Enhancing Operational Visibility in Anode Baking Furnace at Emirates Global Aluminium

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Abstract

A critical need for enhanced data visibility and communication has been identified in the dynamic environment of carbon operations within the aluminium industry. The current state of operations is characterised by challenges, such as delayed data access and the potential for data-entry errors. Gap analysis revealed opportunities for technological advancement to bridge these operational inefficiencies.

The future state is envisioned as a digitally empowered workspace, where seamless communication and real-time data are the norm. To achieve this, an innovative mobile application called the "Carbon Mobility" Project was initiated. This app enables operators and managers to interact with operational data and live plant status, offering a user-friendly interface based on Web technology that makes the invisible visible.

The key implementation steps of the Carbon Mobility app include optimising the packing and unpacking processes, and integrating a firing alert system. The monitoring module of the app facilitates proactive field observations aligned with the process KPIs, enabling immediate corrective actions and efficient maintenance planning. The app is accessible anywhere, fostering a culture of prompt responses to deviations and catalysing continuous improvement. These steps are part of a comprehensive strategy to enhance the operational visibility and efficiency of the anode baking furnace (ABF).

Keywords: Carbon operations in aluminium smelter, Anode baking furnace, Operational inefficiencies, Digital technologies, Carbon Mobility app.

1. Introduction

In the aluminium industry, efficient carbon operations are essential yet often hindered by outdated processes prone to delays and errors. This paper examines the integration of digital technologies at EGA, highlighting a significant shift towards improving these operations. Central to this shift was the "Carbon Mobility" project, which introduced a mobile application designed to enhance data visibility and streamline communication within operational frameworks.

This application provides real-time access to operational data and plant status, thereby bridging the gap between floor operators and management. Web-based technologies offer a straightforward interface that minimises common data entry errors and operational delays, which are significant obstacles in traditional carbon management processes.

This document outlines EGA's steps to digitally enhance its carbon operations, focusing on the challenges encountered and the solutions adopted [1,2]. It critically assesses the areas within operations in which digital tools have led to notable improvements in efficiency and operational responsiveness. The move towards a digital working environment is presented not merely as a technological upgrade but as part of a broader cultural shift towards ongoing improvement and proactive management of operational deviations.

As the discussion unfolds, we will explore the specific functionalities of the "Carbon Mobility" application and their impact on EGA’s operations. This introduction provides the groundwork for a detailed exploration of digital transformation in an industry that is increasingly seeking to innovate and improve its processes.

2. Previous State of Operations

The operational issues that arise in a carbon plant are significantly influenced by manual entries, availability of personnel for operational tasks, and synchronisation of data exchange between the Programmable Logic Controller (PLC) signal and various sensors situated around the smelter to identify faults. The SCADA (Supervisory Control And Data Acquisition) platform, which serves as the primary visualisation and monitoring platform for the status of the plant, facilitates the verification of the implemented correction measures. This process is characterised by intricate sequences of actions and a reliance on coordination and communication among multiple parties, which places a significant burden on the operators and the operational process. Additionally, it necessitates a high level of information sharing and responsiveness as well as a lack of long-term historical records.

The entire journey is taken from identifying defects to rectifying them by analysing the operational process steps. One can highlight the bottlenecks and define them through gap analysis to identify overall improvement opportunities for the operations process. For instance:

- Reducing the delay in informing and attending to issues of the section because the Control Room Operator (CRO) is busy attending to other matters.
- Reducing the number of follow-ups and tasks for the CRO and supervisor, as they are often busy conducting specific tasks such as communication links and follow-up details.
- Provide accurate records of section history, particularly field actions conducted by operators, in a standardised database.
- Linking the gaps in anode quality investigation due to missing information, such as the actions taken in the field, their sequence, and the number of actions.
- Inaccurate tracking of baked anode production furnace-wise with rejection details, including the section, pit, and layer from which they originated
- Disparity between the written Shift Report and executed action caused by human error during data transfer.
- Maintenance is slow to fix equipment problems and repeated alerts.
- Providing the operation and general maintenance team with digitalised current equipment history (including repeated alarms and implemented actions) (coordination).
- Effective management of multiple types of anodes requires precise inventory management; however, this is not currently maintained. This results in production planning complications and unreliable manual counting of anodes.
- Keeping manual records is inefficient and unreliable (Figure 1).

Figure 1. Baking furnace logbook.

3. Future State and Vision

The production of carbon anodes in the aluminium industry is an expanding sector that necessitates the adoption of digital technology to enhance efficiency and accuracy. The introduction of a live visual/audio data entry, alarm, and monitoring module system (app) for field observations, process KPIs, maintenance actions, tasks, and planning is crucial in this regard. This system, which is based on web technology and accessible to all actors of anode quality performance at any location, provides real-time data and interactions, including operator actions and field inputs.

The app is a carbon module with several features, such as real-time interaction between the shareholder CRO, operator, maintenance, supervisor, superintendent, and process engineer; real-time evaluations by the shareholder; on-spot review actions by maintenance for specific equipment; prioritised equipment for shutdown based on the frequency of alarms; real-time data analysis; and digitalised reporting. In addition, the system offers an automated monitoring system for individual operator performance and an accurate inventory of all types of anodes through standardised anode stacks in all storage systems.

