Implementation of SY-235 Technology for Upgrading One Potline to 235 kA at INALUM

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Abstract

INALUM and SAMI finished upgrading Potline 2 at the Kuala Tanjung smelter using SY-235 technology. This upgrade increased its operational amperage from 195 to 235 kA in 170 reduction pots. The objective of this enhancement was to improve metal production and current efficiency while maintaining the existing Pot Control System. The upgraded pots can now produce up to 1790 kg, of metal per pot per day and have DC specific energy consumption up to 13 300 kWh/t Al at 235 kA, which is a big step forward in the smelter productivity.

One of the most important technical changes made during this upgrade was switching from a two-end riser busbar system to a four-side riser configuration. This balances the magnetic field distribution and overall energy efficiency. Additionally, a new Pot Tending Machine (PTM) equipped with a cavity cleaner was introduced to improve the anode-changing. Changing the old bar break system to point feed system was another big improvement. This made feeding alumina and AlF_3 more efficient, which make the pots more stable.

The start-up process of the upgraded pots began in mid-April 2023 and was successfully completed by the end of December 2023. The large-scale start-up was systematically carried out to ensure the smooth integration of the new technologies without significant disruptions to ongoing operations. Even though upgrading a fully operational potline was hard, the project team did a good job of dealing with problems like allocating resources, making changes to the infrastructure, and improving the process.

Keywords: Potline amperage upgrade, Sami technology, Point feeder system, Aluminum reduction optimization.

1. Introduction

The Company, officially established on January 6, 1976, maintained its original name, PT Indonesia Asahan Aluminium (INALUM). However, the Company's status underwent several transformations. In 2014, based on Government Regulation No. 26 of 2014, INALUM became a state-owned enterprise (BUMN). Subsequently, in 2017, the government established the Mining Industry Holding, appointing INALUM as the holding company with majority shares in Indonesia's leading mining firms, including PT Aneka Tambang Tbk, PT Bukit Asam Tbk, PT Timah Tbk, and PT Freeport Indonesia. In 2019, this Mining Industry Holding was rebranded as MIND ID (Mining Industry Indonesia) to differentiate between INALUM's operational role and its holding company function. With the issuance of Government Regulations No. 45/2022 and 46/2022, INALUM reverted to its original operational status in 2023.

INALUM operated three potlines for aluminum smelting, each containing 170 pots. Potlines 1 and 3 utilized Sumitomo S170 technology at 195 kA, while Potline 2 underwent upgrading to 235 kA using SAMI's SY-235 technology (Figure 1). Potline 2 was chosen as the oldest potline, with an average pot life around 2300 days. The upgrade project, executed through an EPC partnership with SAMI, modernized Potline 2 by transitioning to the higher amperage technology.

Figure 1. Aerial view of INALUM's reduction plant.

2. Project Timeline

The project contract was signed on April 9, 2021, with an official commencement date of May 5, 2021. The first step was to look over and complete the Detailed Engineering Design (DED), which included nine sections, such as the main facilities (lining, busbar, superstructure, super-dense phase conveying system, anode covering material conveying system, and potroom) and supporting facilities (lining material shop, workshop, and motor control center room). The successful completion of the DED was extremely important to ensure that all components met the required specifications and standards. Once finalized, the project team could proceed with the procurement of materials and the scheduling of construction activities.

