ALBA Potline 6 Operation during Amperage Increase

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Abstract

ALBA (Aluminium Bahrain) Potline 6 is operating 424 cells of EGA (Emirates Global Aluminium) DX+ Ultra technology. Potline 6 start-up was completed on 31 July 2019 at 460 kA. The cell performance test was successfully carried out at 465 kA from 1 October to 30 November 2019, achieving KPIs well above the contractual figures. EGA has demonstrated the operation of DX+ Ultra technology at 480 kA on five demonstration cells at EGA Jebel Ali site, which confirmed the robustness of DX+ Ultra technology. EGA agreed with ALBA to support amperage increase from 465 kA to 480 kA in Potline 6 and an agreement to this effect was signed between EGA and ALBA in February 2020. In December 2021 ALBA Potline 6 already reached 478 kA. EGA is providing remote and onsite technical support to ALBA operation and process teams. During amperage increase, Potline 6 faced various challenges of maintaining thermal balance, sustaining current efficiency, anode problems, and high bath generation rate. In order to keep cell thermal balance, anode cover was gradually decreased from 15 cm to 6 cm, and metal height target was increased from 20 cm to 25 cm. Bath temperature target was decreased from 957 °C to 955 °C. Potline current efficiency decreased during a few months due to anode problems and carbon dust, but was quickly restored by improving anode quality, cell thermal balance, metal tapping accuracy, and by controlling bath height. Potline was monitored daily for red potshells and action was taken on the red shell pots. Cells with high silicon content in the metal were identified and ranked, and special guidelines were formulated to treat such cells. This paper describes the details of ALBA Potline 6 operation during amperage increase, challenges faced, and actions taken to maintain excellent potline performance.

Keywords: DX+ Ultra technology, Amperage increase, Cell performance, Aluminium Bahrain Potline 6.

1. Introduction

The Kingdom of Bahrain was the first Gulf Cooperation Council (GCC) country to open an aluminium smelter [1]. ALBA started aluminium production with the commissioning of two Potlines 1 and 2 in 1971 using side–break, un-hooded, end-to-end Montecatini technology operating at 100 kA with a capacity of 120 000 tonnes per year. The first expansion was Potline 3 in 1981 using Kaiser end-to-end cell technology. Potline 4 and Potline 5, using the AP30 technology were respectively commissioned in 1992 and in 2005 [2] and are operating at 400 kA at the end of 2021. Then ALBA took a giant leap by commissioning Potline 6 with 424 cells operating EGA DX+ Ultra technology in 2018/2019 [3]. This enabled to increase its annual production capacity by 556 257 tonnes in 2021, bringing total ALBA's aluminium production to 1.561 million tonnes in 2021.

EGA is the largest industrial company in the UAE outside oil and gas and the world's biggest 'premium aluminium' producer. EGA operates aluminium smelters at Jebel Ali in Dubai and at Al Taweelah in Abu Dhabi, with a combined production of 2.501 million tonnes of metal in 2021. EGA is operating its own cell technologies: D18+, CD20, D20, D20+, DX, DX+ and DX+ Ultra. DX+ Ultra technology was developed as low energy version of DX+ technology, operated in EGA Al Taweelah Potline 3 since 2013 [4]. The goal of designing and building DX+ Ultra demonstration cells was to test for future Brownfield expansion or Greenfield smelter with lower CAPEX, higher productivity and lower energy consumption cell than with using DX+ cells. Successful performance of DX+ Ultra technology was demonstrated in five Eagle cells in Jebel Ali Potline 5 from 2014-2021 at 460-480 kA [5]. It is now operating in ALBA Potline 6 and in recent Al Taweelah Potline 3 extension [3, 6].

The Technology Licence Agreement for Potline 6 between EGA and ALBA was for the amperage of 440 kA to 460 kA. In practice, this was the potline start-up amperage. Immediately after the end of potline start-up, the amperage was increased to 465 kA. The Technology Performance Test was successfully carried out at 465 kA in October and November 2019 [3]. Following the successful demonstration of DX+ Ultra technology at 480 kA in EGA Jebel Ali, Potline 5 Eagle section, the Technology Enhancement Agreement between EGA and ALBA was signed in March 2020, with the objective to increase the amperage in ALBA's Potline 6 to 480 kA. This paper describes the amperage increase from 465 kA to the present amperage of 478 kA; 480 kA should be achieved by the end of 2022.

2. Amperage Increase Strategy

ALBA Potline 6 was started up at 440 to 460 kA from 9 December 2018 to 31 July 2019 and the amperage was increased to 465 kA by mid-September 2019. The analysis of potline operation in this paper starts on 1 October 2019, when nearly all cells were "established" (cell age > 56 days) and the potline operation was stabilized. The average cell age on 1 October 2021 was 142.8 days for the age range of 62-296 days. The Cell Performance Test, governed by Technology License Agreement, started on 1 October 2019 for 60 days to 30 November 2019 [3]; during this period, the line amperage was kept constant at 465 kA (Figure 1). After successful completion of the performance test, the amperage was increased further to reach 470 kA in January 2020 and 472 kA in February 2020. Potline operation was kept at 472 kA from 11 February 2020 to 26 September 2020.

Gradual potline amperage increase was resumed from 27 September 2020, reaching 475 kA on 22 October 2020, but then it was reduced by 2 kA (475 kA to 473 kA) for one month (from mid-November to mid-December 2020) due to significant increase of anode problems, including spikes. The amperage reduction and improved carbon quality helped to reduce anode problems.

instead, local material was used, increasing the alumina content in anode covering material by 10 % (from 28 % to 38 %). All these actions helped to control bath generation and metal height on the target.

