Optimizing Rework Management in Manufacturing: A Barcode-Based Tracking Approach

[1]Hridya Soumia Krishna, [2]Parthvi Shekhawat
Christ University, School of Engineering and Technology

***Abstract—* Efficient rework management is very essential in modern manufacturing environments for optimizing production flow and minimizing downtime. This paper presents the development of a tracking system for monitoring the movement of units between the main production line and the rework station at the Schneider Electric SEIPL plant located in the Attibele, Bangalore. This proposed system aims to enhance visibility, reduce delays, and improve overall efficiency by providing real-time tracking of the rework units. Various tracking technologies, such as barcodes, RFID and IOT- enabled solutions have been evaluated for the present industrial setup. As there in no existing MES system used in the plant right now, this proposed tracking system aims to replace the need for an MES system and serves as a cheaper alternative. Implementation of this tracking system helps in the digitization of the movement of meters and provides real time traceability. This system also helps in identifying bottlenecks and optimize resource allocation. The findings from this study provide valuable insights into the impact of digital tracking solutions on production efficiency and serve as a foundation for further advancements in smart manufacturing.**

***Index Terms*—Barcode, Rework, Tracking System, UI**

I. INTRODUCTION

Failing of meters during testing is inevitable in any manufacturing plants. It could be due to numerous issues ranging from supplier issue to machine failure. Product rework is an inevitable process that occurs due to defects, quality issues, or process deviations. Managing rework efficiently is crucial to maintaining production efficiency, reducing waste, and ensuring product quality. However, in this plant tracking the movement of units between the main production line and the rework station remains a challenge.

Currently in the plant a manual tracking system is used which consists of the yellow tag system. This system involves using a yellow tag to mark the units that must be sent to rework station. All the information regarding the unit must be entered on the yellow tag manually by the operator. These might include various key information such as movement number, operator name, reason for failure and the details of the unit that failed. But this system leads to numerous mistakes and confusion and lacks any kind of digital tracking.

In most cases when a meter fails, the operators keep all the meters that failed to a side and tend to write in random reasons on the yellow tag and sends it to the rework station. Hence the main point of this project was to eliminate the yellow tag system.

To address this issue, a digital tracking system can provide real-time visibility into the rework process, improving traceability and decision-making. This makes the jobs easier for both the operators at the line and for the operators at the rework station and provides real time tracking and visibility for all.

II. BACKGROUND

In modern manufacturing, rework is an unavoidable process that occurs when products deviate from quality standards and require modifications before being released to customers. Efficient tracking and management production efficiency, reducing costs and ensuring timely delivery. However, in many industrial setups, rework tracking is still handled manually, leading to inefficiencies such as misplaced units, process delays, and inaccurate data recording.

At schneider electric SEIPL plant, rework units were previously tracked using manual logs and yellow tags making it difficult to efficiently monitor unit movement. To address this issue, a barcode-based tracking system was developed.

III. OBJECTIVES

The primary objective is to develop and implement a digital tracking system for monitoring the movement of units between the main and production line and the rework station at the Schneider Electric SEIPL plant. Specific objectives are:

1. To analyse the existing rework tracking process – Identify inefficiencies, bottlenecks and challenges in the current manual or semi-automated tracking system.

2. To evaluate suitable tracking technologies – Asses various technologies such as barcode system, RFID system or IoT based tracking system.

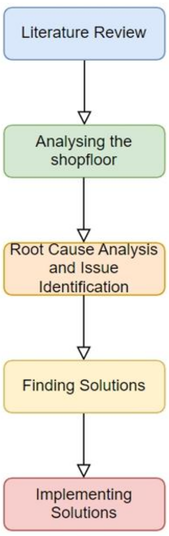
3. To design and develop a digital tracking system- Implement a real-time tracking solution that enables seamless monitoring of rework units.

4. To improve visibility and traceability- Ensure accurate and real-time tracking of units moving to and from the rework station.

5. To optimize production flow and resource utilization- Minimize downtime, enhance process efficiency, and enable better decision-making through automated data collection and analysis.

6. To assess the impact of the tracking system – Evaluate the improvements in rework process efficiency, production cycle time, and overall plant performance after the implementation of the tracking solution.

IV. METHODOLOGY



The development of a rework movement tracking system follows a structured methodology consisting of 5 key steps: Literature review, shop floor analysis, root cause analysis and issue identification, finding the solutions, and implementing them.

