AL15 - Smart Cranes at Emirates Global Aluminium

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Abstract

This paper explains the journey of transforming existing cranes to Smart Cranes in one of EGA's potlines. This in-house development has improved Reduction's operational and crane maintenance performance. Smart Cranes enable the tracking real-time crane locations from the Supervisor control room. The system is equipped to monitor crane activities and compliance to Standard Operating Procedure (SOP) with alerts and voice alarms through EGA's Pot Control System. Work completion status against schedule is updated in real-time dashboards to assist better shift planning and achieve planned jobs on time.

Smart Cranes have improved the quality of jobs and resulted in lower rework, such as anode position adjustment and anode setting quality related to anode problems. They contribute to improved shift performance as all data is directly fed into the Performance Management System (PMS) of the potline. The system is programmed to estimate the life cycle of crane tools and equipment and triggers alarms at given threshold limits to enable prompt changeover. This improves crane availability and increases the mean time between repairs (MTBR). The system can evaluate its own budget for a given year, based on the inbuilt predictive analysis tool. This paper is a synopsis of the Smart Cranes project, which can be used by smelters and crane manufacturers worldwide.

Keywords: Smart potlines, Smart cranes, Crane maintenance, Standard operating procedure.

1. Introduction

Emirates Global Aluminium is the world's largest 'premium aluminium' producer and the biggest industrial company in the United Arab Emirates outside oil and gas, producing 2.653 million tonnes of aluminum in 2022. The company operates a bauxite mine, an alumina refinery and two aluminium smelters. In the two aluminium smelters, located at Jebel Ali and Al Taweelah, EGA operates seven cell technologies, developed inhouse since 1990, given in Table 1.

Table 1. EGA smelting technology and installed production capacity.

Smelter and Location	Technology	No of Cells	Production Capacity
Jebel Ali, Dubai	CD20, D20, D18+, D20+, DX, DX+ Ultra	1576	1.1 Mt/y
Al Taweelah, Abu Dhabi	DX, DX+, DX+ Ultra	1262	1.5 Mt/y

Aluminium electrolysis is carried out in cells connected in series to form a potline. The work practice in potlines is repetitive on cell-to-cell basis and shift-to-shift basis. Each shift crew follows the same jobs patterns. Potroom cranes, also called pot tending machines (PTMs) are used for many operations, such as anode change, anode covering with anode cover recycled material (ACRM), metal and bath tapping, etc.

The Smart Cranes project was undertaken with the goal of achieving 100% SOP compliance for scheduled operational activities, and to improve the process. Any deviation in the scheduled activity and its SOP is recorded and shared with the team to improve compliance. Process improvement enhances operational stability, contributing to better KPI performance, such as current efficiency (CE) and lower anode problems.

The Smart Cranes system provides visibility of crane activities in real time to supervisors, and any deviation from the planned activity and its practice is flagged in the Smelter Analytics iPOTs screen, which is continuously monitored by the shift supervisor. The Smart Cranes manufacturing execution system (MES) provides information on work progress through the Power BI report to the shift supervisor, and monitors the corrective actions on unstable and abnormal cells, so that he or she can do better shift planning. The system is designed to highlight non-compliant activities with alerts and voice alarms for corrective action. Individuals can check and analyse shift performance at any given point of time for year to date (YTD) and month to date (MTD), and this is recorded in the Performance Management System to evaluate team performance.

2. Background of Smart Cranes and the Reasons for Developing the Application

Artificial intelligence (AI) and Industry 4.0 creates opportunities for improved performance across manufacturing. The Smart Cranes project was one of many projects to harness the power of AI and Industry 4.0 at EGA. The five main drivers for the trial were:

- The required data is already available in multiple locations on our system.
- The team had the capability to migrate this data to a single location for analysis and programming.
- Data has the potential to be processed into valuable insights that could be beneficial for the operations and maintenance.
- The infrastructure needed for the entire project could be installed in a reasonable time.
- The infrastructure would be able to combine all the operational activities of a potline and crane maintenance as well, so that all the aspects can be studied and maximum benefits extracted.

