

Operational Excellence in Rodding Plant - A Path to Control Sodium in Anode Butts

Mohammad AlShaibani¹ and Zobida Farzanah²

1. Manager - Process Control, Carbon and Port

2. General Superintendent - Process Control, Carbon and Port
Emirates Global Aluminium, Abu Dhabi, United Arab Emirates

Corresponding author: malshaibani@ega.ae

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Abstract

Carbon anodes are consumed in electrolysis cells during primary aluminium production. Carbon consumption in pre-baked anode cells is typically between 400 and 430 kg C/t Al and is affected by the CO₂ reactivity and air reactivity of anodes. The anode reactivities are affected by the properties of raw materials, the quality of the butt returned and the parameters of the manufacturing processes. In Al Taweelah Plant prior to 2019, sodium levels in butts were exceeding the normal levels of 800 ppm that had a significant impact on the entire manufacturing process from producing anodes to the multiple operational challenges in the potlines. This paper covers the successful journey Al Taweelah Carbon & Port rodding department to reduce Na in butts from over 800 ppm to a target of 250 ppm through strategic operational changes. The measures included adjustments to operational protocols, enhancements to the butts stripping process, introducing optical analyser, and clear process definitions. These steps have improved the quality and efficiency of the anode production process, setting a standard for future manufacturing processes.

Keywords: Lower sodium in anodes, Anode performance, Butt condition, Sodium impact, Potline process.

1. Introduction

Contaminants such as sodium in recycled anode butts can lead to operational challenges in the manufacturing process of prebaked anodes [1]. In 2019, at the Al Taweelah Plant rodding, one operation involved receiving butts from potlines for a multi-stage cleaning process. This process comprised an initial Hot Bath Removal Facility, followed by manual cleaning, and subsequently treatment in a Butt Shot Blasting Machine designed to remove residual fine bath layers from the top surface of the butts. As per operational quality standards, the cleaned butts were required to achieve a sodium (Na) content of 600 ppm or less. However, performance data from 2019 showed that, on average, 360 butts were processed per shift, with only 50 % meeting the specified Na content requirement. The remaining 50 % had elevated sodium levels, averaging 920 ppm, thus failing to comply with the acceptable limit (Figure 1). These findings indicate a substantial performance deficiency within the existing cleaning process and suggest the need for further evaluation of process parameters, equipment effectiveness, and operational controls to enhance cleaning efficiency and improve product quality outcomes.

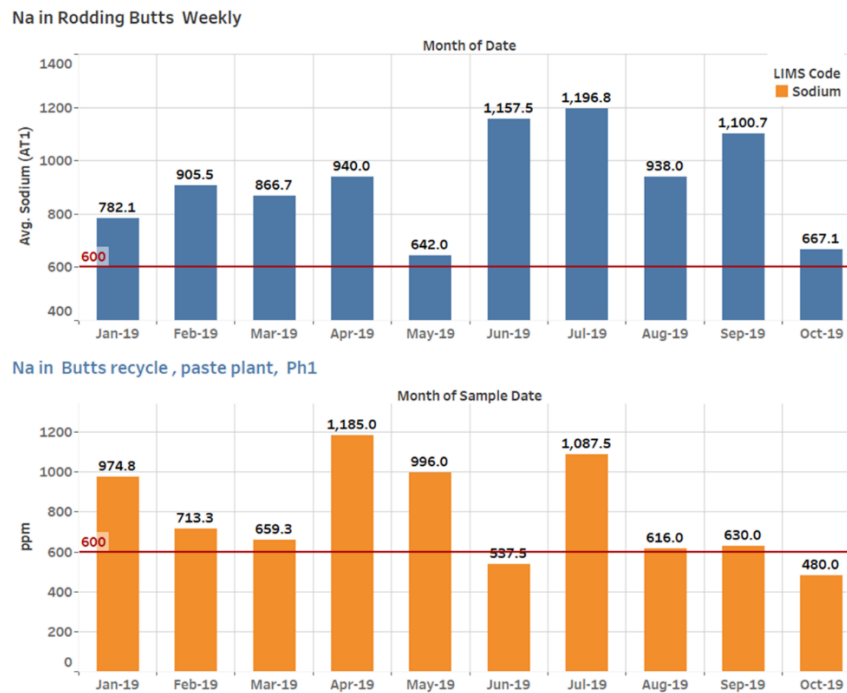


Figure 1. Sodium levels in recycled butts.