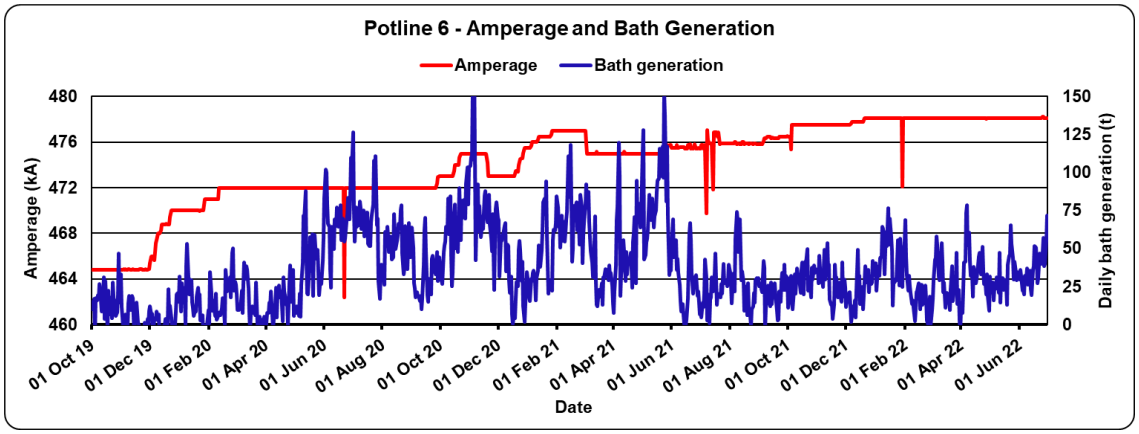

Figure 13. Daily bath generation in Potline 6.

6. Design Validation Measurement Campaign at 465 kA and 475 kA

Potline 6 electrical and thermal design validation measurement campaign was carried out at 465 kA and at 475 kA. At 475 kA, the measurement campaign was carried out on four cells, two cells in each potroom. The design validation measurement campaign data indicate that the potline is thermally and electrically well balanced. Good thermal balance is confirmed by freeze profiles, shown in Figure 5. External voltage drop (from the end of collector bars of a cell to anode rods below the anode beam of the next cell) at 465 kA was 239 mV, and at 475 kA it was 247 mV, which is by 3 mV greater than proportional to the amperage increase. However, in Table 1, it is taken proportional to the amperage from the value at 465 kA; this has a very small effect on the ACD. Cathode voltage drop is measured on regular basis by the Process control team; the measurement campaigns just confirmed the data of the regular measurements. Anode voltage drop from the anode rods below the anode beam to the bottom of the anode carbon was 420 mV at 465 kA and 452 mV at 475 kA; which is by 23 mV greater than proportional to the amperage. The average anode voltage drop over the whole anode bottom surface is calculated by the model as explained in [11], which was 365 mV at 465 kA. This value is used for the ACD calculation in Table 1, with values proportional to the amperage for other amperages in the table.

7. Cell Performance

Table 3 gives cell key performance indicators (KPIs) for full period of 465-478 kA, 465-472 kA, 472-478 kA and 478 kA.

Table 2. Performance of ALBA's Potline 6 cells from 465 kA to 478 kA.

Parameter	Unit	1 Oct 2019 - 30 June 2022	1 Oct 2019 – 31 Jan 2020	1 Feb 2020 - 31 Dec 2021	1 Jan 2022 - 30 June 2022
Target amperage	kA	465-478	465-472	472-478	478
Actual amperage	kA	474.20	467.04	474.43	478.070
Current efficiency- tapped	%	94.00	94.71	93.90	93.920
Current efficiency, adjusted for metal height increase*	%	94.17	94.79	94.14	93.81
Metal production*	kg/cell-day	3596	3568	3597	3612
Net cell voltage	V	4.097	4.110	4.090	4.113
BRSP	μ□	5.069	5.131	5.052	5.094
Net specific energy (DC)*	kWh/kg Al	12.96	12.92	12.95	13.07
Net carbon consumption*	kg C/t Al	408	398	407	411
Gross carbon consumption	kg C/t Al	544	547	540	559
Excess AlF_3	%	9.6	9.3	9.6	9.8
CaF_2	%	7.5	8.0	7.5	7.5
Bath temperature	°C	956	957	956	956
Metal height before tap	cm	23.6	20.3	23.6	25.7
Fe	%	0.073	0.083	0.072	0.071
Si	%	0.031	0.029	0.030	0.034
Anode effect frequency	AE/pot-day	0.036	0.051	0.028	0.056
Anode effect duration	s	12.5	16.3	10.6	17.5
PFC emissions, CO_2 equivalent**	CO_2 kg/t Al	8	15	5	18
Cathode voltage drop	mV	193	178	193	204

***** Adjusted for metal height increase in each period.
******CO_2 equivalent is calculated as in Reference [12], using the Tier 2 method and SAR (Second Assessment Report).

8. Conclusions

ALBA has successfully increased amperages in DX+ Ultra Potline 6 from 460 kA to 478 kA. It will be able to increase the amperage further to the next short-term target of 480 kA, which has been already demonstrated in EGA Eagle DX+ Ultra cells.

During amperage increases from 465 kA to 478 kA, reported here, excellent results were achieved: current efficiency of 94.2 %, energy consumption of 13 kWh/kg Al, net carbon consumption of 408 kg C/t Al, and benchmark 8 kg CO_2 eq./t Al of PFC emissions.

9. References

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