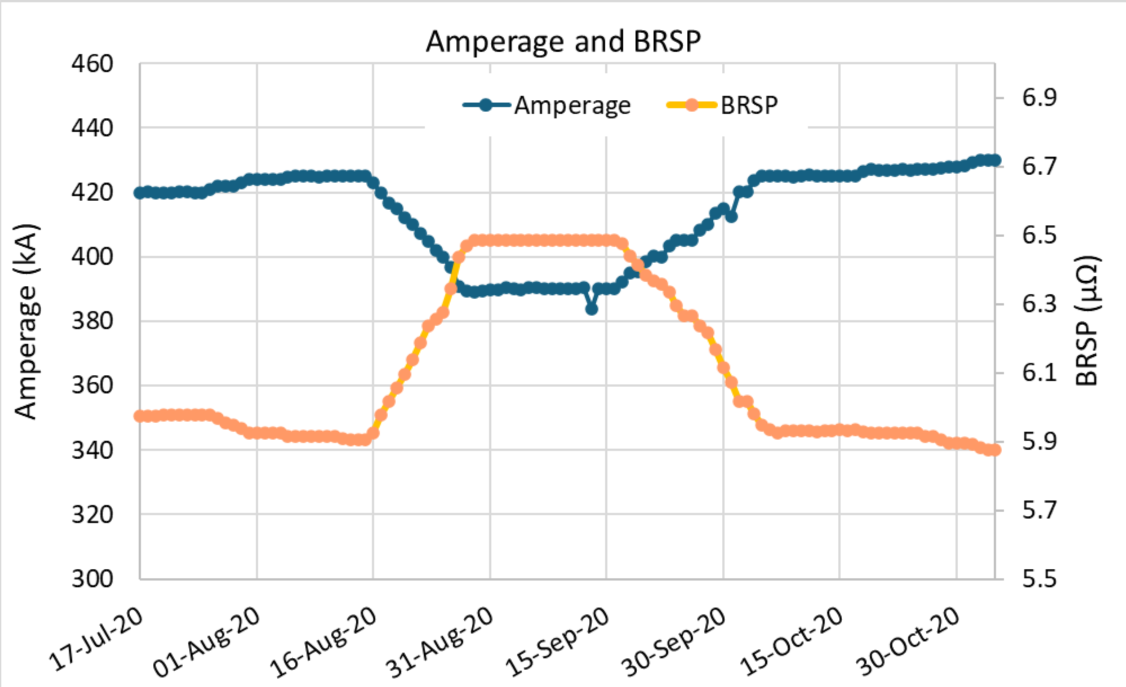

Figure 1. Amperage and BRSP from 17 July to 4 November 2020, comprising the RT maintenance period.

Table 3. Cell operation parameters before during and after RT maintenance in 2020.

	Before RT maintenance 17 Jul – 15 Aug 2020 30 days	During RT maintenance 28 Aug – 15 Sept 2020 19 days	After RT maintenance 5 Oct – 4 Nov 2020 30 days
Amperage, kA	422.76	389.73	426.67
Cell voltage, V	4.20	4.23	4.22
BRSP, µΩ	5.94	6.49	5.92
Bath T, °C	963	953	969
Excess AlF_3, %	9.2	10.3	7.3
Q_{in}, kW	780	730	784
ACD, cm	2.34	2.86	2.45