The images in Figure 2 illustrate the condition of the 50 % of butts that failed to meet quality standards despite undergoing cleaning process. These butts retained excessive bath residues, with sodium (Na) content exceeding the 600 ppm limit which indicate the inconsistencies in the current cleaning process and the need for operational improvements to enhance cleaning efficiency and product quality.



Figure 2. Images of butts with bath presence after cleaning.

2. Innovation Strategy

A cross-disciplinary team, comprising personnel from Operations, Process, Maintenance, and the Potline department, was assembled to investigate and identify the contributing factors to elevated sodium content and inadequate butt cleaning performance. As part of this root cause analysis, a Fishbone (Ishikawa) diagram was developed to systematically classify the potential causes, as shown in Figure 3.

The objective of this study was to enhance the cleaning efficiency by 80 % while reducing the manual cleaning process by 80 % and reduce the average Na content in cleaned butts from 920 ppm to 600 ppm (Figure 4). Through a structured root cause analysis, the primary contributing factors to elevated sodium levels were identified and categorised, as illustrated in the Fishbone (Ishikawa) diagram presented in Figure 3.

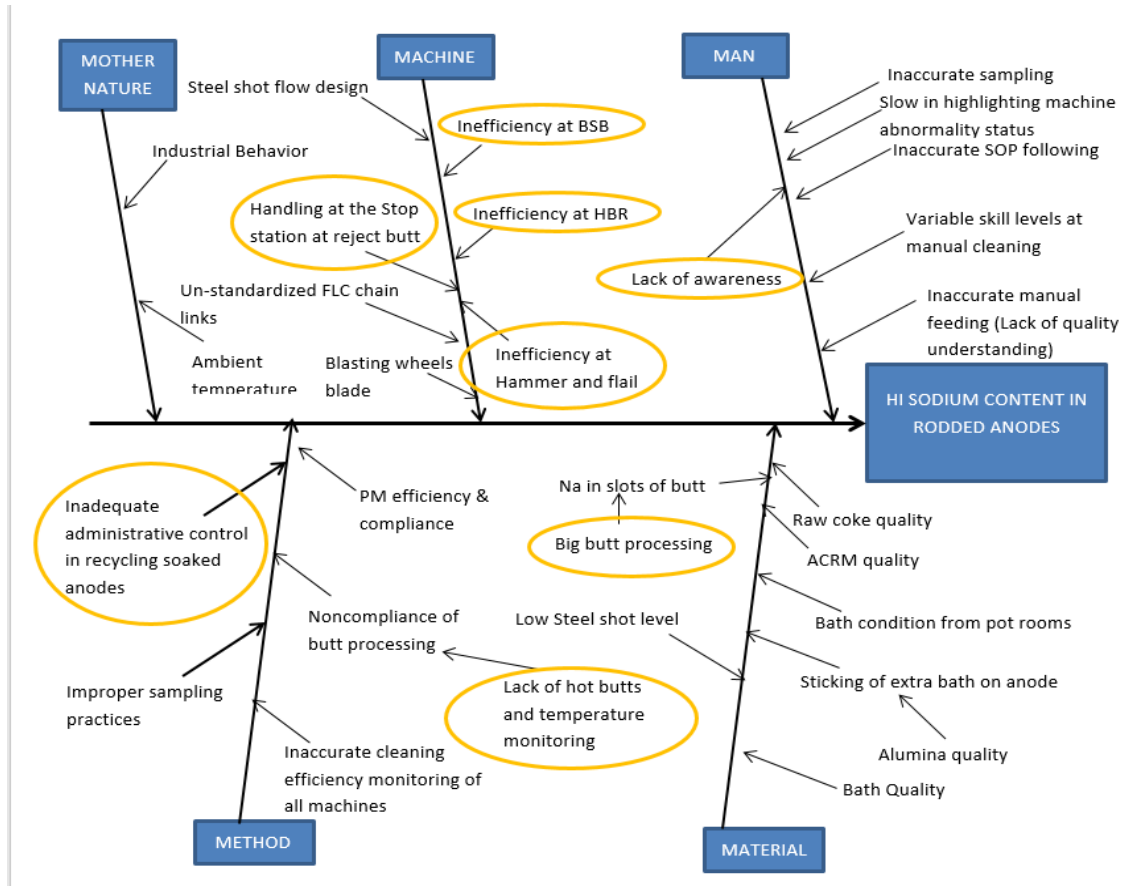


Figure 3. Fishbone diagram for root-cause analysis.

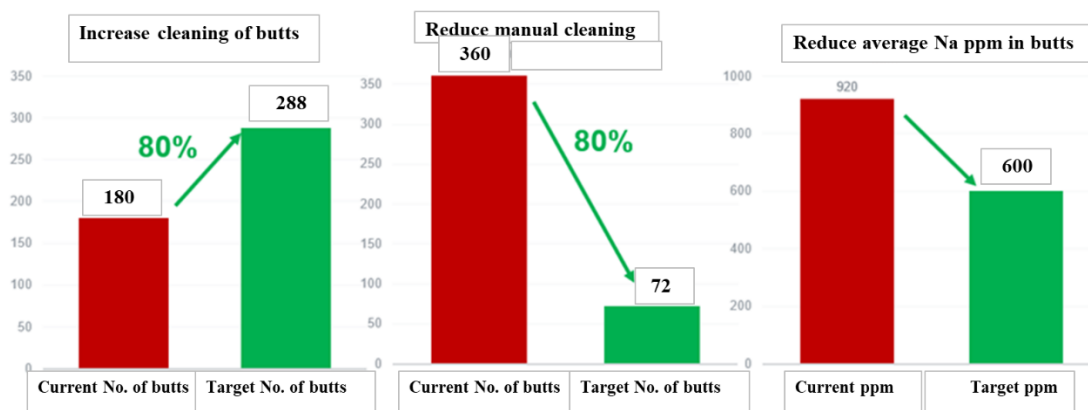


Figure 4. Objectives for butt cleaning.

3. Experiment 1

Prior to the primary cleaning stage at the Hot Bath Removal (HBR) facility, as shown in Figure 5, butts were inspected to assess their initial condition. The HBR process consists of three sequential cleaning steps: hammering, chain flailing, and air blowing. Observations revealed that significant bath residue remained adhered to the butt surfaces following this stage, as presented in Figure 6.