A. *Literature Review*

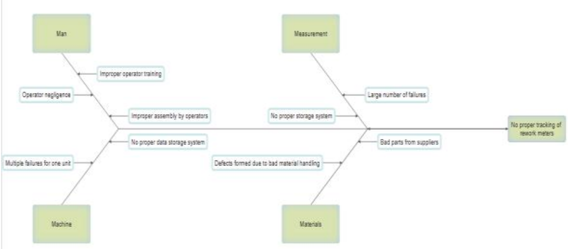
The study begins with comprehensive review of existing research on rework management, tracking technologies, and smart manufacturing solutions. Various digital tracking methods were looked into. This step helps in understanding best practices, evaluating the feasibility of different technologies, and identifying gaps in current industrial applications.

B. *Analyzing the shopfloor*

A detailed analysis of the production and rework processes at the Schneider Electric SEIPL plant is conducted to understand the movement of units, workflow patterns, and existing tracking mechanisms. I spent three weeks on the shop floor working on the lines with the operators to observe and identify the mistakes. Through this process I was able to understand the processes and identify mistakes that occurred on the line which weren't in the system.

C. *Root cause analysis and issue identification*

A structural approach such as the cause-and-effect diagram was used to identify the root causes that send a unit to the rework station. Common issues such as missing or misplaced units, lack of real-time visibility, delays in processing, and manual data entry errors are analyzed.



D. *Developing solutions*

After careful considerations, using RFID and Iot based systems were deemed not to be viable in this process, taking into consideration, the present state of the plane and other factors such as budget, time, and ease of usage. A comparative analysis is performed to select the most appropriate solutions that meets the plants requirements. The barcode system was selected for the development of the tracking system. A Ui was designed for the same.

E. Implementing solutions

The selected tracking system is implemented in a phases manner, starting with a pilot project on a specific production line or rework station. Demo sessions are conducted for the managers and the operators. Performance metrics are compared with baseline data to evaluate improvements in rework tracking efficiency, reduction in process delays, and overall production optimization.

This methodology ensures a systematic and data-driven approach to developing a robust and efficient rework movement tracking system, contributing to enhanced production performance and digital transformation in manufacturing.

V. COMPARATIVE STUDY OF TRACKING SYSTEMS

To determine the most suitable tracking system for monitoring rework unit movement, various tracking technologies were evaluated. This comparison considered factors such as cost, implementation complexity, accuracy, real-time visibility and integration with existing systems. The primary contenders included barcode system, RFID, and Iot based tracking system.

Criteria	Cost	Implementation Complexity	Accuracy & Reliability	Real-time data access	Infrastructure requirements	Scalability
Barcode	Low	Simple and easy integration with existing workflows	High as scanning ensures accurate data retrieval	Moderate (requires manual scanning)	Minimal – only scanners and barcode signals	Highly scalable with minimal cost increase
RFID	High (RFID tags and readers are more expensive)	Moderate – requires installation of RFID readers and tags	High as it can scan multiple items at once	High (automated scanning within range of readers)	Moderate – RFID antennas, and database integration	Moderate scalability, but cost increases with more tags and readers
IoT	High (requires sensors, IoT gateways, and cloud infrastructure)	Complex as it requires IoT sensor deployment and network setup	Very high as it has real time tracking with continuous updates	Very High (real-time tracking with continuous updates)	High (IoT sensors, network connectivity cloud storage, and analytics)	Scalable but requires significant investment for expansion.

While RFID and IoT based tracking systems offer real-time automation and batch scanning capabilities, they involve higher costs, complexity, and infrastructure modifications. Given the plant's requirements, barcodes provided the best balance between affordability, accuracy, and ease of deployment, making them the optimal choice for tracking rework unit movements.