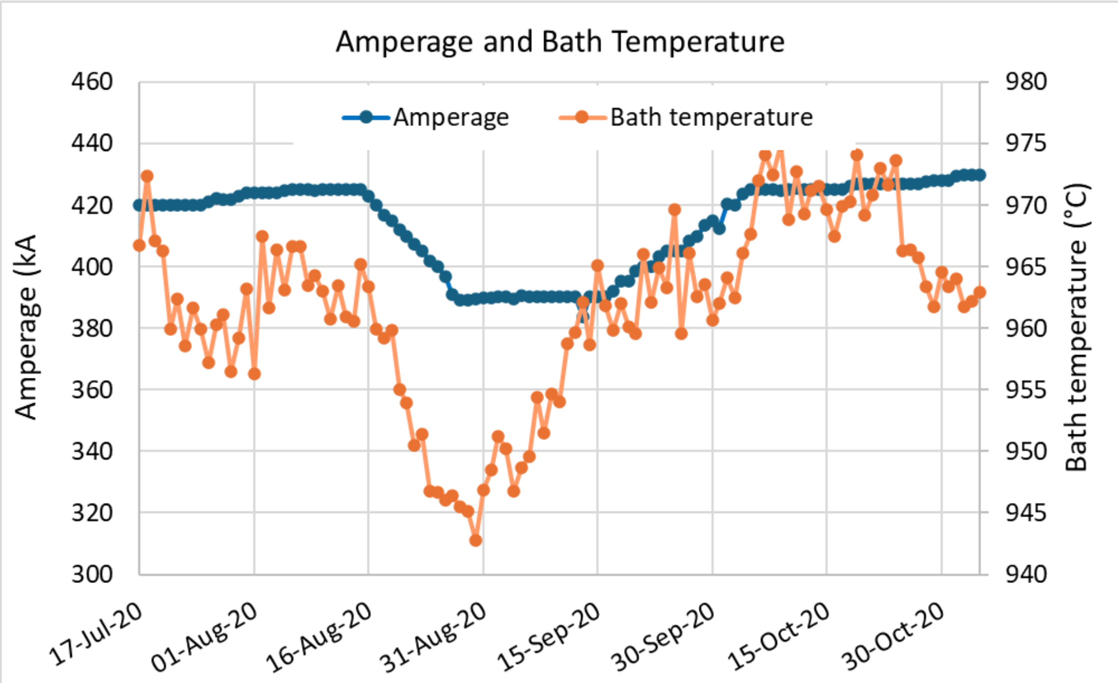

Figure 2. Amperage and bath temperature from 17 July to 4 November 2020, comprising the RT maintenance period.

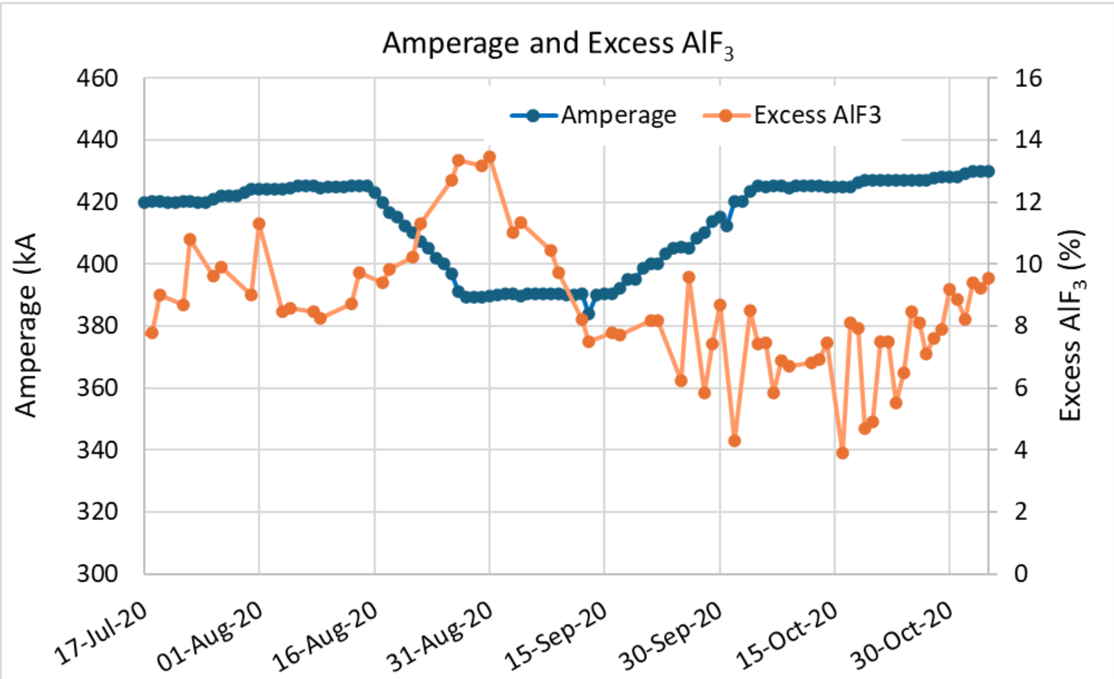

Figure 3. Amperage and excess AlF_3 from 17 July to 4 November 2020, comprising the RT maintenance period.

2. New Approach (Present Work Practice)

To ensure the transition period of amperage de-loading and loading time is minimized during RT maintenance, a detailed plan of actions was set up (Table 4).