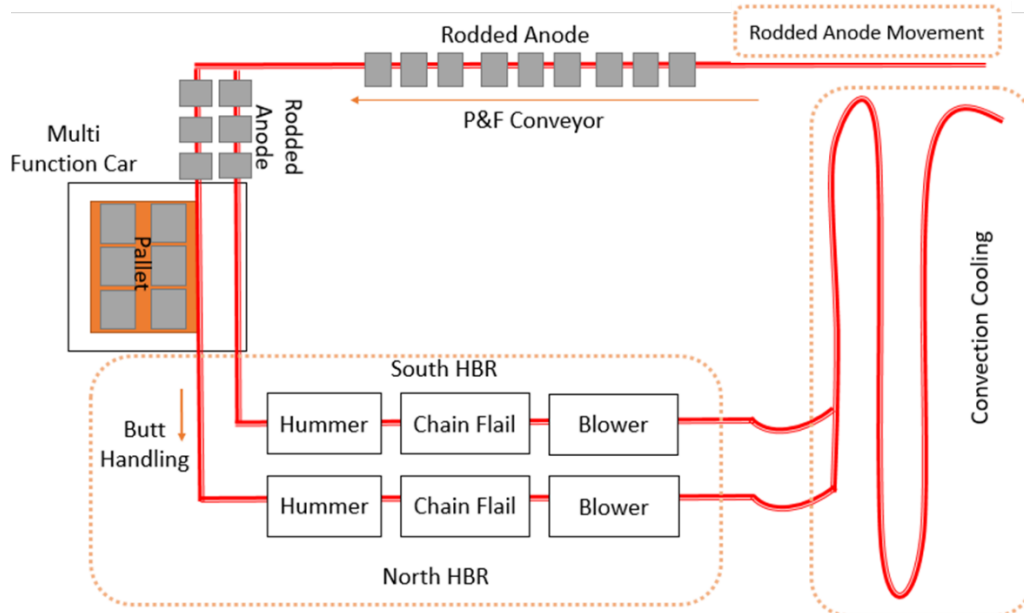
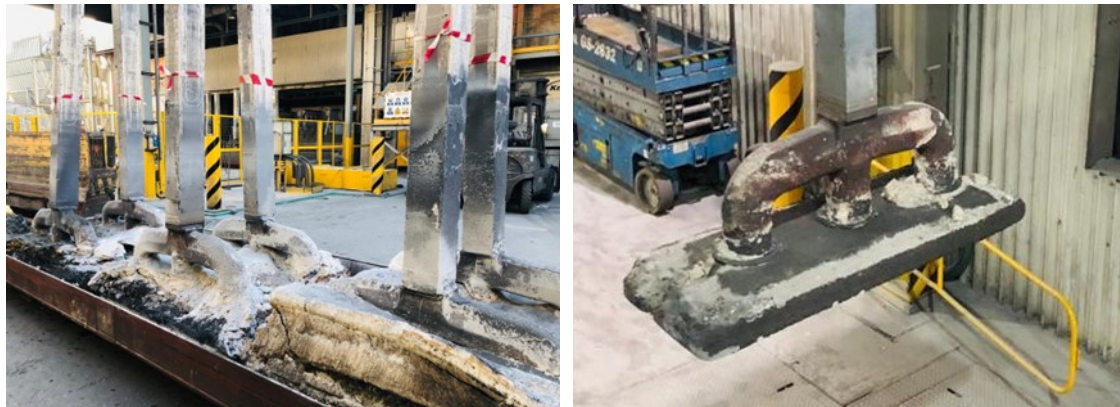


Figure 5. Hot Bath Removal (HBR) facility.



Butt condition before HBR

Butt condition after HBR

Figure 6. Butt condition before and after HBR.

The persistence of fine, thin bath residues on the butt surfaces at the exit of the HBR facility indicated that the chain flail process (Figure 7) may not have been functioning at optimal effectiveness. This observation necessitated a comprehensive assessment of the chain flail mechanical condition and operational performance. To validate this hypothesis, an experimental trial was conducted in which a butt was fully coated with paint and processed through the HBR system. This method allowed for the identification of areas where the chain flails failed to make effective contact with the butt surface. The results confirmed that certain surface regions remained untouched, and it was determined that increasing the chain link length was required to improve coverage and enhance the overall cleaning efficiency as presented in Figure 8.