Figures 2–3 show an overview screen for anode packing and unpacking. Figures 4–5 show graphs and numerical details of ABF packing and unpacking status by date.

These figures provide an overview of the essential aspects of controlling baking furnaces, various types of anodes, logistics, and inventory. Figures 2–3 depict the initial stage of anode baking, in which the packing plan is digitised, and real-time crane operator entries are made by selecting pre-defined packing stage information based on the baking cycle. This information includes details such as section, layer, crane number, packing stage, and anode type, particularly mix-section packing. After completing the firing cycle, this information is reflected on the unpacking screen, recording all unpacking stages.

A live, automated illustration supports supervisors in managing any disruptions to anode quality, inventory, or packing plans through real-time dashboard monitoring, as depicted in Figures 4–5. Each level of detail provided by the dashboard is crucial for a supervisor to stay informed about the status of individual baking sections, aligned with the specific processed anode type inventory in all kilns, and crane operator performance, particularly in the event of anode quality investigations or fire delay.

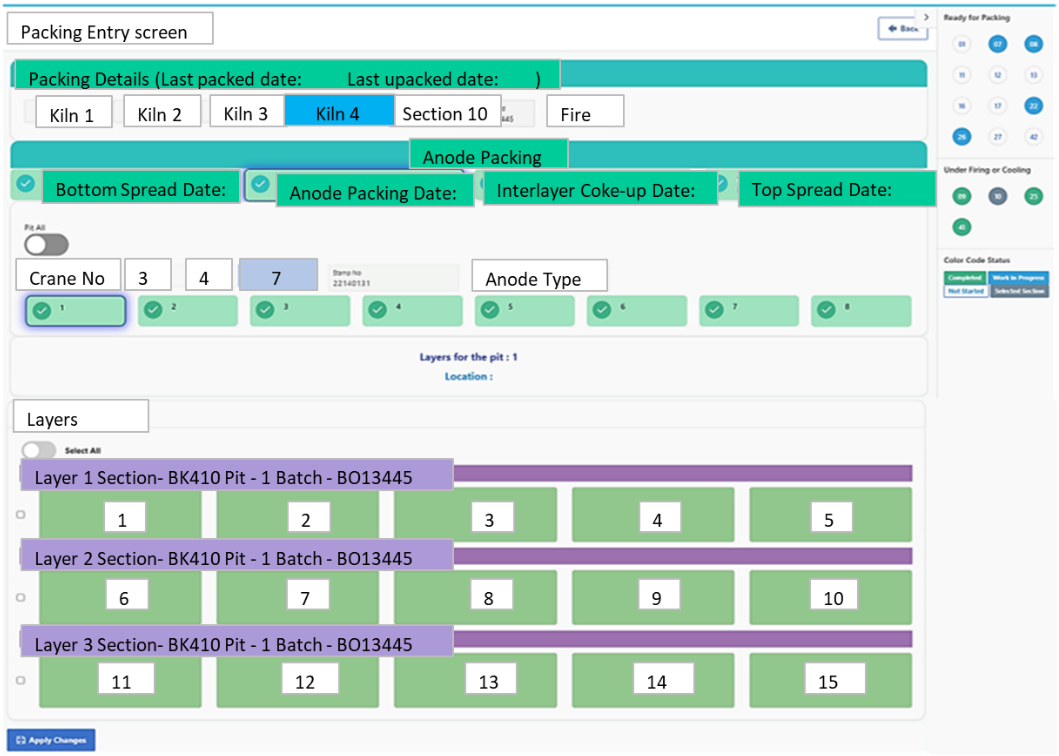

Figure 2. Crane operators Section Packing entry screen.