Table 4. Action plan time sheet during RT maintenance in 2021.

Expected RT Initiation date	07-Nov	Line-8 RT preparation plan																						
Date		16-Oct	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	31-Oct	01-Nov	02-Nov	03-Nov	04-Nov	05-Nov	06-Nov	07-Nov
Anode cover thickness increased by 8cm	Plan																							
Extra Metal tapping for-1cm MH Tgt	Plan																							
Target Bath Height & bath tap table revision as per 20cm target	Plan																							
Reduce AlF3 addition & Ex. Alf3 target - 1% from target	Plan																							
Install Heat retainers in <56days cells	Plan																							
Increase BRSP by +0.5 µΩ /ACD	Plan																							

Expected RT completion date	19-Dec	Line-8 RT completion plan																						
Date		27-Nov	28-Nov	29-Nov	30-Nov	01-Dec	02-Dec	03-Dec	04-Dec	05-Dec	06-Dec	07-Dec	08-Dec	09-Dec	10-Dec	11-Dec	12-Dec	13-Dec	14-Dec	15-Dec	16-Dec	17-Dec	18-Dec	19-Dec
Anode cover thickness reduced by 8cm	Plan																							
Additional Metal cutting to revert MH Tgt	Plan																							
Target Bath Height & Tap table revised to normal	Plan																							
Increase AlF3 addition & Ex. Alf3 target +1%	Plan																							
Remove Heat retainers from <56days cells	Plan																							
Reduce BRSP by -0.5 µΩ /ACD	Plan																							

2.1 Preparation Plan

1. Assessment and data collection
   - Evaluate current de-loading and loading procedures.
   - Collect data on current transition times and identify bottlenecks.
2. Operational parameter adjustments
   - Identify and list the operation parameters that can be altered to speed up the process.
   - Test the impact of these changes on a small scale before full implementation.
3. Automation implementation
   - Develop an automated time sheet to manage and track the process.
   - Integrate automated controls to adjust parameters swiftly and accurately.
4. Staff training
   - Train relevant personnel on new procedures and the use of automated systems.
   - Conduct drills to ensure everyone is familiar with their roles.
5. Maintenance schedule optimization
   - Plan maintenance schedules to minimise impact on production.

Ensure availability of necessary resources such as bath crucibles and launders and personnel during transfer of liquid bath from other potlines.

2.2 List of Parameter Changes During RT Maintenance

2.2.1 De-Loading Actions

1. Change target amperage
   - Adjust the target amperage to the new lower level for de-loading.
2. Increase BRSP in stages
   - Incrementally increase the Base Resistance Set Point (BRSP) in stages to manage the de-loading process smoothly.
3. Base Feed Time (BFT) + 2 seconds (theoretical and actual)
   - Increase BFT by 2 seconds, both in theoretical and actual parameters, to accommodate the de-loading.
4. Anode set (AS) adder duration increase for lower kA
   - Increase the duration of the AS adder to suit the lower kiloampere (kA) setting.
5. Undercurrent trip protection

   - Update the undercurrent trip protection settings by adding a +30 V buffer to prevent premature trips during de-loading.
6. End of search reduction for alumina feeding
   - Reduce the end of search voltage by 5 mV to ensure stability during the lower amperage phase.
7. End of track reduction
   - Similarly, reduce the end of track voltage by 5 mV to align with the new operating conditions.
8. Superfast feed dumps increased
   - Increase the number of superfast feed dumps by 5 to ensure adequate material flow during the transition.
9. Anode Effect (AE) alumina dumps increased
   - Increase the AE dumps by 5 to manage the process more effectively during de-loading.

The summary is given in Table 5.

Table 5. Summary of parameter changes required during amperage reduction.

Line-8 RT maintenance action plan checklist	
Sl. No	**Activities**
1	Change target amperage
2	Base Resistance Setpoint (BRSP) increased in stages
3	Base Feed Time (BFT) + 2 sec.
4	Anode set adder duration increase for lower kA
5	Undercurrent trip protection to be updated with +30 V buffer
6	End of search in alumina underfeeding has to be reduced by 5 mV
7	End of track has to be reduced by 5 mV
8	Superfast feed dumps increased by 5 dumps
9	Anode Effect (AE) dumps increased by 5

All the above changes are set back on the completion of RT maintenance during the amperage ramp-up. By following these detailed actions during both de-loading and ramp-up phases, a smooth and controlled transition was achieved. Ther amperage and BRSP are shown in Figure 5. Table 6 gives cell operation parameters. The internal heat during the RT maintenance was approximately 61 kW lower than during normal operation. This was partially compensated by anode cover height increase of 8 cm which reduced the heat loss by approximately 44 kW. Heat retainers were also installed on the anode cover in cells < 56 days old (Table 4).