A cross-functional team was formed for the Smart Cranes project with clearly defined scope and timelines. Figure 1 shows the structure and scope of each part of the team.

Smart Cranes	**Potline Operations & Process Control**	Generating the use case
		Participating in logic building
		Testing the logic and sharing feedback
		Iteration cycles: sharing feedback from work area to further improve the system
	Area Crane Maintenance	Understanding the use case story from the Potline team
		Selecting the system to handle temperature, humidity, and accuracy of the results.
		Installing and verifying the high-speed wireless system
		Selecting mechanism to pinpoint exact locations
		Transfer of data from the location to the IT System
		Selecting and installing camera backups for verification and cross checking
	IT Department	Understanding the use case story from Potline team
		Developing and testing the logic
		Selecting medium for generating dashboard reports
		Synchronising deviation in the SOP to be flagged in iPots
		Creating a dashboard with capability to update the work completion at any given time of a shift
		Generating MES reports for shift performance

Figure 1. Cross-functional team and scope.

3. Smart Cranes Infrastructure

Smart Cranes have been installed in model potline cranes, and equipped with low maintenance radio-frequency identification (RFID) sensors, and programmed PLCs that transfer data through latest-in-class Wi-Fi technology to MES system for further data quality check and analysis. Then the data is sent to Smart Cranes dashboard and Pot Control System as shown in Figures 2 and 2a.

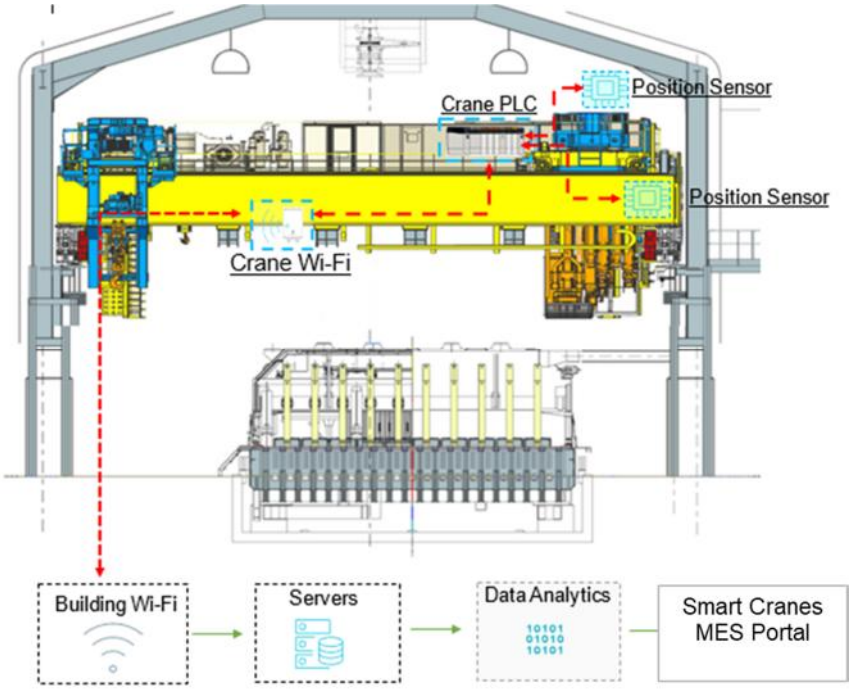


Figure 2. Data flow from a crane to dashboards using Wi-Fi technology.