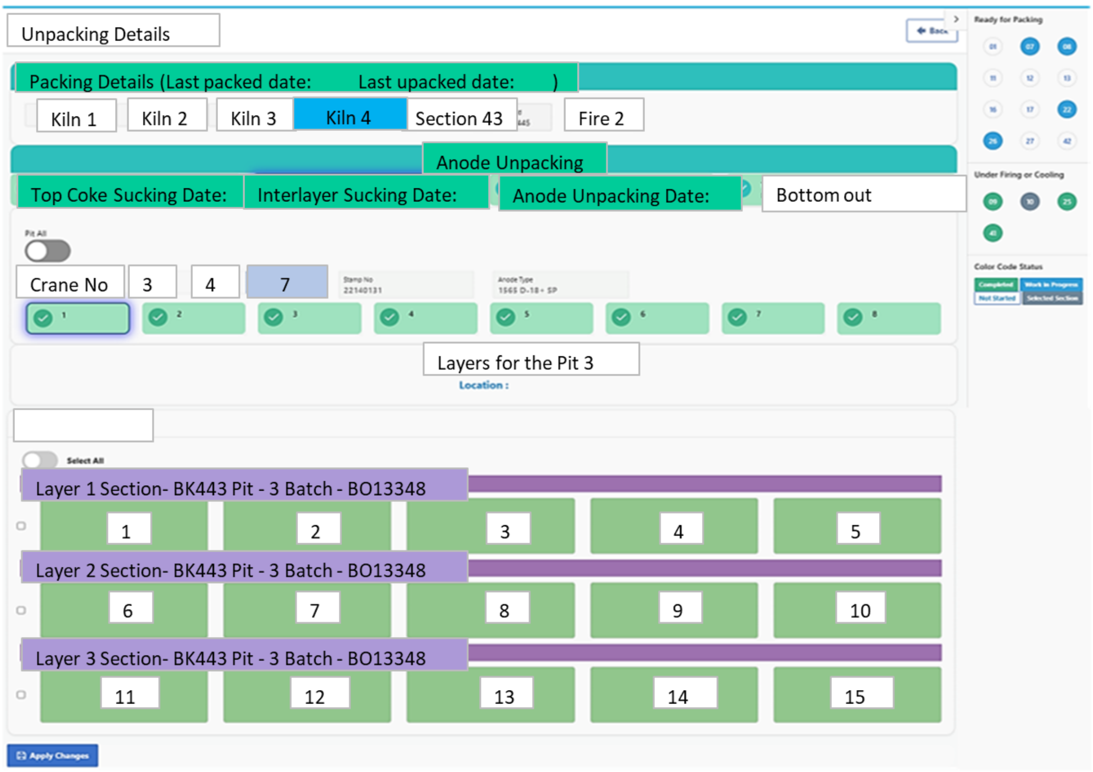

Figure 3. Crane operators Section Unpacking entry screen.

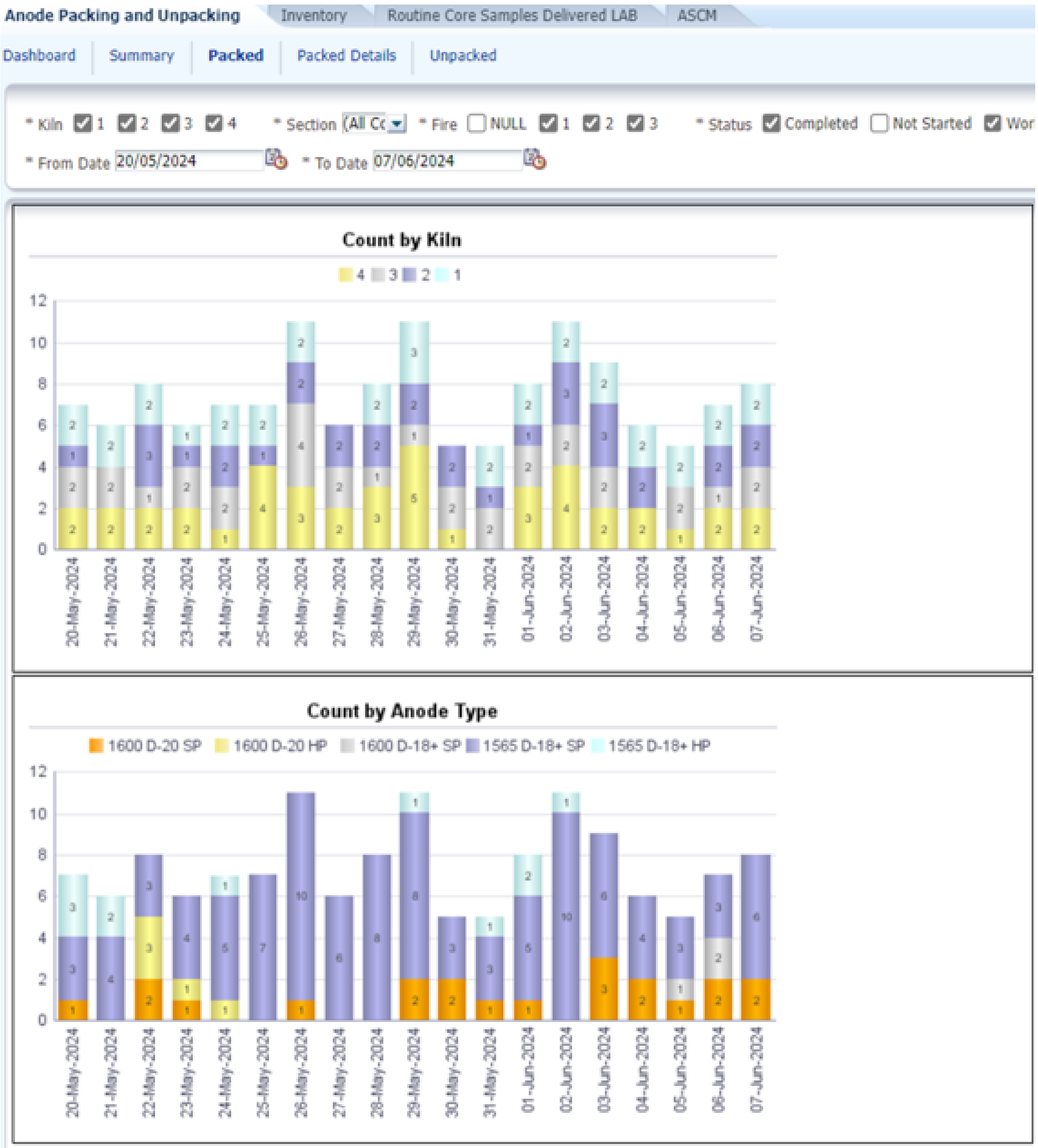

Figure 4a. Anode types inventory with section packing and section process details. Count by kiln and anode type.