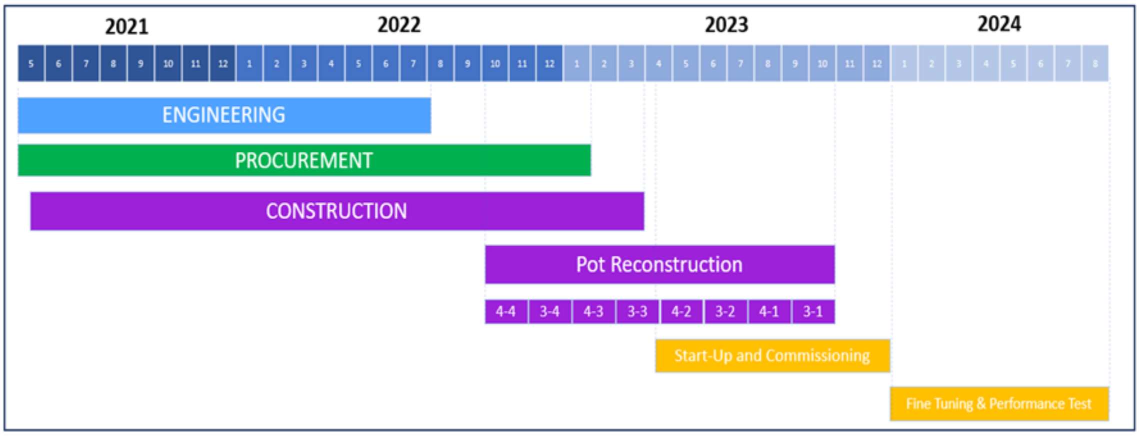

Figure 2. Timeline of project execution

Key phases of the EPC project were as follows (Figure 2):

- Detailed Engineering Design (DED): 5 May 2021–18 July 2022
- Procurement: 5 May 2021–9 January 2023
- Construction: 20 May 2021–6 March 2023

- Pot reconstruction: 8 December 2021–October 2023
- Start-up and commissioning: 13 April 2023–30 December 2024
- Fine tuning and performance test: 1 January 2024–20 August 2024

In parallel with the Detailed Engineering Design (DED) review and finalization process, procurement and construction activities were initiated. The early construction work included geological surveys for the areas designated for the workshop and the motor control center (MCC) room, as well as the delining of pots which had been cut out prior to the official signing of the project.

The procurement phase of the project proved particularly challenging due to the ongoing global COVID-19 pandemic. The pandemic significantly disrupted project activities, as many manufacturing operations and shipping activities both maritime and air freight were halted due to global lockdowns. These disruptions, combined with other factors such as the processing of import quotas and master list approvals, resulted in delays to the overall project timeline. Consequently, the targeted project completion date, originally set for October 2023, was postponed to August 2024.

3. Technology Implementation

SAMI's approach proven high-amperage technologies used globally in smelter upgrades [1]. The upgraded configuration retained compatible elements while replacing outdated components with advanced materials and controls.

Key design innovations included:

- A new 4-end riser busbar system to manage current management and magnetic field (Figure 3).
- Redesigned busbar system improving magnetohydrodynamic stability [2].
- Redesigned pot lining materials and installation tools.
- Point-feed technology replacing the old bar-breaker system. This upgrade contributes to enhanced alumina distribution, improved bath temperature stability, and lower anode effect frequency, supporting more stable pot operation [3].
- Pneumatic alumina conveying system replacing manual alumina charging to pot bin (Figure 4)
- Advanced preheating devices with integrated PLC automation
- Retained existing Blue Box Pot Control System for compatibility and minimal operational disruption
- Installation of five new Pot Tending Machines (PTMs) equipped with integrated cavity cleaners (Figure 5).
- Two aluminium fluoride vehicles for precise additive dosing.
- Anode size remained the same as in SY170.

Figure 3. Side riser busbars. Left: S170 pot, Right: SY-235 pot.

Figure 4. Alumina handling system. Left: S170 pot,Rright: SY-235 pot.