Table 6. Cell operation parameters before during and after RT maintenance in 2021.

	Before RT maintenance 9 Sept – 8 Oct 2021	During RT maintenance 11 Oct – 25 Nov 2021 45 days	After RT maintenance 29 Nov – 28 Dec 2021
Amperage, kA	423.98	385.73	424.15
Cell voltage, V	4.26	4.27	4.30
BRSP, μΩ	6.05	6.61	6.11
Bath T, °C	959	948	957
Excess AlF_3, %	10.7	10.6	8.7
Q_{in}, kW	789	728	817
ACD, cm	2.58	3.17	2.78

Figures 5 and 6 show the reaction to low internal heat, well below the normal. Due to the lack of heat, the temperature decreased to 939 °C, and as consequence of rapid bath freezing the excess AlF_3 increased to 16 %. This could have been mitigated by putting extra anode cover a few days earlier.

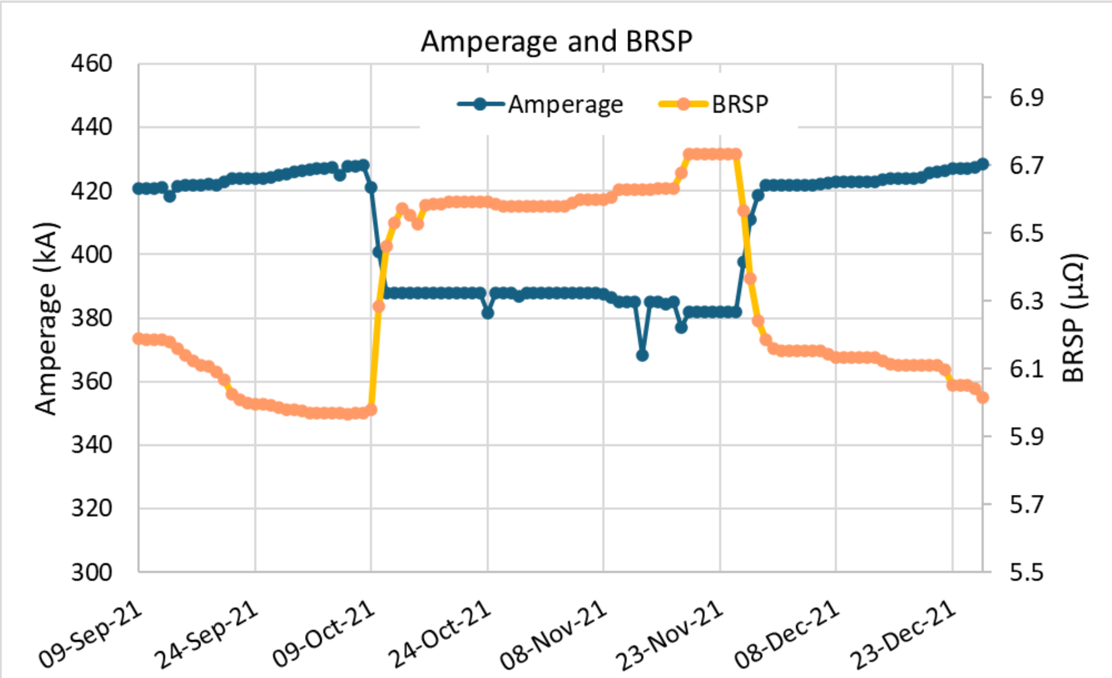

Figure 4. Amperage and BRSP from 9 September to 28 December 2021, comprising the RT maintenance period.