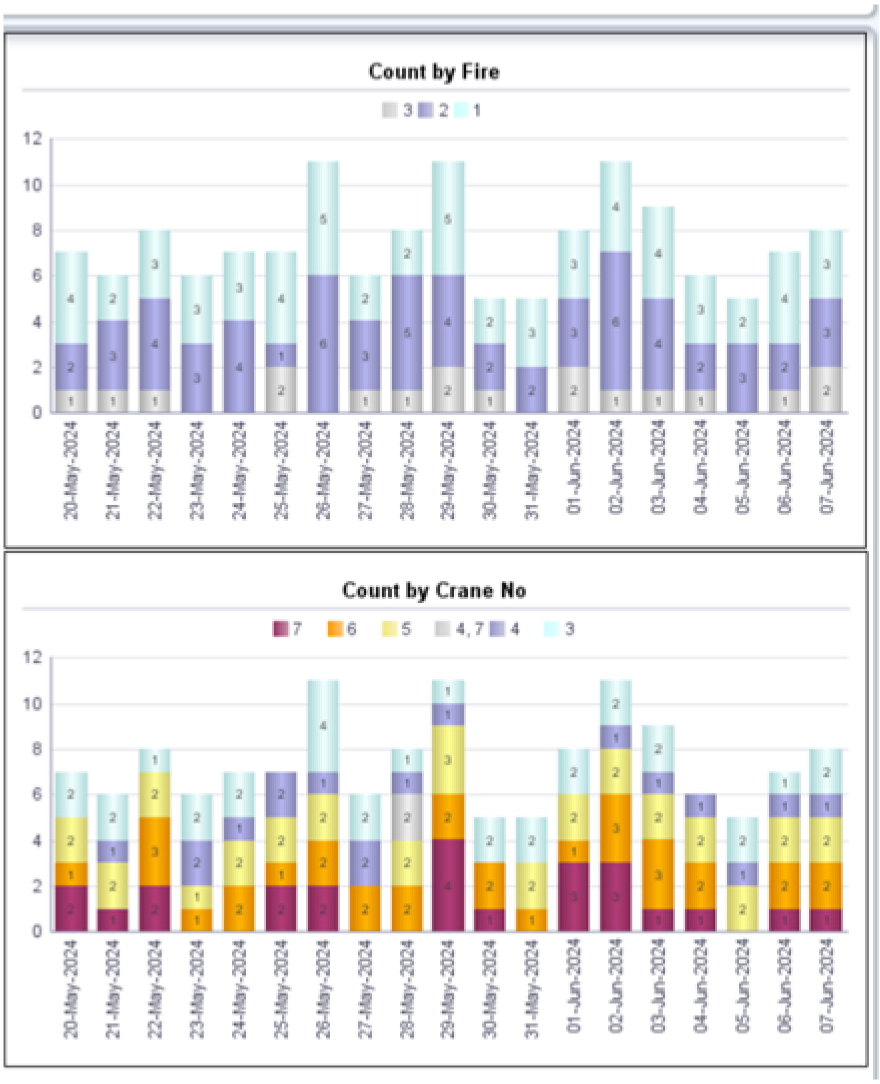

Figure 4b. Anode types inventory with section packing and section process details. Count by fire and crane number.