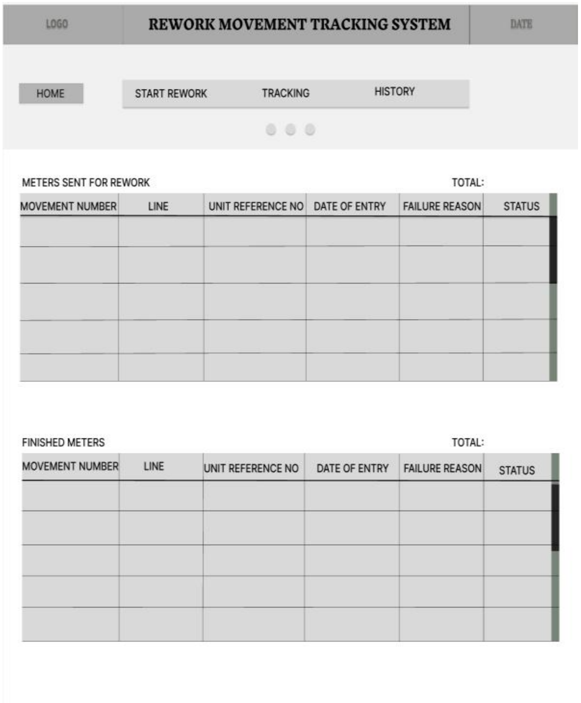
VI. WORKING OF THE TRACKING SYSTEM

The barcode system was implemented in the following manner. Each meter will be equipped with barcodes that are integrated with the ERP systems. The two ERP's currently being used in Schneider are Lean Digitization System (LDS) and SAP.

For a unit to be sent to the rework station, it must've failed testing at least three times. When a meter fails, details such as the unit reference, number of times the unit has failed, location of the unit including the line and station in which it has failed, and the reason for failure along with other details. Each time the meter is kept back for testing, the barcode must be scanned to record the number of times the unit is being tested and failed. This eliminates the need for the yellow tag and manual entry of details.

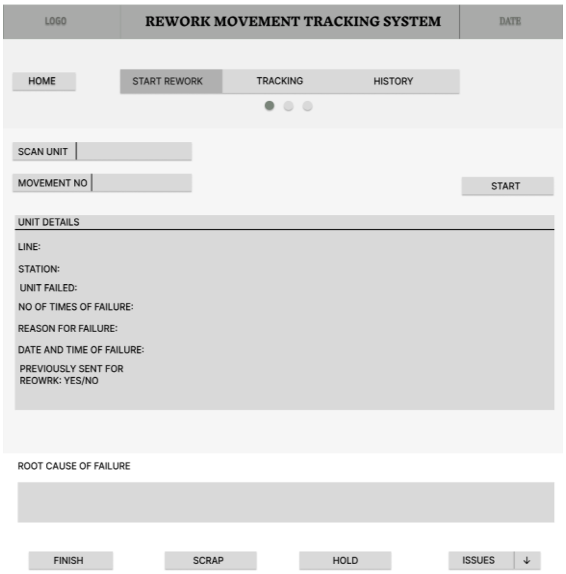
When this unit is sent to the rework station, and once the operators scan this barcode all the details pertaining to the unit will be visible to the operator. Making it easier for the identification and correction of the defect. This system helps in real time tracking of the unit. Once the unit is scanned at the rework station, the location information of the unit will also be automatically changed. Making it easier for locating units.

A user interface was created for the same. This UI consists of 4 pages – Home, Rework, Tracking and History. This was developed in such a way that the manual data entry will be completely eliminated and all information can be digitized making it easier to retrieve data anywhere and anytime.



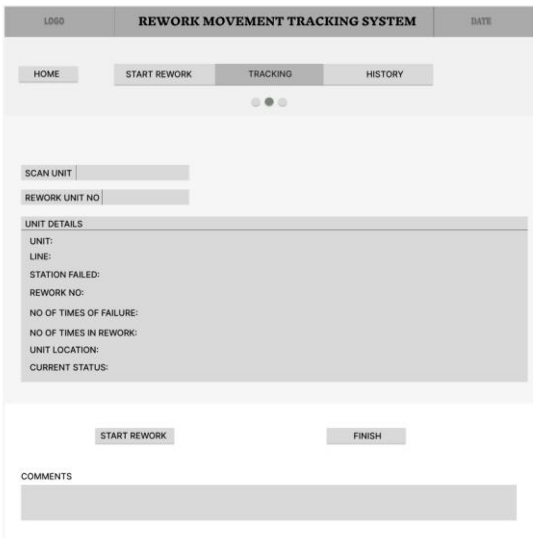
A. Home page

The home page is the first screen that will be displayed when the system is opened. The home page displays all the information about the units that have been sent to rework and the units that have been sent back to the line.