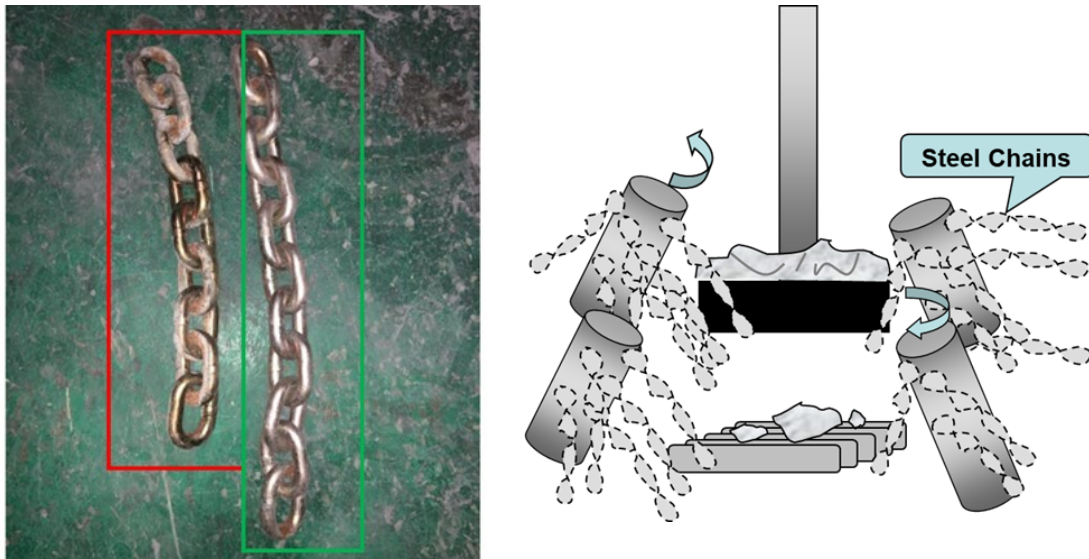


Figure 7. Chain flail process.

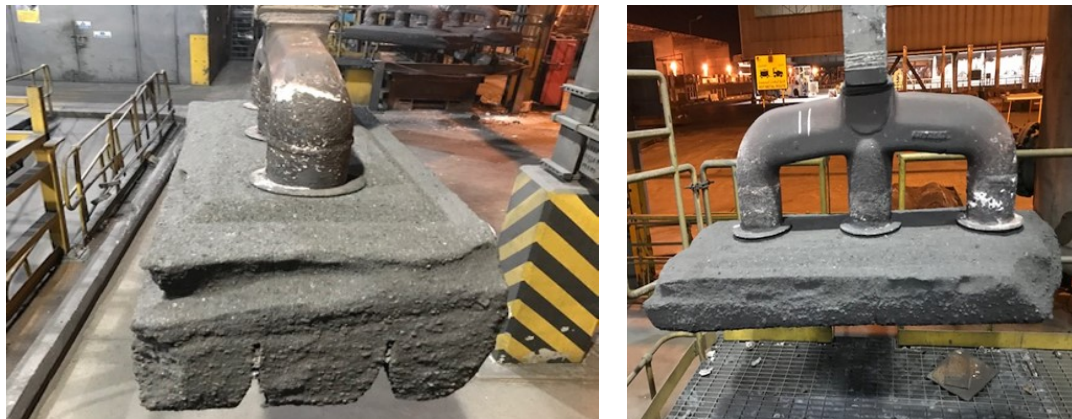


Figure 8. Butt condition after chain flail modification.

4. Experiment 2

After achieving improvements in the efficiency of the primary cleaning stage, the quality of butt cleaning in the secondary cleaning process was systematically monitored. This secondary process involves the use of high-velocity steel shot blasting, where steel shots are propelled forcefully onto the surface of the butt from multiple directions. The objective is to ensure the complete removal of any residual fine and thin layers of bath material adhering to the surface. Following the blasting phase, an air blower system positioned at the exit stage of the process ensures that the butt surfaces are entirely free from any remaining bath particles. This operation is referred to as the *Butt Shot Blasting Process*, Figure 9.



Figure 9. Butt shot blasting process.

4.1 Results and Observations

During the monitoring of the Butt Shot Blasting Process, several operational issues were identified:

- As the level of steel shots in the hopper decreased, the system lacked an automatic alarm mechanism to alert the shopfloor team. This oversight resulted in suboptimal blasting performance and poor butt surface cleaning at the machine's exit stage.
- It was also observed that, during operation, some of the six blasting wheels were not consistently operating under the required load, further affecting cleaning effectiveness.
- Additionally, a fine layer of bath dust continued to adhere to the butt surfaces even after passing through the blower stage.

4.2 Corrective Actions

To address these issues and improve process performance, the following corrective measures were implemented:

1. A **steel shot low-level alarm interlock** was integrated into the system. This interlock notifies the shopfloor team when the hopper level falls below the defined minimum threshold (refer to Figure 10).
2. The **indexer cycle time** was increased from 45 seconds to 53 seconds per cycle to enhance the cleaning exposure and effectiveness (refer to Figure 11).
3. **Additional air blowing nozzles** were installed within the exit chamber of the Butt Shot Blasting Machine to improve the removal of residual bath dust from the butt surfaces (refer to Figure 12).