Packed Details Report

Start Date	Kiln	Section	Fire	Stamp No	Anode Type	Batch ID	Crane No	Quantity	Captured By	Bottom Spread Status	Anode Packing Status	Interlayer Coke Up Status	Top Spread Status	Status	Packed Date
22-May-2024	2	26	2	12041492	1600 D-20 SP	B013285	6	126	DUB09024	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	22-May-2024
22-May-2024	2	27	2	12141512	1600 D-20 HP	B013272	6	126	DUB13698	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	22-May-2024
22-May-2024	3	2	2	11841913	1565 D-18+ SP	B013286	3	120	DUB12460	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	22-May-2024
22-May-2024	4	8	1	21840800	1565 D-18+ SP	B013291	7	120	DUB04757	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	22-May-2024
22-May-2024	4	24	3	21841232	1565 D-18+ SP	B013292	7	120	DUB04757	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	22-May-2024
23-May-2024	1	14	2	12141717	1600 D-20 HP	B013299	5	126	DUB13977	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	23-May-2024
23-May-2024	2	12	1	12042129	1600 D-20 SP	B013300	6	126	DUB08553	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	23-May-2024
23-May-2024	3	3	2	22142424	1565 D-18+ SP	B013296	3	120	DUB12460	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	23-May-2024
23-May-2024	3	20	1	22142485	1565 D-18+ SP	B013295	3	120	DUB12460	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	23-May-2024
23-May-2024	4	9	1	22142380	1565 D-18+ SP	B013297	4	120	DUB12431	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	23-May-2024
23-May-2024	4	41	2	22142549	1565 D-18+ SP	B013294	4	120	DUB14935	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	23-May-2024
24-May-2024	1	15	2	12143187	1565 D-18+ SP	B013304	5	126	DUB16084	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024
24-May-2024	1	30	1	12141142	1600 D-20 HP	B013301	5	126	DUB09021	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024
24-May-2024	2	13	1	22143414	1565 D-18+ SP	B013302	6	126	DUB09021	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024
24-May-2024	2	29	2	22143729	1565 D-18+ SP	B013306	6	126	DUB13698	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024
24-May-2024	3	4	2	22143166	1565 D-18+ SP	B013305	3	120	DUB10094	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024
24-May-2024	3	21	1	12143683	1565 D-18+ SP	B013308	3	120	DUB10094	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024
24-May-2024	4	42	2	21942789	1565 D-18+ HP	B013303	4	120	DUB08936	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	24-May-2024

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Figure 4c. Anode types inventory with section packing and section process details.

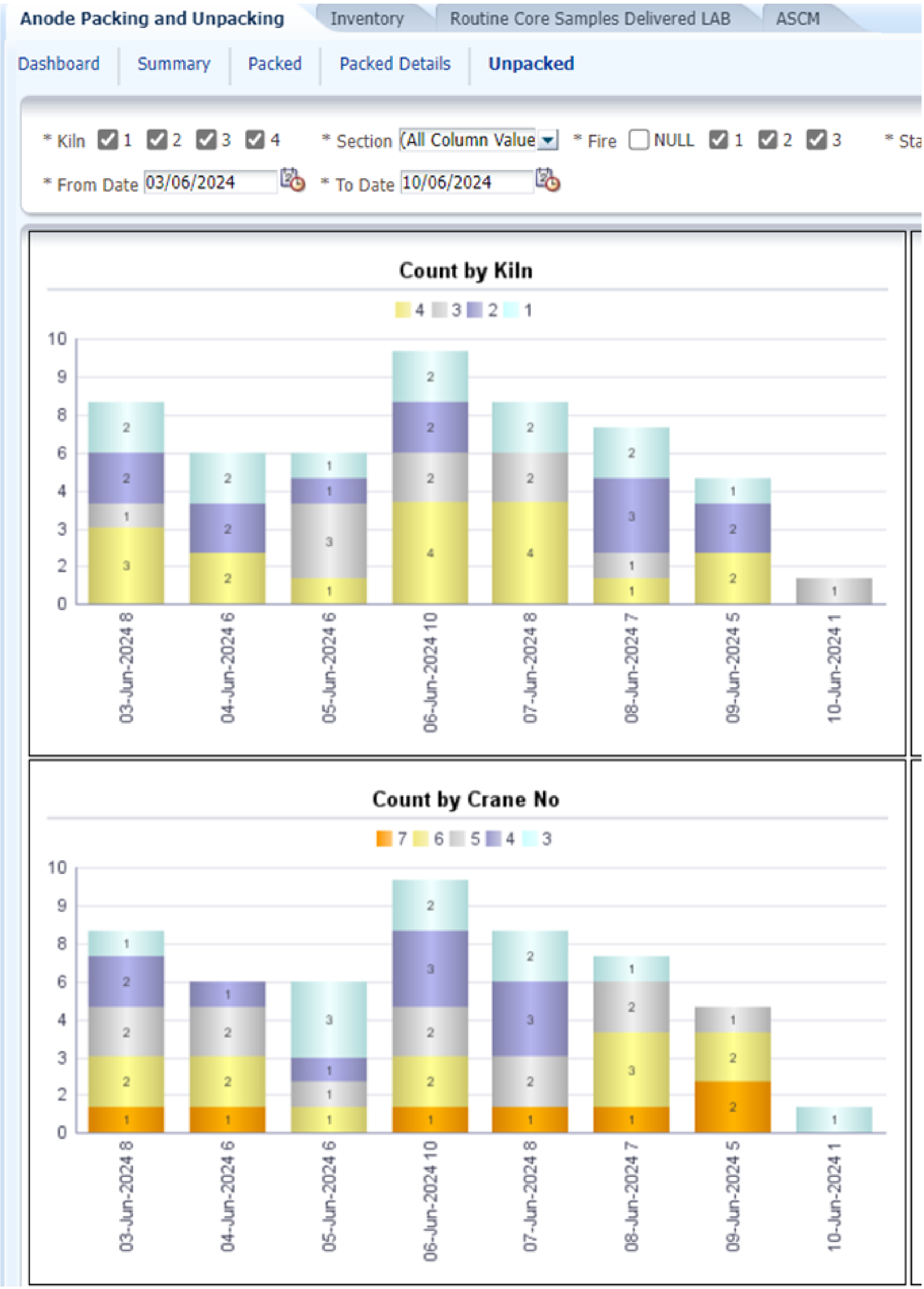


Figure 5a. Anode Types Inventory with Section Unpacking details. Graph of count by kiln and crane.