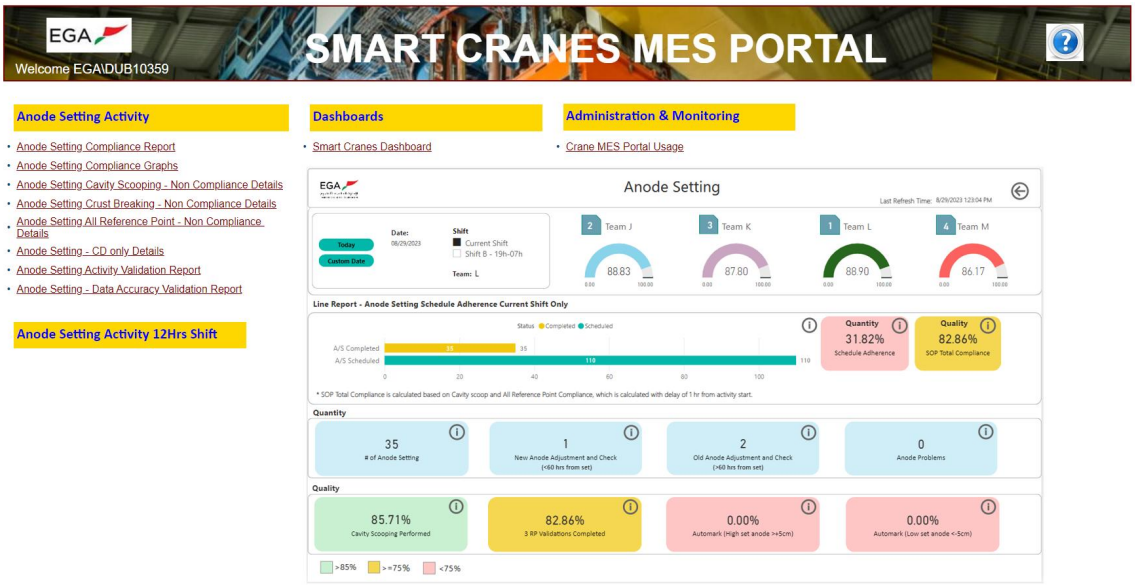


Figure 2a. Smart Cranes MES portal.

The MES system acquires data from multiple sources including crane PLC, SCADA, Pot Control System and reduction plant management system. Initial data quality check filters the data before analysis. Later the data is processed stage-wise to get the detailed dashboard which will cover the full cycle (Figure 3).

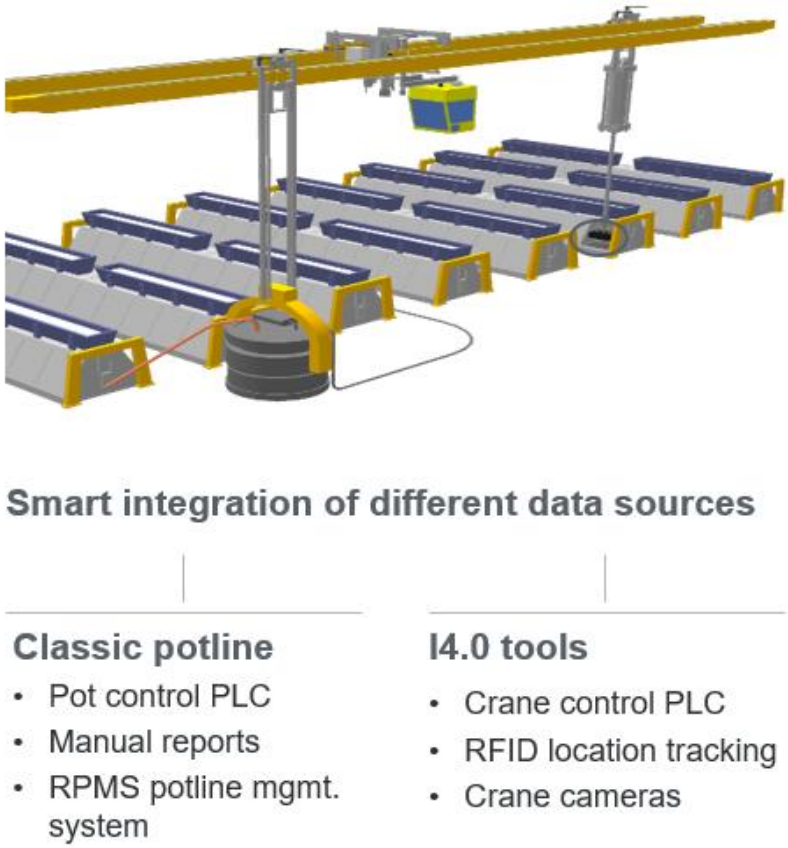


Figure 3. Data integration from different sources.