These modifications were aimed at stabilising process performance and ensuring consistent butt surface quality at the completion of the secondary cleaning stage (refer to Figure 13).

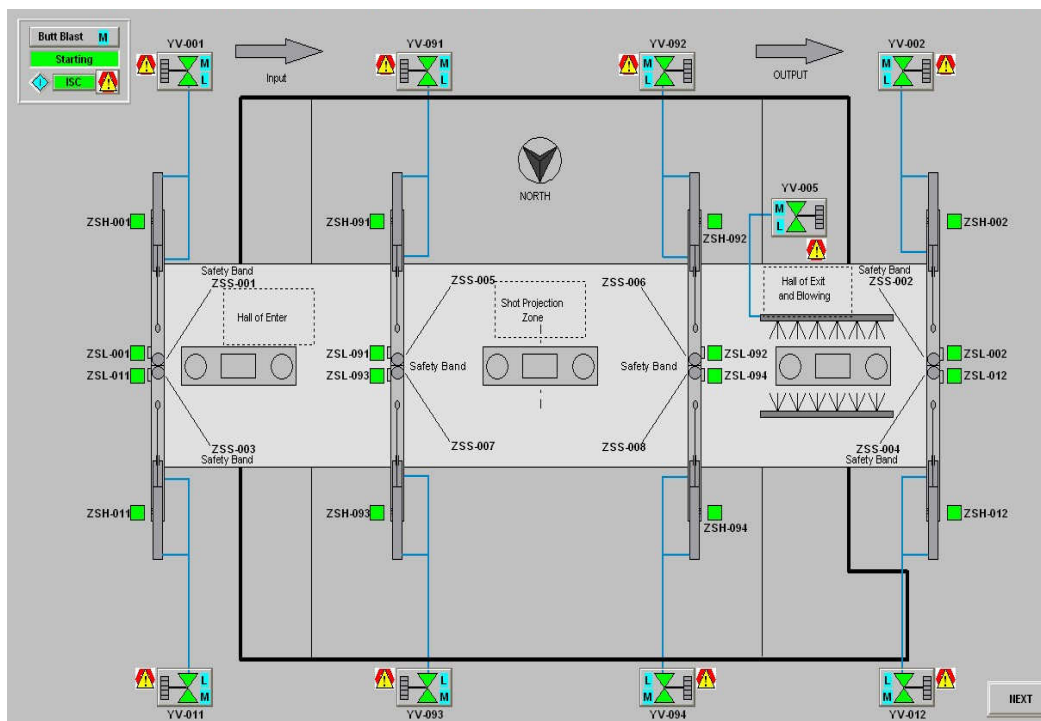


Figure 10. A steel-shot low-level alarm interlock was integrated into the system.



Figure 11. The indexer cycle time was increased.



Figure 12. Additional air-blowing nozzles for removal of residuals.



Before



After

Figure 13. Removing of residuals by additional air-blowing nozzles.

5. Awareness Strategy

To support the implemented modifications and ensure the sustained improvement of butt cleaning quality, an educational awareness initiative was introduced for the shopfloor team. This initiative aimed to reinforce the importance of process discipline and the critical relationship between butt cleaning quality and the overall anode quality and performance. The following actions were undertaken:

1. **Classroom Refresher Awareness Sessions:** Structured training sessions were conducted to educate shopfloor personnel on the expected standards of butt cleaning quality at each stage of the cleaning process. These sessions emphasised the direct impact of cleaning quality on anode performance and process efficiency.
2. **One-Point Lessons (OPL):** A concise, visual one-point lesson outlining the key learnings and expectations from the improved Butt Shot Blasting Process was developed and displayed prominently within the shopfloor area. This served as a continuous reference tool for operational staff to reinforce awareness and process adherence during routine activities.

These awareness strategies were designed to institutionalise knowledge retention, encourage proactive process monitoring, and promote a culture of quality ownership among the operational workforces.