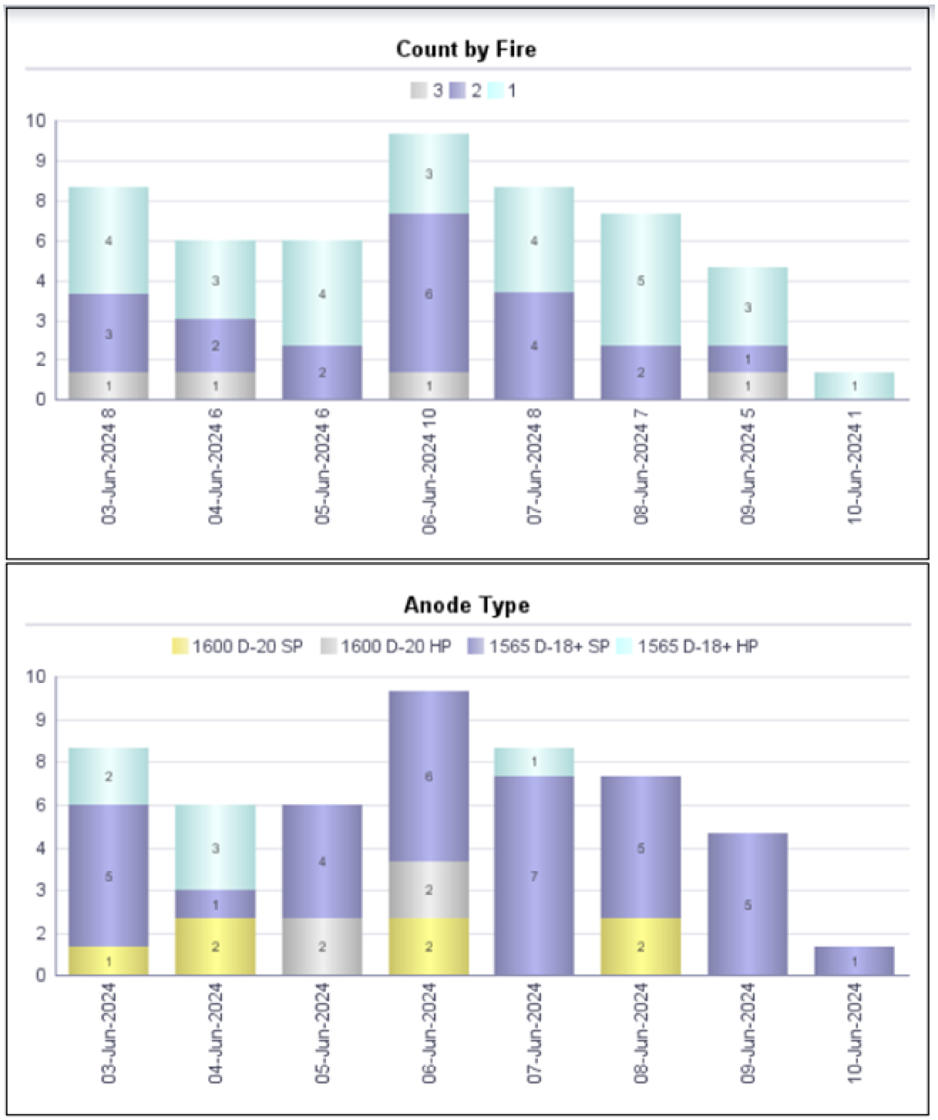


Figure 5b. Anode Types Inventory with Section Unpacking details. Count by fire and anode type.

Unpacked Details Report

Date	Kiln	Section No	Fire	Batch Id	Crane No	Anode Type	Anode Code	Captured By	Top Coke Sucking	Interlayer Coke Sucking	Anode Unpacking Status	Bottom Out Status	Status	Unpacked Date
03-Jun-2024	1	11	2	B013271	5	1565 D-18+ HP	HB	DUB14520	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	1	27	1	B013276	5	1565 D-18+ HP	HB	DUB04757	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	2	7	1	B013247	6	1565 D-18+ SP	B	DUB08553	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	2	9	1	B013263	6	1600 D-20 SP	D	DUB08553	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	3	31	2	B013252	3	1565 D-18+ SP	B	DUB14913	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	4	6	1	B013261	4	1565 D-18+ SP	B	DUB12551	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	4	22	3	B013274	7	1565 D-18+ SP	B	DUB12431	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
03-Jun-2024	4	37	2	B013245	4	1565 D-18+ SP	B	DUB12551	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	03-Jun-2024
04-Jun-2024	1	12	2	B013279	5	1565 D-18+ HP	HB	DUB14520	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	04-Jun-2024
04-Jun-2024	1	28	1	B013275	5	1565 D-18+ HP	HB	DUB14520	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	04-Jun-2024
04-Jun-2024	2	10	1	B013277	6	1600 D-20 SP	D	DUB10094	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	04-Jun-2024
04-Jun-2024	2	26	2	B013285	6	1600 D-20 SP	D	DUB08553	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	04-Jun-2024
04-Jun-2024	4	7	1	B013267	4	1565 D-18+ HP	HB	DUB15529	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	04-Jun-2024
04-Jun-2024	4	23	3	B013281	7	1565 D-18+ SP	B	DUB12431	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	04-Jun-2024
05-Jun-2024	1	29	1	B013293	5	1600 D-20 HP	HT	DUB09021	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	05-Jun-2024
05-Jun-2024	2	27	2	B013272	6	1600 D-20 HP	HT	DUB09024	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	05-Jun-2024
05-Jun-2024	3	1	2	B013280	3	1565 D-18+ SP	B	DUB10094	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	05-Jun-2024
05-Jun-2024	3	16	1	B013265	3	1565 D-18+ SP	B	DUB10094	✔ Completed	✔ Completed	✔ Completed	✔ Completed	✔ Completed	05-Jun-2024