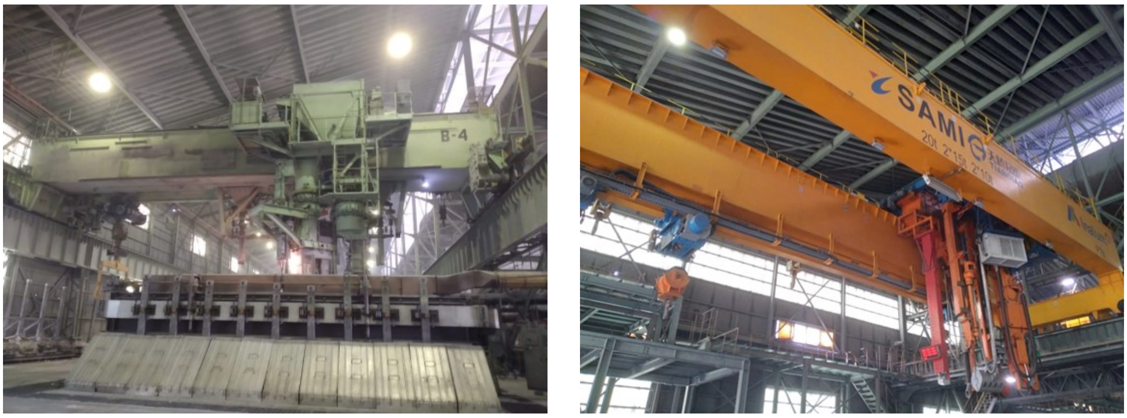

Figure 5. Pot tending machine. Left: old PTM, Right: new PTM.

4. Preheating and Start-up

The energization of the 170 pots occurred in stages from April to December 2023, gradually increasing amperage from 195 kA to 235 kA. The start-up process utilized liquid baths provided by other pot lines, requiring approximately 14–16 tonnes per pot. Later, after 24 hours, 12 tonnes of liquid metal were added into each pot.

Preheat operations were carried out using a modern gas preheating system integrated with PLC based automation, replacing the older manual preheat configuration. This system allows precise temperature control, improved safety, and efficient energy usage during preheating cycles. There are 10 sets of new preheating devices used during the process.

Figure 5. Preheating process preparation.

INALUM has been very particular about environmental aspects, and this is the reason why potline 2 was modified with better technology available and manual alumina filling was replaced by super dense phase system. Figure 5 shows the preheating of Pot R385 in progress. We were unable to hood the pot due to typical design of gas heating devices which are protruded above the anodes. The pot is well insulated to conserve the heat.

Prior to the start-up of the reduction pot, a controlled preheating process was carried out to gradually raise the graphitized cathode temperature to operational levels. All anodes were already covered by crushed bath before starting the preheating process. As illustrated in the preheating curve, the temperature increased steadily over a 72-hour period, reaching above 900 °C by the end of the cycle. The gas burner was prepared with four thermocouples in the middle of the pot to monitor the preheating temperature (Figure 6). Liquid petroleum gas (LPG) was used to power the 72-hour preheating process.

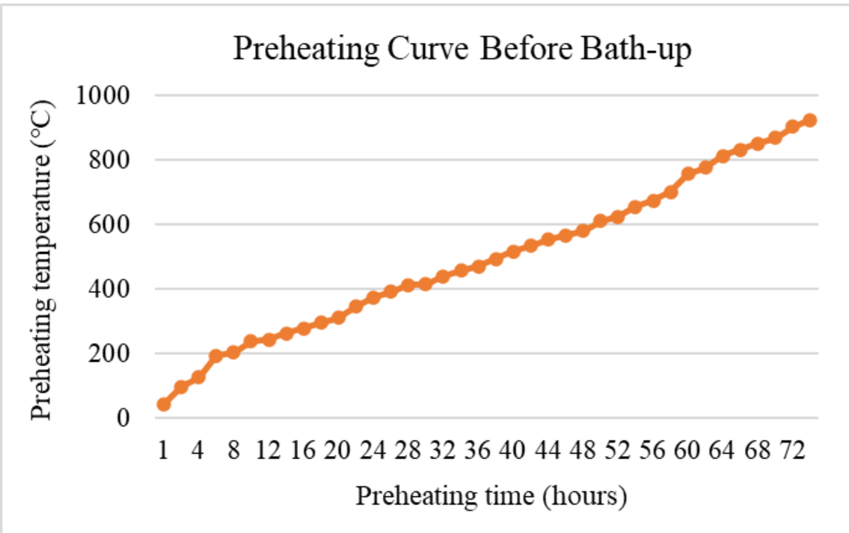

Figure 6. Preheating process before bath-up.