4. Smart Activity Monitoring

Smart Cranes have the capability to identify the cell and stall location simultaneously with crane activity in real time. Each crane is linked with the operator's ID to track the performance of individual team members (Figure 4).

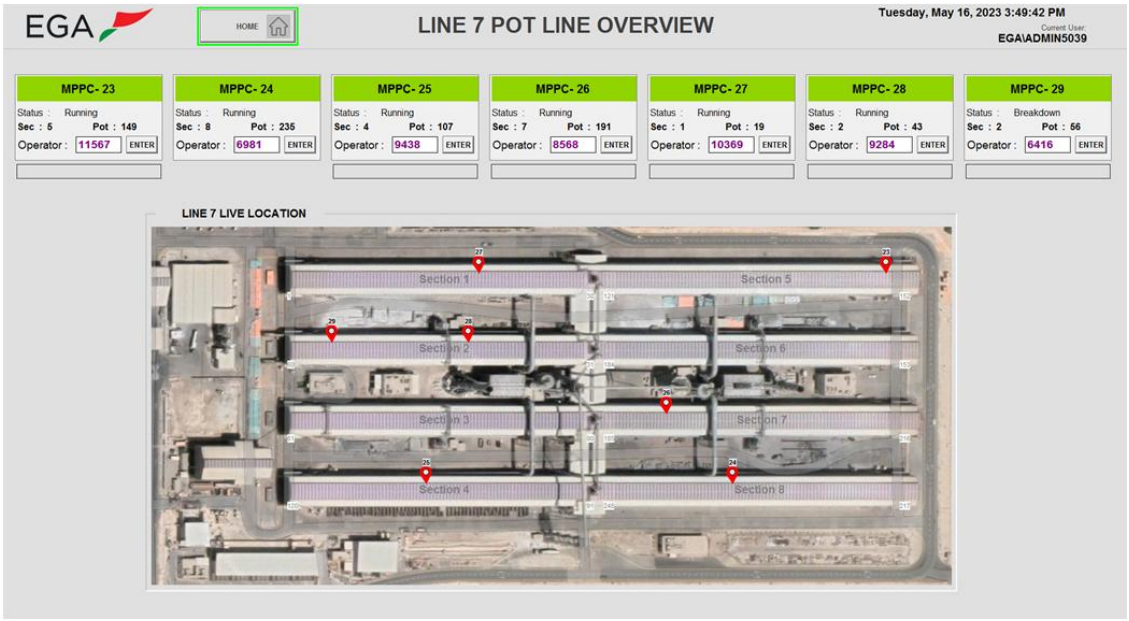


Figure 4. SCADA for crane live location with operator ID details.

Each crane is equipped with multiple angle live-video cameras. All crane activities can be monitored from the potline supervisors' office (Figure 5).