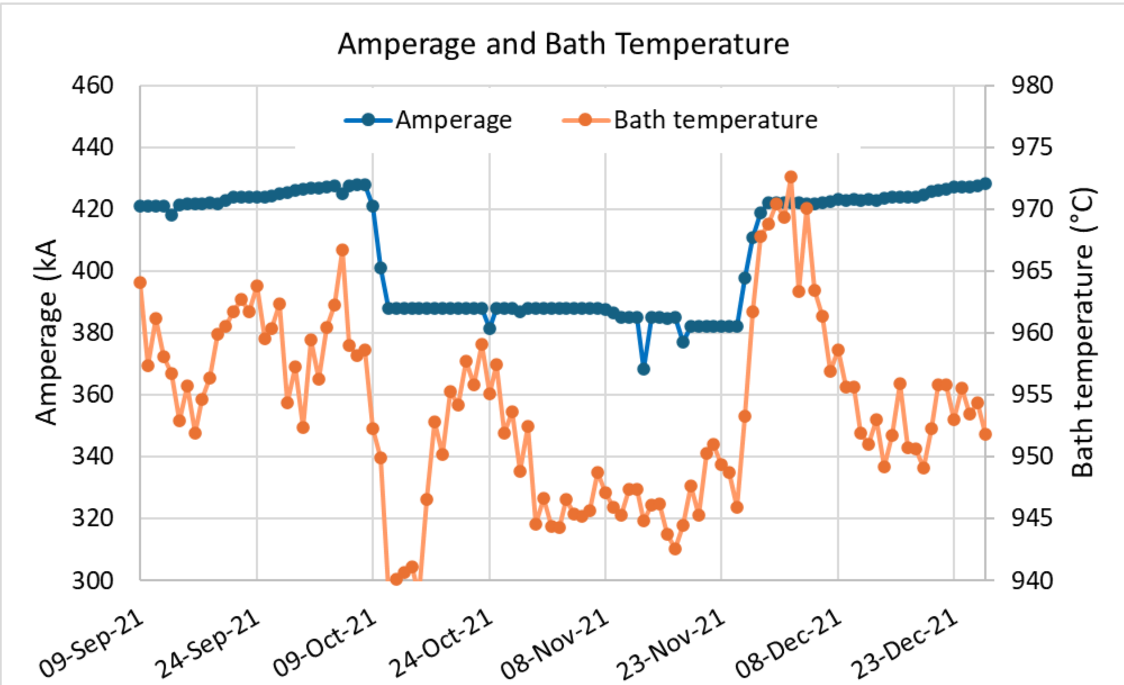

Figure 5. Amperage and bath temperature from 9 September to 28 December 2021, comprising the RT maintenance period.

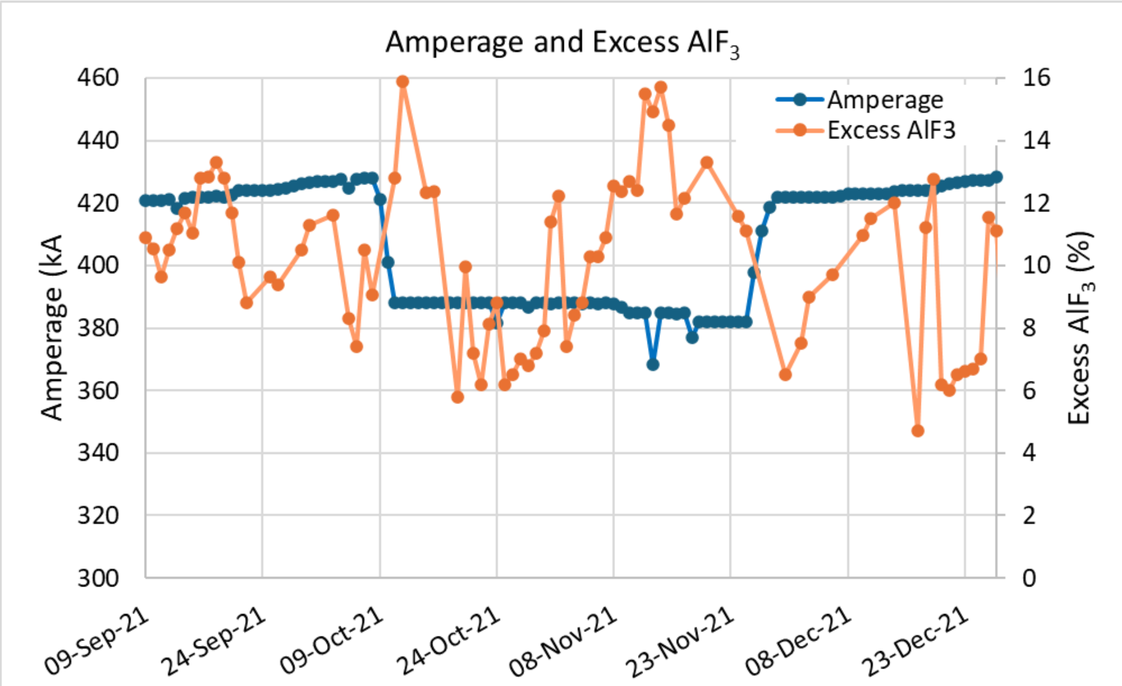

Figure 6. Amperage and excess AlF_3 from 9 September to 28 December 2021, comprising the RT maintenance period.