The start-up procedure was carried out by the addition of 10 tonnes of liquid bath (Figure 7), removing the wedge, and gradually lifting the anodes while charging around 5 tonnes more liquid bath. After pot start-up, the hooding system was replaced with the existing pot hood, and the anode positions were adjusted accordingly to maintain the pot voltage within the range of 6 to 7 V. Metal charging was carried out after 24 hours, and anode changing/metal tapping started 24 hours later following the working schedule in that section. To increase aluminum production efficiency, temperatures were kept below 1000 °C for the first few hours and were gradually reduced [5]. The slow temperature reduction (Figure 8) allowed the lining materials to adapt to operational conditions and reach thermal equilibrium. If the temperature was reduced too quickly, it could have led to internal stresses in the materials, particularly the cathode blocks, as they underwent uneven contraction, which could have resulted in cracking or weakening of the lining and shortened the pot life.

Figure 7. Bath-up in progress.

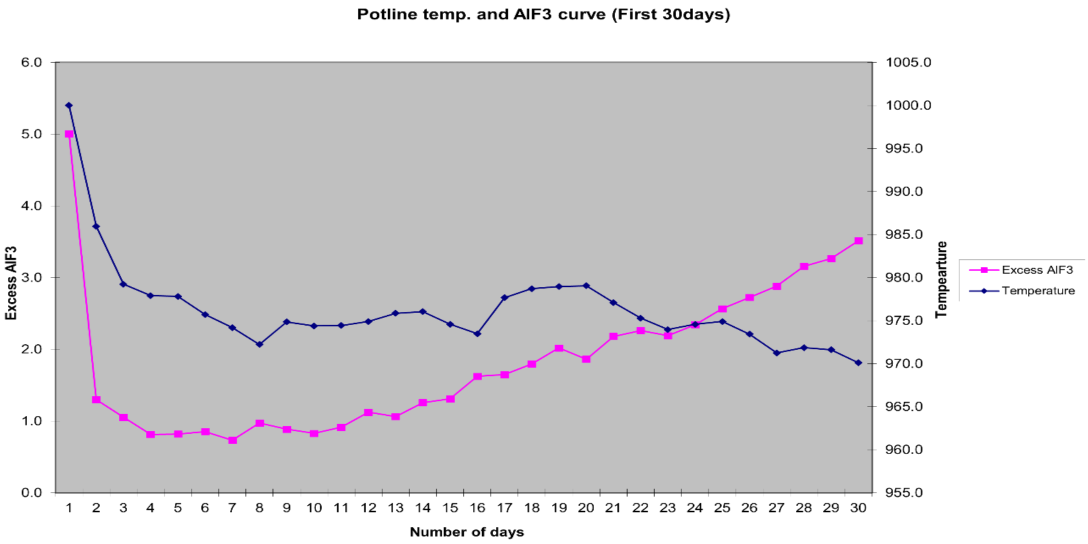

Figure 8. Potline temperature and AlF_3 curve.

During early operation, around 1800 kg of soda was added to the long sides of the pot to reduce bath acidity and help establish the desired chemical balance. Following that, bath powder (crushed recycled bath) was added periodically to maintain the bath height, particularly as ledge formation began to develop along the pot sidewall. Bath temperature, metal, and bath height were measured every morning and used as key indicators to determine the appropriate amount of metal to tap and to guide pot voltage adjustments. To ensure stable thermal conditions, the bath temperature was carefully managed through gradual adjustments in energy input and alumina feeding. The pot parameter during the transition period was shown in Table 1.

Table 1. Pot parameter during transition or normalization period.