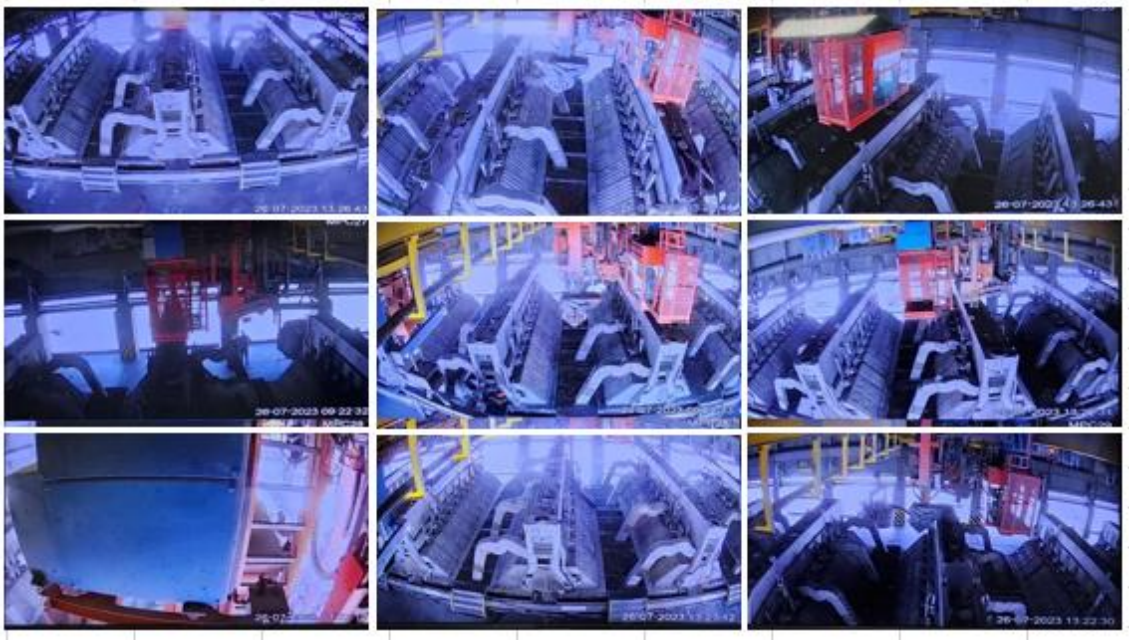


Figure 5. Live video stream of crane activities in supervisors' office.

5. Smart Cranes for Anode Setting

Anode setting is one of the most critical activities in aluminium electrolysis cells. The first phase of the Smart Cranes project was fully focused on anode setting.

The EGA model potline selected for the smart crane trial is D20 technology, and consists of 248 electrolysis cells operating at an amperage of 270 kA. The potline's annual metal production is 185 kt. Each cell has 20 anodes, shown in Figure 6, which are consumed in 22 days. Figure 6 shows anode changing pattern.

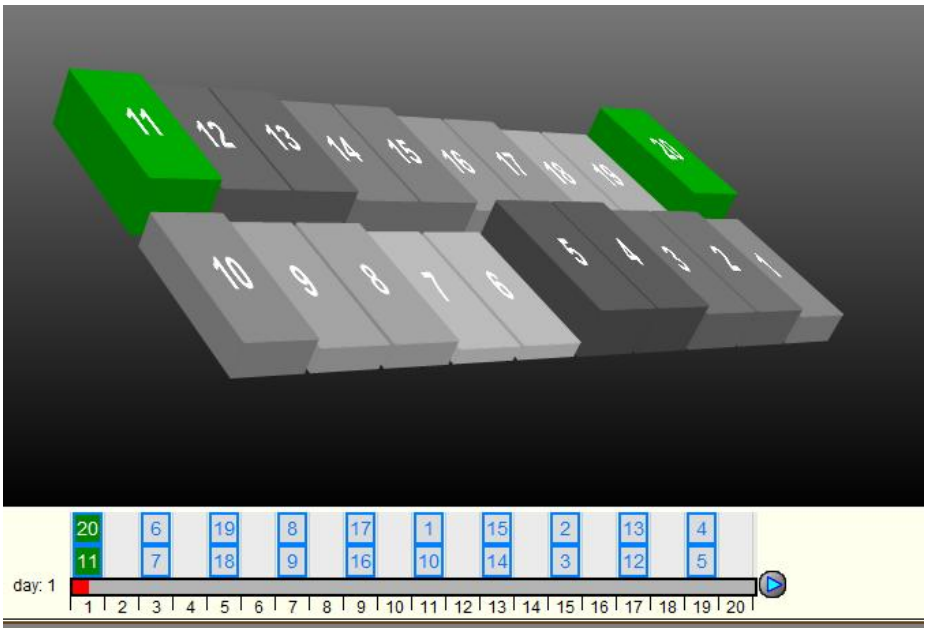


Figure 6. Anode setting pattern of D20 cells.

5.1 Scheduled Activity Compliance

A detailed algorithm compares scheduled activity with actual work completion to evaluate compliance, and to ensure that the work completed in a shift per cell number and corresponding anode stall numbers is as defined in the shift schedule. Simultaneously, unscheduled activity related to anode setting, such as anode position adjustment and anode problem removal are also tracked and a detailed report is updated in live dashboard display in the supervisors' office.

