

Ma'aden Reduction Potline Partial Failure Incident and Recovery

Subah Al-Shammari¹, Kishor Pant², Abdulrahman H. Al-Shammari³, Brent M. Pekoba⁴
and Mohammed Al Hunaini⁵

1. Director, Production Engineering & Quality
2. Superintendent, Production Engineering
3. VP, Refinery Operation
4. Manager, Reduction operation
5. VP, Smelter Operation

Ma'aden Aluminium Company, Ras Al-Khair, Saudi Arabia

Corresponding authors: shammarisu@maaden.com.sa and pantk@maaden.com.sa

<https://doi.org/10.71659/icsoba2024-al003>

Abstract

The Saudi Arabian Mining Company (Ma'aden) and Alcoa (USA) joint venture is the largest fully integrated aluminium complex in Ras Al-Khair, Kingdom of Saudi Arabia, and consists of an alumina refinery, an aluminium smelter and a rolling mill. The Aluminium smelter commenced operation on 12 December 2012 with 720 AP 37 technology reduction pots in two potlines at 370 kA. The potlines were upgraded with Alcoa Center of Excellence (ACE) 410 kA package from 2019 to increase amperage to 410 kA producing 805 kt/a of aluminium.

In November 2022, Ma'aden experienced a significant operational challenge when 304 pots were cut out due to a series of anode collapses and anode fall-offs in addition to other operational challenges. Remarkably, there was no power shutdown of the potline due to various preventative actions, taken to save the potlines. During five months of continuous pot cleaning, inspections and relining, all affected pots were back into operation safely at zero lost time incident, and production targets were back to normal. This paper explores the various factors that led to the sudden pot stoppages in pot operations, which significantly impacted metal production, and it gives details of the successful recovery. The incident provided a unique opportunity to perform extensive multiple pot autopsies, which in turn facilitated enhancements in cathode design, the assessment of diverse preheating techniques, and the examination of lining materials performance in addition to anode quality improvement.

Keywords: Potline crisis, Potline recovery, Amperage increase, Anode failures, Pot relining.

1. Introduction: Event of Operation Upset

Both Ma'aden potlines experienced an upset condition in November 2022 with exceptionally high anode incidents after receiving under-baked batches of anodes from carbon plant which led to an increase in potline instability and a deviation in potline indicators. A stepwise amperage reduction from 410 kA to 370 kA, and stopping 304 pots followed for both potlines to minimize the severity of the incident.

- Many pots with multiple anodic incidents, spikes and fallen blocks (Figures 1-2), put the potlines at risk of having open circuit if not removed on time.
- High number of pending unscheduled anodes, spikes and fallen blocks increased workload in equipment and manpower.
- Late work in potlines increased due to high number of anodic incidents removed.
- Number of critical pots with high silicon increased sharply in potlines with many pots with red shells and also a few pots tapped out from side shell due to high instability.

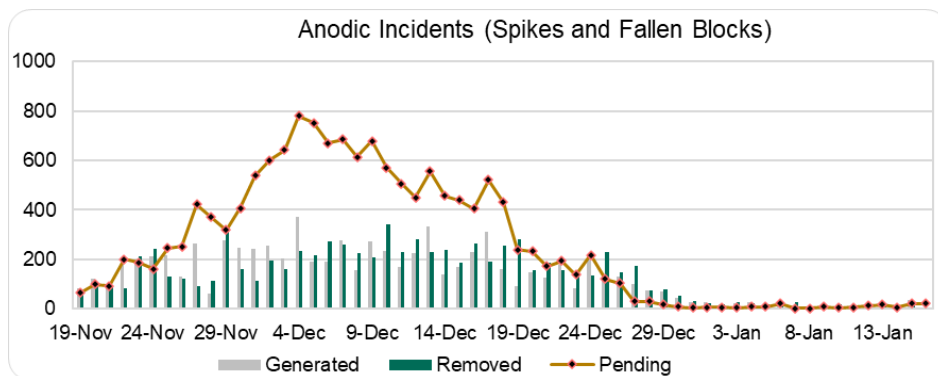


Figure 1: Trend of anodic incidents and fallen blocks.



Figure 2. Type of anodic incidents and fallen blocks.

2. Instability and Metal Purity

Pot instability increased from 45 nΩ to above 100 nΩ in mid-crisis, at the end December 2022 (Figure 3). When improvements in the potlines were made, and good anodes were supplied, the instability started to improve in January 2023.

- Pots tapped out with busbar damage. Planning of these depends on whether the potline has partially or totally failed.

The above information, displayed on a map of the potline assisted in determining the schedule for all recovery activities and for developing a drumbeat.

- **When developing the schedule and timeline consider logistical constraints in each room:**
 - Develop standards and procedures for in-situ cleaning.
 - Ma'aden Strategy: Pot cutout → In-situ cleaning → Start-up. On completion of all pots, we returned to repair those requiring busbar repair.
 - Work from end passages to central passage if cleaning is following pot cutout.
 - Preferably, pot cutout should be complete in the potroom where cleaning is in progress.
 - Congestion means delays.
- **Equipment availability:**
 - Do not assume each crane has the same ability.
 - Verify the capability of each crane, pot tending assembly (PTA), tapping metal assembly (TMA), construction crane.
 - Bobcat and mini excavators can be used in the pots for cleaning. Older models have less electronics and work better in the magnetic field.

11. Conclusions

In November 2022, a major crisis occurred in the potlines after receiving batches of underbaked anodes. These were produced due to the lack of maintenance of the burner ramp in the anode baking furnace, where the fuel injector was not supplying enough fuel for baking.

Remarkably, there was no power shutdown of the potline due to various preventative actions, taken to save the potlines, but 304 pots were cut out due to a series of anode collapses and anode fall-offs in addition to other operational challenges. During five months of continuous pot cleaning, inspections and relining, all affected pots were back into operation safely at zero lost time incident, and production targets were back to nearly normal.

During the crisis, the potline amperage was reduced from 410 kA to 370 kA and current efficiency dropped to monthly average of 79.3 % at the top of the crisis in December 2022. A large number of underbaked anodes were sent back for re-baking. Stopped pots younger than 1200 days were restarted after cathode cavity cleaning and repairs. The restoration of normal operation was successful, but the loss of metal production was significant, 3.5 % in 2022 and 12.4 % in 2023 of annual production of 805 kt.