The two examples we have discussed here show that amperage decrease by 10 % for an extended time is manageable but not easy when the internal heat at low amperage is well below the normal one. Thermal imbalance with temperature swings pulls along also excess AlF_3 in the opposite direction, which then becomes difficult to control.

2.3 Overall Amperage Increase

The Line 8 amperage from 2019 is shown in Figure 7.

- Line 8 target amperage was 430 kA, bound to increase steadily towards 440 kA.
- However, in 2021 the target was set to 422 kA due to Line 6 operating at a lower amperage (Line 8 is at the end of Line 6).
- In 2023 and in 2024, Line 8 target amperage is 440 kA.

Each year, Line 8 operated at target amperage for some time, but the average amperage is well below the target due to rectifier maintenance or other issues. The longest reduction to approximately 390 kA was in 2019 from June 2019 to end of January 2020. In 2024 the operating amperage has been very close to the target (data until 4 July).

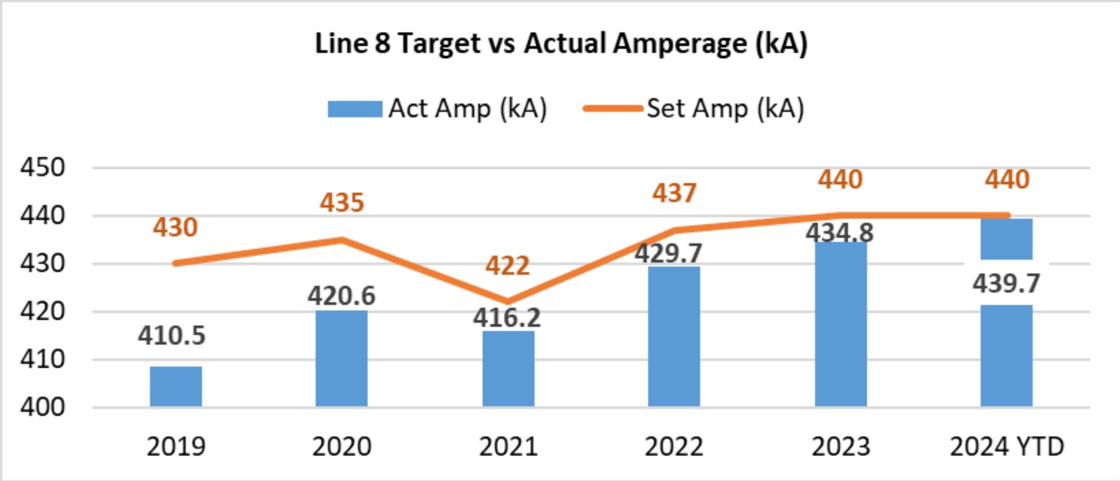

Figure 7. Line-8 amperage from 2019 to 4 July 2024 (YTD).

3. Results for Metal Production

Figure 8 shows the comparison between the two approaches on de-loading and re-loading of the amperage during RT maintenance time along with the corresponding metal production loss per day. and the metal loss during the ramp-down and ramp-up periods before and after the project implementation.