5.2 SOP Compliance

Scheduled anode setting Standard Operating Procedure (SOP) non-compliance is a key driver of anode problems, cell stability and current efficiency. Tracking SOP compliance as per the defined sequence of activities is based on spot checks. Individual anode setting activity is verified with the actual PLC data of crane tools usage and its time stamp from the start to end against the in-built programmed anode setting activity sequence with detailed procedure. Any missing sequence identified is highlighted with details in the Pot Control System with a red icon and at the same time a voice announcement is triggered in the potline and the supervisors' office.

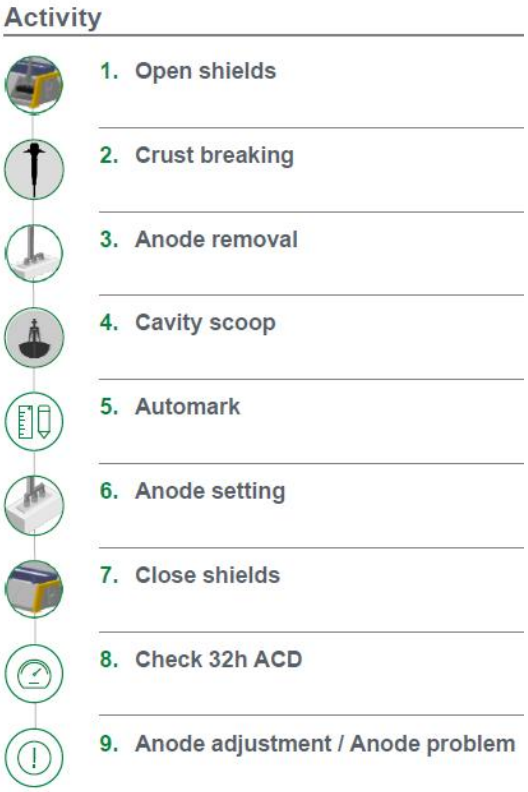
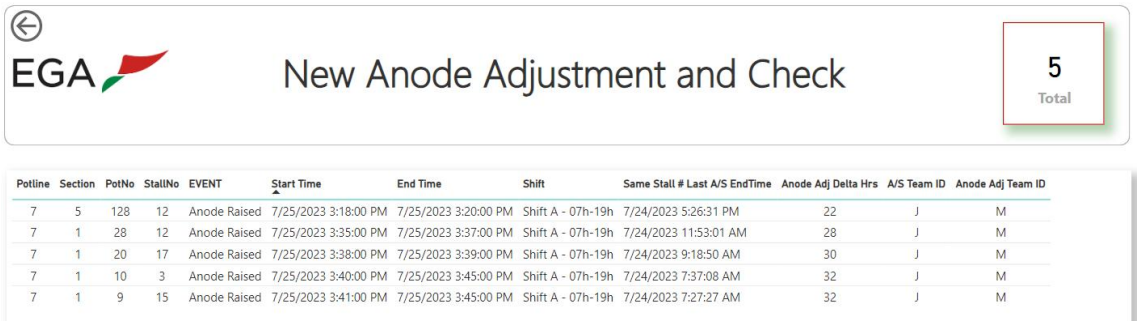


Figure 7. Sequence of anode setting activity.

5.3 Process Improvement

We use the anode setting quality data to track correlations with cell stability disturbance after this activity, to enable finetuning of process parameter setting and process improvement. Anode current distribution measurement and its related anode adjustments after new anode setting, are also linked with quality of setting to enhance the teamwork quality and to reduce the rework. Smart Cranes provide the history of any anode problem from the day it is set until the current date; this helps to investigate and identify the root causes of problems.