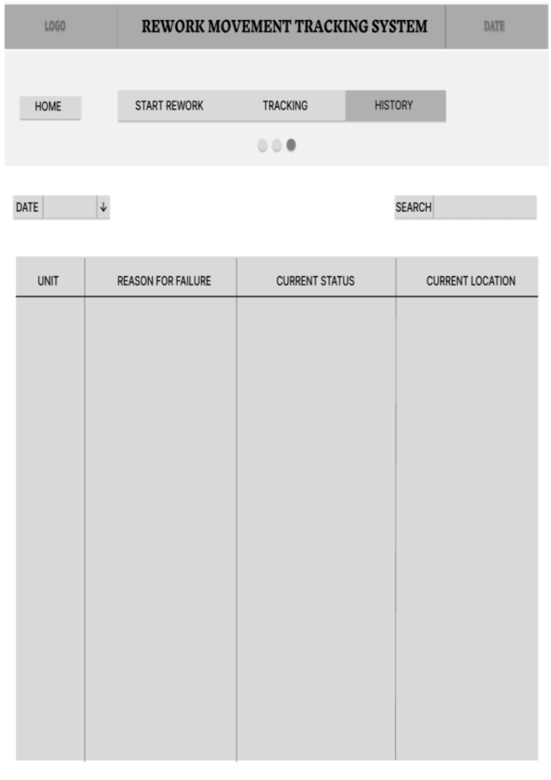
B. Rework page.

The rework page allows you to start the rework. The process begins when the operator scans the unit and all the information about that unit will be displayed. The operator starts the rework once the start button has been clicked. Space has been provided for the technician to enter their root cause. They have been given different options at the bottom which allows them to take the necessary actions. The finish button allows them to finish the rework and send it back to the lines. If a unit is not salvageable it is considered scrap. If the operator wants to hold the unit and work on something else, that option has been provided too. If the operator finds and issue not related to the meter, that can be reported. External issues are mainly of 5 types – Design, SQE, Maintenance, Methods and Production.



C. Tracking page

This page allows you to track any unit at any time. By scanning the unit or by manually entering the unit details, the location and other information of the particular unit will be displayed.



D. History page

This page displays the history of all the units that have been worked on. The desired date can be selected or the desired unit details can be entered manually onto the search bar to retrieve all the necessary information.

VII. APPLICATIONS

A. The system provides detailed insights which help quality managers and operators to identify trends, perform root cause analysis and implement targeted corrective actions to improve overall product quality.

B. By tracking units in real time and monitoring rework cycles, the system enables managers to identify bottlenecks and inefficiencies in the line.

C. The data can be leveraged to schedule preventative maintenance, calibrate testing equipment, or adjust manufacturing processes, ensuring that production machinery operates efficiently and reliably.

D. Detailed record-keeping of every unit's journey-from initial production through rework cycles-ensures robust traceability.

E. Enhancing customer satisfaction

VIII. RESULTS

The implementation of the barcode-based tracking system successfully digitized the movement of rework units, improving traceability and operational efficiency at the Schneider Electric SEIPL plant. A dedicated UI was developed to display unit information in real-time, enabling seamless communication between the production line and the rework station.

A. Enhanced efficiency in rework operations

The automated tracking system streamlined rework operations by reducing the time spent on identifying defective units and retrieving information. The UI allows operators to quickly access rework instructions, minimizing downtime and ensuring that repairs start immediately. Additionally, since all information is digitized, there is no dependency on physical logs, reducing administrative burden and improving data accuracy.

B. Improved tracking and data visibility

With the new system, each unit is scanned using a barcode containing detailed information such as product specifications, defect type, and rework instructions. When an operator scans the unit at the production line, all relevant data is instantly displayed, eliminating the need for any paper work. This real-time data accessibility has significantly reduced errors, misplacements, and delays in the rework process.

C. Data digitization

By implementing this system, the entire rework process has been digitized, ensuring all unit movements and status updates are recorded in a centralized database. This digitization provides valuable insights into rework frequency, defect trends, and process inefficiencies, allowing for continuous improvements in production quality. The collected data can also be leveraged for predictive analytics, enabling proactive decision-making to reduce defect rates and optimize production flow.

D. Quantifiable improvements

A comparative analysis of key performance indicators (KPIs) before and after system implementation revealed significant improvements:

1. Reduction in rework processing time by eliminating manual data retrieval and entry.
2. Increase in tracking accuracy, ensuring that no units are lost or misplaced during transit between production line and rework station.
3. Improved operator productivity, as workers spend less time searching for information and more time performing rework tasks.

Overall, the barcode-based tracking system has enhanced visibility, efficiency and traceability in the rework management process. This digital transformation not only improves current operations but also sets the foundation for further advancements in smart manufacturing and Industry 4.0 initiatives.

IX. DISCUSSIONS

The implementation of a barcode -based tracking system for monitoring rework unit movements at the schneider Electric SEIPL plant has demonstrated significant improvements in traceability, efficiency, and process automation. The comparative study between barcode systems, RFID, and IoT-based tracking solutions highlight the advantages and limitations of each technology.