Pot Parameter	1st month	2nd month	3rd month
Average Voltage (V)	4.285	4.310	4.263
CE (%)	62.1	84.6	95.6
Bath acidity (%)	0.5	3.5	6.9
Bath temperature (°C)	978	972	968
Metal height (cm)	25.7	26.8	26.0
Bath height (cm)	21.4	19.0	16.5

When the first block (batch of pots) was started, there were still 37 old pots in operation. The old pots were gradually shut down while the new pots started up. After two blocks had already started, the potline current was increased from 195 kA to 198 kA in June 2023. The original plan for the creeping current was as follows: after the temporary busbar was installed in Block 4-1, the first five blocks would begin to creep to 235 kA while Block 4-2 started up during the creeping process. Ideally, the last two blocks would start up directly at 235 kA. Based on the progress at that time, this creeping process was expected to begin around mid-September, with more than 100 pots requiring close monitoring during that period. Managing over 100 pots in five blocks to creep from 198 kA to 235 kA was more challenging and riskier than managing only 40 pots. The former demanded significantly more resources and a higher level of care (such as temperature monitoring and forced cooling) compared to the latter, increasing risk exposure.

Creeping to 235 kA with 40 pots earlier (and with less complex operations) provided more assurance of completing the startup of all eight blocks as quickly as possible. In contrast, adhering to the original plan of bringing over 100 pots to creep to 235 kA in September could have introduced operational uncertainties, potentially disrupted subsequent startups and delayed our goal of initiating all eight blocks by the end of 2023 (or even sooner).

Potline-2 amperage creep commenced on July 4, 2023, as indicated in Table 2. To prevent disturbances in pot heat balance, pot voltage will be adjusted in accordance with potline amperage to maintain consistent heat input. Pot setting voltage should be modified immediately after each current creep to allow sufficient time for the removal of the liquid bath. The metal level must be kept at the upper limit before each current creep, while the bath level should be maintained at the lower limit prior to each current creep. As anode consumption increases with higher amperage, the anode cycle for all operating pots will be adjusted from 28 days to 24 days right before the initiation of amperage creeping.

Table 2. Potline amperage increase schedule.

Start Date	Time	Amperage Increase
4th July, 2023 (Tuesday)	10:00 am	198 kA → 205 kA (+7)
5th July, 2023 (Wednesday)	10:00 am	205 kA → 210 kA (+5)
6th July, 2023 (Thursday)	10:00 am	210 kA → 215 kA (+5)
11th July, 2023 (Tuesday)	10:00 am	215 kA → 230 kA (+15)
25th July, 2023 (Tuesday)	10:00 am	230 kA → 235 kA (+5)

5. Process Optimization and Performance Metrics

During the commissioning phase, extensive process optimization was undertaken to meet the targeted performance parameters. Key activities involved continuous monitoring and fine-tuning of operational conditions such as bath temperature, alumina concentration, and anode-cathode distance (ACD). Adjustments were systematically applied based on real-time data analytics and diagnostic feedback from the pot control system. The operational team introduced a structured approach to anode management, employing regular anode redressing schedules to reduce carbon consumption and anode effects frequency. The integration of new Pot Tending Machines (PTMs) equipped with cavity cleaners significantly improved cavity cleanliness and thus enhanced current efficiency and bath stability. Optimized point-feeding practices were implemented to ensure uniform alumina distribution, maintain bath chemistry stability, and significantly lower anode effect occurrences. This improvement in feeding efficiency resulted in stable bath temperature and reduced fluctuations in pot voltage. Furthermore, the less forced cooling that occurred at the pot indicated precise thermal management practices. Adjustments to bath height and targeted alumina feeding intervals provided effective thermal balance, ensuring pot operation remained within optimal parameters for high current efficiency and energy performance.