Figure 5c. Anode Types Inventory with Section Unpacking details report.

4. Implementation Stages

Embarking on our digital platform development, we traversed various stages, initiating three use cases with distinct attributes and competencies, addressing diverse field concepts, and exploring digital entries and automated analytical dimensions. The three use cases are described as follows:

A. Digitalization System for Anode Inspection

Baked anodes are examined after the anode slot-cutting machine in the ABF process and before the rodding stage. This inspection requires a physical assessment of the visible sides of the anodes, except for the bottom surface and one long side, which cannot be inspected because a standing platform is absent on the opposite side.

Several challenges are associated with the current inspection process, including the manual recording of data on paper, which is then transferred to an Excel spreadsheet for analysis, leading to a high incidence of human errors and inaccurate data. Additionally, there is a delay in summarising anode defect analysis and data collection into a single database in the event of an investigation into anode defects. These challenges are being closed by leveraging digital process automation, one of the ten digital capabilities identified by EGA [1].

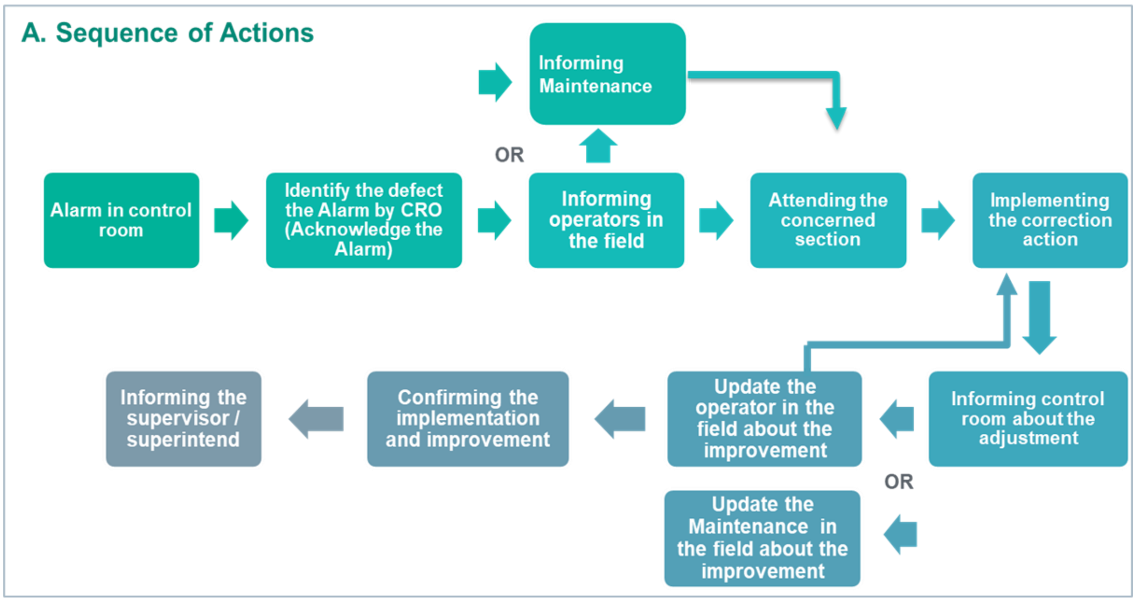
B. Baked Anode Production and Inventory Planning

Five distinct types of anodes were produced in the baking furnace. We manage the packing and unpacking processes of these anodes and their inventories to ensure a continuous supply to the potroom. The operation currently utilises multiple databases and manual field data entry Excel sheets to update each kiln production, each anode-type inventory, and the packing and unpacking plan daily, which takes approximately three hours per day. This amounts to a total of 15–20 hours per week. On the basis of these inputs, multiple analyses were performed to update the overall weekly plan.