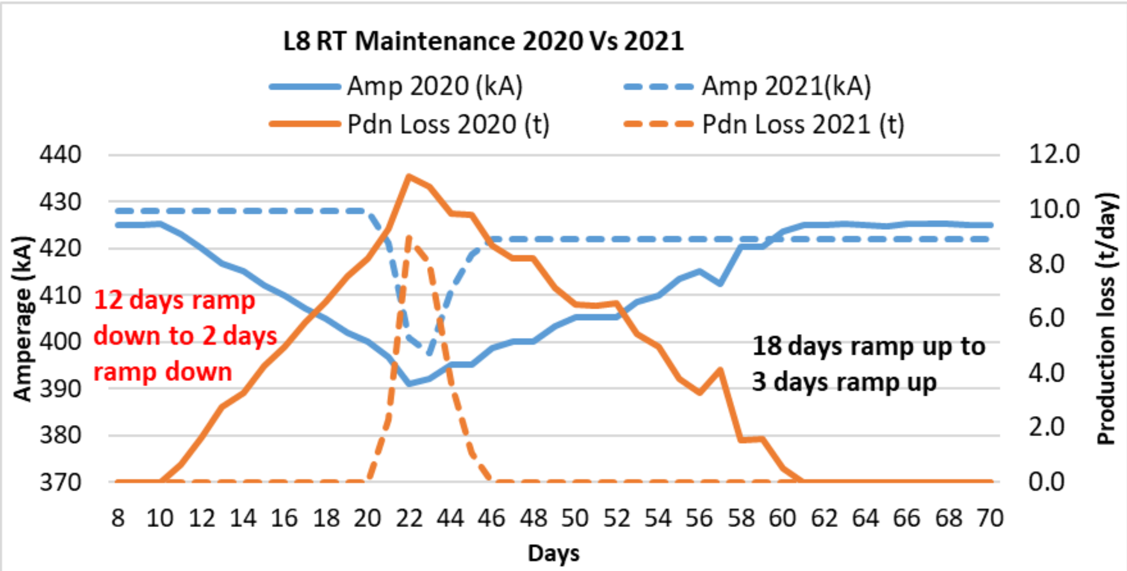

Figure 8. Line-8 amperage and production loss comparison during amperage reduction and restoration for RT maintenance (2020 vs 2021). Note that this graph shows only the periods of amperage reductions and increases with 22 days jump on the horizontal axis between the two.

Figure 5 shows the total hot metal savings of 150 t achieved by the new approach during the RT maintenance.

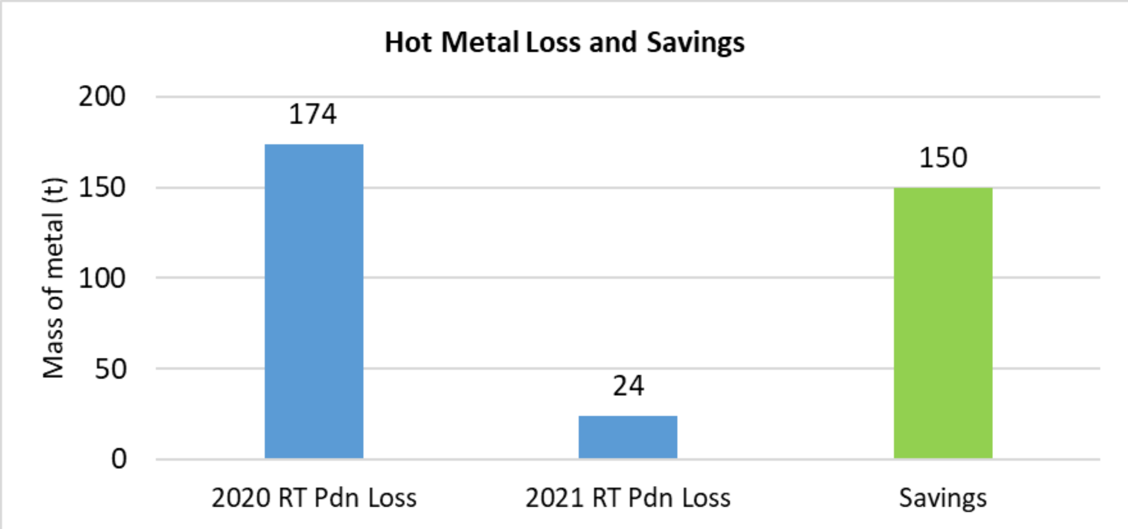

Figure 5. Production loss comparison before and after the project. Pdn = Production.

4. Conclusions

The work practice developed has resulted in a significant time reduction of de-loading and loading of the amperage during the rectifier maintenance. The practice now decreases the amperage in 48 hours instead of 10 days, and increases it back to normal operating target in 48 hours instead of 18 days previously. This reduced the metal loss by 150 t during the rectifier maintenance.

The two examples analysed in this paper show that the operation at internal heat much below the normal is not easy, particularly with rapid amperage reduction and restoration which can cause bath temperature and excess AlF_3 swings. This gave us the indication that better predictive actions, in use now, are required.

5. References

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