Potline	Section	PotNo	StallNo	EVENT	Start Time	End Time	Shift	Same Stall # Last A/S EndTime	Anode Adj Delta Hrs	A/S Team ID	Anode Adj Team ID
7	5	128	12	Anode Raised	7/25/2023 3:18:00 PM	7/25/2023 3:20:00 PM	Shift A - 07h-19h	7/24/2023 5:26:31 PM	22	J	M
7	1	28	12	Anode Raised	7/25/2023 3:35:00 PM	7/25/2023 3:37:00 PM	Shift A - 07h-19h	7/24/2023 11:53:01 AM	28	J	M
7	1	20	17	Anode Raised	7/25/2023 3:38:00 PM	7/25/2023 3:39:00 PM	Shift A - 07h-19h	7/24/2023 9:18:50 AM	30	J	M
7	1	10	3	Anode Raised	7/25/2023 3:40:00 PM	7/25/2023 3:45:00 PM	Shift A - 07h-19h	7/24/2023 7:37:08 AM	32	J	M
7	1	9	15	Anode Raised	7/25/2023 3:41:00 PM	7/25/2023 3:45:00 PM	Shift A - 07h-19h	7/24/2023 7:27:27 AM	32	J	M

Figure 8. New anode adjustment tracking.

6. Smart Cranes Dashboard

The anode setting module dashboard provides the insight on work completion percentage of the current shift. Adherence of completed anode setting activity to the schedule is cross checked. The break-down of scheduled and unscheduled activity can also be viewed in real time with the details of the time of anode setting and by which team as well as anode adjustment or anode problem.

We can view the ranking of the team's performance in dashboard based on inbuilt evaluation criteria.

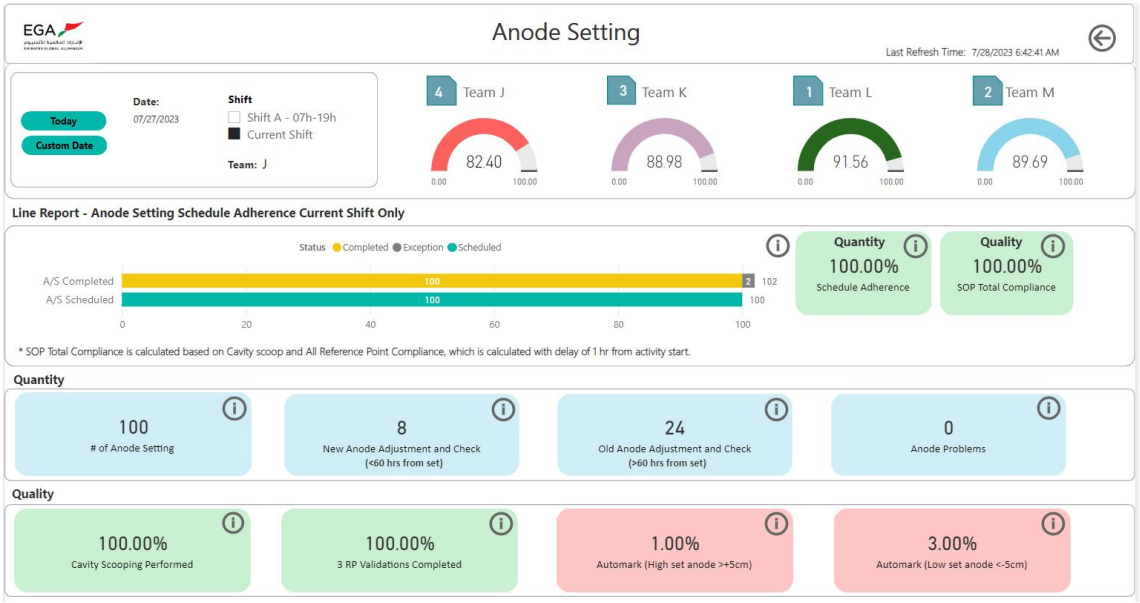


Figure 9. Smart Cranes dashboard of current shift with real time information.

7. Conclusions

The Smart Cranes journey is ongoing as there are many further applications for this technology in EGA's potlines. Like anode setting, other potline activities, such as metal tapping and beam raising will be developed along with crane utilisation tracking. The maintenance team is looking for options to analyse the break-down of crane downtime to minimise the gap and increase the overall crane availability. Looking ahead, we are working on utilising the live video cameras to improve the Smart Cranes testing and validation by advanced video analytics techniques. The initial phase of labelling the individual anode setting activities to be identified in real time video has been completed. This enables us to scale up this project in faster mode across EGA potlines.