The choice of a barcode system was primarily driven by its cost-effectiveness, ease of implementation, and reliability, making it the most suitable solution for the given industrial environment.

CONCLUSION

Effective rework management is essential for maintaining production efficiency and ensuring product quality in manufacturing industries. This study focused on developing a digital tracking system to monitor the movement of units between the production line and the rework station at the Schneider Electric SEIPL plant.

Through a systematic approach involving literature review, analysis, root cause identification etc, key inefficiencies in the existing rework tracking process were identified and addressed. The implementation of the real time tracking system using various other technologies were tested and compared to find the best possible solution for the existing problem.

The findings from this study highlight the potential benefits of digital tracking solutions in rework management, contributing to improved resource utilization and production performance. This research also serves as a foundation for further advancements in smart manufacturing, with the possibility of scaling the tracking system to other production processes. Future work can explore advanced data analytics, predictive.

REFERENCES

[1] Soujanya Mantravadia, Charles Møllera,'An Overview of Next-generation Manufacturing Execution Systems: How important is MES for Industry 4.0', Elsevier, 14th Global Congress on Manufacturing and Management, 2019, 10.1016/j.promfg.2019.02.083

[2] Rajesri Govindaraju, Krisna Putra, 'A methodology for Manufacturing Execution Systems (MES) implementation', Purpose led publishing, 2016, doi:10.1088/1757-899X/114/1/012094.

[3] Dalibor Berić, et al, 'The Implementation of ERP and MES Systems as a Support to Industrial Management Systems.' International Journal of Industrial Engineering and Management (IJIEM), Vol.9 No 2, 2018

[4] Riley Elliot, 'Manufacturing Execution System (MES), Examination of Implementation Strategy', Faculty of California Polytechnic State University, 2013

[5] Leonor Costa et al., 'Methodology for Implementing a Manufacturing Execution System in the Machinery and Equipment Industry', Procedia Computer Science Volume 232, 2024, Pages 2028-2037, doi.org/10.1016/j.procs.2024.02.025

[6] Gautam Dutta et al., 'Overcoming the barriers of effective implementation of manufacturing execution system in pursuit of smart manufacturing in SMEs', Procedia Computer Science Volume 2300, 2022, Pages 820-832, doi.org/10.1016/j.procs.2022.01.279

[7] Václav Kaczmarczyk et al., 'Revisiting the Role of Manufacturing Execution Systems in Industry 4.0', IFAC-PapersOnLineVolume 55, Issue 4, 2022, Pages 151-157 doi.org/10.1016/j.ifacol.2022.06.025

[8] Longfei Qin et al., 'Real-time Tracking System for Distribution Information of Logistics Enterprises Based on IOT Technology', Procedia Computer Science 243 (2024), Elsevier 10.1016/j.procs.2024.09.012

[9] Zhihui Chen et al., 'Production efficiency analysis based on the RFID-collected manufacturing big data, Manufacturing letters', volume 41, October 2024, Pages 81-90

[10] Muhammad al-salamah, 'Economic production quantity in an imperfect manufacturing process with synchronous and asynchronous flexible rework rates', Operations research perspectives, Volume 6, 2019, 100103. https://doi.org/10.1016/j.orp.2019.100103

[11] Ritu Arora et al., 'Smart manufacturing system with rework and partial outsourcing for battery industry', cleaner engineering and technology, volume 24, February 2025, 100885. https://doi.org/10.1016/j.clet.2025.100885

[12] M.Hirsch et al., 'Targeted rework strategies for powder bed additive manufacturing', Additive Manufacturing, Volume 19, January 2018, pages 127-133. https://doi.org/10.1016/j.addma.2017.11.011

[13] Marcello Colledani, Alessio Angius, 'Production quality performance of manufacturing systems with in-line product traceability and rework', CIRP Annals, Volume 69, Issue 1, 2020, pages 365-368.

[14] Anjali Gupta, Aditi Khanna, ' A holistic approach to sustainable manufacturing: Rework, green technology, and carbon policies', Expert Systems with Applications Volume 244, 15 June 2024, 122943 https://doi.org/10.1016/j.eswa.2023.122943

[15] Cheng Zhu et al., 'Data-Enabled Modeling and Analysis of Multistage Manufacturing Systems with Quality Rework Loops, Journal of Manufacturing Systems Volume 56, July 2020, Pages 573-584 https://doi.org/10.1016/j.jmsy.2020.07.019