6. Sustaining Improvements

To sustain these improvements, updated operating standards and continuous shop floor awareness have been embedded into daily practices. Since 2019, close monitoring has ensured sodium levels in the butts remain consistently below 600 ppm, supporting ongoing optimisation of the anode butt cleaning process. Success metrics of this development are shown in Figure 14.

After applying the experimental practices, a steady reduction in sodium (Na) levels was recorded, as shown in Figure 15. These actions successfully lowered the sodium content in the anodes, improving process and product quality. The experience gained during this work also helped the team better understand how sodium contamination occurs and how to manage it in the future.

To support this improvement, an online chemical analyser was installed to continuously measure sodium levels. This tool makes sure that only broken butts with low sodium content are sent to the paste plant, helping to keep the process stable and the product consistent. Overall, this study showed the value of regular monitoring and specific process changes in maintaining good anode performance by ensuring the Na in baked anode is improved and maintained as low as possible < 250 ppm as it is shown in Figure 16. which contributed to a significant reduction in CO₂ reactivity and better anode performance [1, 2].

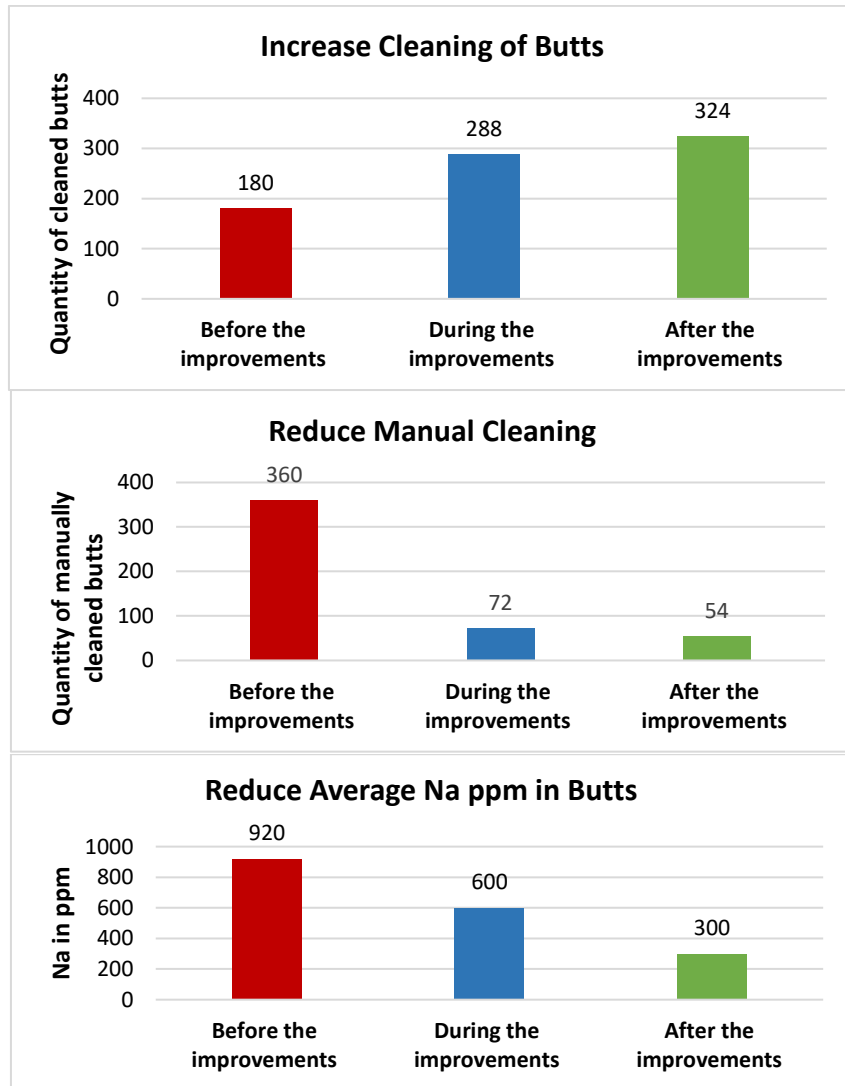


Figure 14. Metrics of success of the improvements.