Transitioning to a digital platform using the developed visualisation application can help us achieve on-the-spot accuracy and update data regarding kiln production (live data for packing and unpacking), frequent inventory updates for each anode type, and daily proposed packing plans for each kiln based on field live entries. In addition, this system can provide accurate information on the quality of the packing and unpacking processes in each kiln, related to specific shifts (actual records). We focused on individual production from each furnace with more rejection details, monitoring, and individual operator production. Overall, this system has supported the maintenance of a healthy anode inventory of various types by streamlining production planning and providing accurate month-end production figures by maintaining a high-standard anode storage.

C. Improved Operational Efficiency and Stakeholder Communication through Digital Integration

As illustrated in the Figure 6 diagram, a substantial amount of time-sensitive information was manually exchanged between the stakeholders before the implementation of this app. The primary stakeholders involved were the CRO, field operator, supervisor/superintendent, process engineer, and maintenance. As described in Table 1, both sequences of actions and people have been improved.



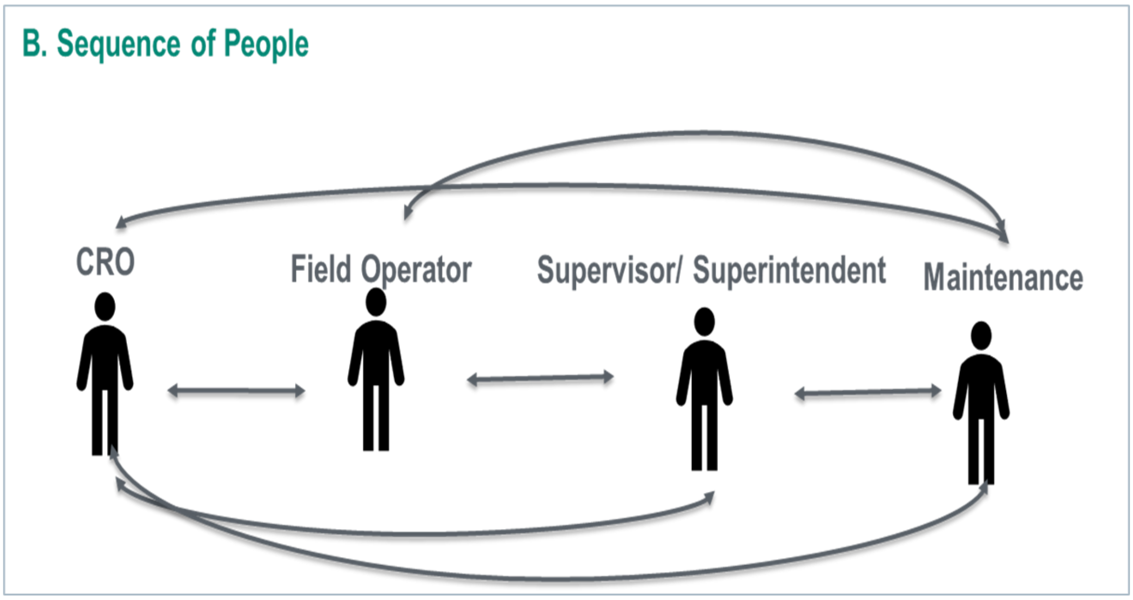


Figure 6. Manual exchange process of time-sensitive information before the implementation of the app.

We have implemented the developed application, which has significantly reduced the number of information exchange interfaces between stakeholders. In addition, we have created a digital user interface that automatically sends alerts to appropriate personnel. This interface allows stakeholders to easily monitor progress and actions taken, provide instantaneous feedback, and review past actions.

Table 1. Workflow improvement.

Aspect	Previous Workflow	Improved Workflow
Sequence of Actions (Figure A)	• Alarm in control room. • CRO identifies and acknowledges alarm. • Information communicated to maintenance or field operators. • Attending the concerned section. • Implementing corrective actions. • Updates provided to stakeholders. • Confirmation of implementation and improvements reported back to supervisor.	• Alarm in control room. • Automated alert sent to appropriate personnel. • Real-time monitoring of actions. • Immediate updates to stakeholders. • Confirmation and feedback mechanisms integrated.
Sequence of People (Figure B)	• CRO initiates the process • Field Operators receive information and act. • Supervisors/Superintendents oversee and ensure compliance. • Maintenance addresses technical issues	• CRO initiates the process. • Automated alerts facilitate quick response. • Supervisors monitor real-time updates. • Maintenance receives precise information for quick action.
Communication Flow	Manual and complex information exchange among CRO, field operators, supervisors, and maintenance personnel, leading to potential delays and inefficiencies.	Streamlined communication via a digital interface, reducing manual exchanges, improving response times, and enhancing operational efficiency.

5. Operational Enhancements

The application seamlessly integrates with existing SCADA and PLC systems to enhance data accuracy and availability. Features such as inventory management modules have improved task approaches and completion.

6. Way Forward

Expanding on our current successes, the next phase will focus on increasing the app's usage across similar process units to ensure a unified digital experience throughout the plant. Integrating with other information systems will further enhance operational synergy and data utilization to drive decisions as EGA's digital ambition is implemented and advanced technologies become available [1, 3, 4].

7. References

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