Key operational activities followed SAMI's protocols, with enhanced practices such as anode redressing, optimized cavity cleaning using the new PTMs, and real-time amperage balancing.
The implementation of the super dense phase alumina feeding system offered significant advantages over the previous manual feeding method using Pot Tending Machines (PTMs). In the manual system, PTMs had to travel back and forth frequently to refill alumina into each pot, increasing the load on the overhead rail infrastructure and contributing to mechanical wear. Additionally, the manual process often resulted in environmental alumina spillage, which required recycling – representing a material and financial loss, as alumina is a valuable commodity. From a health and safety perspective, workers were exposed to higher levels of airborne alumina dust during manual feeding. In contrast, the super dense phase system provided a closed and controlled feeding environment, significantly reducing dust emissions and improving workplace safety while enhancing overall operational efficiency. The introduction of the new aluminum fluoride (AlF_3) vehicle equipped with a point feeding system significantly improved the accuracy and efficiency of AlF_3 addition in the pots. Unlike the old method, where the AlF_3 vehicle discharged a fixed quantity into each pot twice daily—typically in the evening and early morning—the new system distributed AlF_3 gradually over a 24-hour period through computer-controlled point feeding. In the previous setup, the accuracy of AlF_3 dosing depended heavily on the scale calibration of the vehicle, which, if inaccurate, could lead to inconsistent fluoride concentrations and unstable bath chemistry. The new system reduced the risk of over or underfeeding and ensured more consistent control of bath acidity. As a result, the pot's chemical stability improved, which in turn supported more stable bath temperatures and contributed to more efficient and predictable pot performance. The modernization led to substantial improvements, in line with global aluminum industry benchmarks. The comparison between the old pot (S170) and the new pot is shown in Table 3.

Through the implementation of SY-235 technology, Potline 2 achieved a production increase of approximately 20 000 tonnes compared to the SM-170 technology used in Potlines 1 and 3. This capacity enhancement contributed to an estimated additional revenue of 51 million USD. The successful upgrading of Potline 2 also served as the main contributor to INALUM reaching its highest-ever annual aluminium production, totalling 274 230 tonnes in 2024 – marking a historic milestone for the company.

Table 3. Comparison of pot parameter in INALUM.

Parameter	Unit	S170	SY-235
Line Current	kA	195	235.4
DC energy consumption	kWh/t Al	14 426	13 300–13 800
Current efficiency	%	92.2	92.5–94.5
Metal production	kg/pot·day	1447	1749–1790
Anode effect frequency	AE/pot·day	0.52	0.05–0.30
Number of pots in standard bath temperature range (950–970 °C)	%	54.5	81.8
Number of pots in standard bath acidity range (8.5–11.5 %)	%	34.4	50.1

6. Conclusions

The collaboration between INALUM and SAMI has delivered a large-scale upgrade across all 170 pots of Potline 2, setting the stage for enhanced operational stability, lower energy consumption, and increased aluminum output. Comprehensive risk management and proactive project management are critical. Continuous operational monitoring ensures sustainable performance and rapid response to challenges. These lessons help aluminum smelters successfully implement amperage increases and expansions, achieving targeted efficiency, environmental compliance, and operational stability.

7. References

1. Marc Dupuis and Kangjian Sun, Review of the SAMI retrofit project in QTX smelter in China., Proceedings of the 39th International ICSOBA Conference, Virtual, 22-24 November 2021, *TRAVAUX* 50, 671–678.
2. Anthony Kjar, Jeffrey Keniry and Dagoberto Severo, Evolution of Busbar Design for Aluminium Reduction Cells, Eighth Australasian Aluminium Smelting Technology Conference and Workshop, Yeppon, Australia, October 2004, Paper 5.07.
3. Bjørn Lillebuen, Marvin Bugge and Helge Høie, Alumina dissolution and current efficiency in Hall-Héroult cells. *Light Metals* 2009, 389–394.
4. Alton Tabereaux, Super-high amperage prebake cell technologies in operation at worldwide aluminum smelters, *Light Metal Age*, 2017, 75(1), 26–29.
5. Halvor Kvande and Per Arne Drabløs, The aluminum smelting process and innovative alternative technologies, *Journal of Occupational and Environmental Medicine* 2014, May 8; 56(5 Suppl) S23-S32. https://doi.org/10.1097/jom.0000000000000062