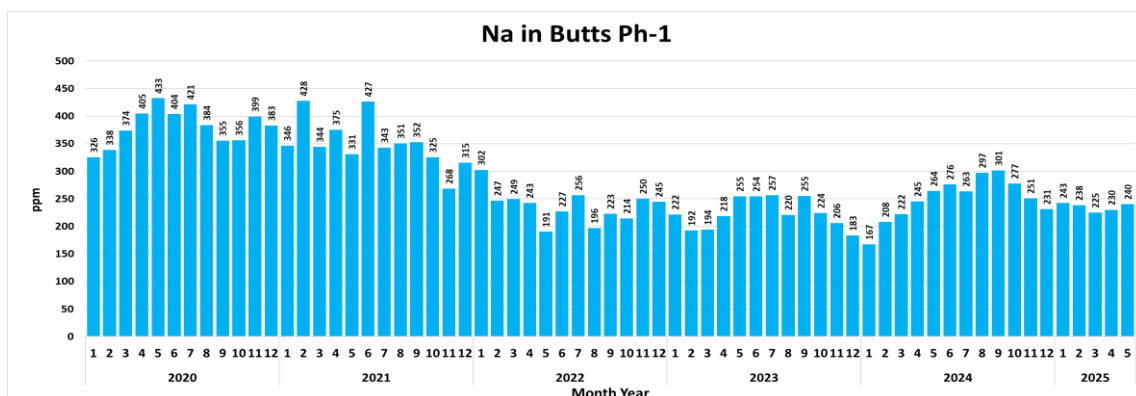


Figure 15. Reduction in Na levels in butts.

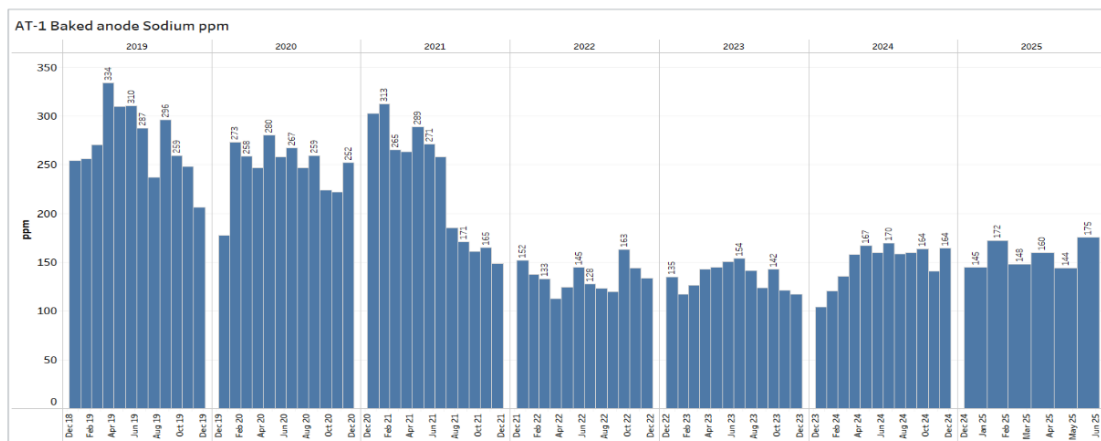


Figure 16. Reduction in Na levels in Baked Anodes

7. Conclusions

The butt cleaning performance enhancement project at Al Taweelah Rodding Plant-1 surpassed its original target of 80 % improvement. Through a combination of process changes, equipment upgrades, and heightened operator awareness, the initiative achieved an 85 % reduction in residual sodium content lowering it from 920 ppm to 300 ppm and reduced manual butt cleaning efforts by 85 %, boosting automated cleaning efficiency to 90 %.

This success reflects a data-driven, collaborative effort between the operation, process and maintenance teams, resulting in measurable, sustainable gains in both quality and productivity. The project exceeded expectations and set new benchmarks for operational performance.

To sustain these improvements, updated operating standards and continuous shop floor awareness have been embedded into daily practices. Since 2019, close monitoring has ensured sodium levels in the butts remain consistently below 600 ppm, supporting ongoing optimisation of the anode butt cleaning process.

8. References

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