MANUFACTURING PERFORMANCE IMPROVEMENT IN AUTOMOTIVE INDUSTRY

A. El Mamouni1, Y. Abouelhanoune2 and A. Bakkali1
1Faculty of sciences,
University Abdelmalek Essaadi, Tetouan, Morocco.
2National School of Applied Sciences
University Abdelmalek Essaadi, Tetouan, Morocco.
**Corresponding Author's Email: yabouelhanoune@uae.ac.ma*

ABSTRACT*: The Key Performance Indicators (KPIs) of manufacturing, especially for our case, Overall Equipment Effectiveness (OEE), scrap rate, and IPPM (Issues per Million), are important metrics that measure the efficiency and quality of manufacturing processes. Low OEE, high scrap rate, and high IPPM are all indicative of inefficient manufacturing processes that can lead to production delays, increased costs, and reduced customer satisfaction. Therefore, it is crucial for manufacturing companies to improve these KPIs. In automotive industry we have adopted a strategy to improve these KPIs in all areas by using industry 4.0 and Lean six sigma. In this paper we will present a case of study.*

KEYWORDS*: CAO System, Lean Six Sigma, IPPM, OEE, Connected Factory.*

1 INTRODUCTION

The industry 4.0 refers to the incorporation of advanced technology into industrial processes such as artificial intelligence, the Internet of Things (IoT), Big data, and automation. It aims at creating smart factories that can optimize the production process, improve efficiency, and reduce costs (Salunkhea and Berglunda 2022). On the other hand, Lean management is a production management philosophy that emphasizes the creation of value for the customer by eliminating waste in all forms in the production process. Lean management focuses on creating a culture of continuous improvement, visual management, and employee empowerment to maximize productivity (Larsson et al. 2020; Koren et al. 2018.

Integrating Industry 4.0 and Lean management can result in a comprehensive approach to improve production performance (Kumar 2021; Ballestero et al. 2020 and Schneider 2018). By using Industry 4.0 technologies, the process can be optimized, and enhanced traceability and transparency can be achieved (Mittal et al. 2017; Gan et al. 2016 and Verma et al. 2016). Meanwhile, Lean management practices can eliminate waste and optimize process to create value for the customer.

A connected factory is a facility where industrial equipment, machines, and workers are connected through advanced technologies. By using Industry 4.0 and Lean manufacturing principles, several steps need to be taken to optimize the production process starting from data collecting and analyzing, implementing predictive maintenance, integrating with suppliers then optimizing process flow and enhancing workforce skills (Skalli et al. 2023; Tortorella et al. 2020).

The aim of a connected factory is to create a production environment that is optimized, efficient, and transparent.

2 PROBLEM SYMPTOMS, CAUSES AND IMPACT

The company was facing several problems related to their key performance indicators (KPIs) such OEE, scrap rate, IPPM. These issues arise due to the company's use of manual operations and a random distribution of configurations on the cutting area.

One of the main problems is the low OEE. This KPI measures the efficiency of the manufacturing process by comparing the actual production time with the planned production time. With manual operations and random configurations, there is a higher risk of downtime due to machine failures, tooling issues, or human error, resulting in a lower OEE.

Another issue is the high scrap rate, which is the percentage of the total production that is discarded due to defects or non-conformities. Manual operations and random configurations increase the chances of mistakes and inconsistencies, leading to more scrap and lower yields.

Finally, the company is also struggling with low IPPM, which is a measure of the number of defective parts per million produced. This KPI is closely related to the scrap rate and reflects the quality of the production process. With manual operations and random configurations, there is a

higher risk of producing defective parts, which negatively impacts the IPPM.

Table 1. Overall Equipment Effectiveness 2021

Year	Real	Objectif	Gap
2021	61,19%	62,50%	-1,31%

The objective of OEE is to achieve a score of at least 62.5%. However, in the previous year (2021), the company failed to achieve this target, with a deviation of -1.31%. In this report, we will analyze the situation and propose solutions to achieve the OEE target in the next year (2022).

Table 2. Scrap rate gap

Year	Real	Objectif	Gap
2021	1,81%	1,32%	-0,49%

The same situation we can observe on Scrap rate. The objective of the scrap rate is to achieve a target rate of 1.32%. However, in the previous year, the company was unable to achieve this target and presented a deviation of -0.49%.

3 PROPOSED SOLUTION BASED ON LEAN SIX SIGMA & INDUSTRY 4.0

To improve OEE, Scrape Rate, and IPPM we have conducted a study based on lean six sigma and Industry 4.0 technologies, the following study and solution has been proposed and implemented. Apply lean principles can help to identify and eliminate waste in the production process. A value stream mapping has been done to identify the non-value adding activities in this area, which can be eliminated or reduced, below the current and future state in Figures 1 and 2.

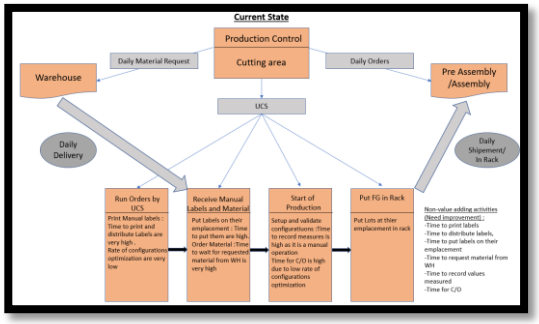

Fig. 1 VSM Current state

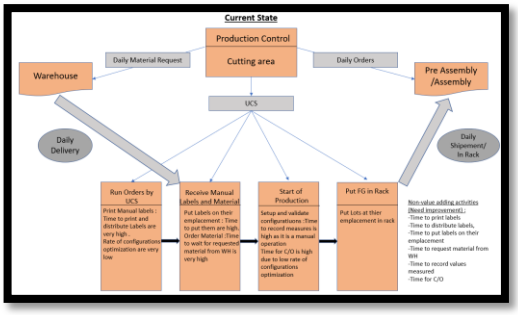

Fig. 2 VSM Future state

This diagram shows the current state VSM and the future state VSM. The current state VSM identifies all the activities that are currently taking place in the cutting area, including value-adding and non-value adding activities. The future state VSM represents the redesigned process that eliminates or reduces the non-value adding activities identified in the current state VSM.

In the current state VSM, we can see that there are several non-value adding activities such as waiting for recording values of validation, waiting for Labels distribution, and unnecessary movement of materials and Tools (time for C/O). In the future state VSM, these activities have been eliminated or reduced, leading to a more efficient and effective cutting process. For example, Labels are now printed directly to the cutting area by CAO system, eliminating the need for UCS agent to print, split and move them manually. Also, inspection and validations are now done in-line and recorded in real time, reducing the waiting time for recording values manually, in addition the movement of Tools and materials has been improved due to C/O configuration optimization done by CAO,

By using a VSM to identify non-value adding activities and developing a plan for improvement, we can streamline their processes and improve KPIs in the cutting area.

Table 3. Steps with current and future state

Step	Current State	Future State
Scope and Boundaries	The cutting area is defined as the area where Wires with different CSA are cut into the desired length with adding Seals and Terminals	The cutting area is still defined as the area where Wires are cut, but the boundaries are expanded to include material delivery.

Identify Non-Value Adding Activities /Analyze and Prioritize Opportunities for Improvement	Non-value adding activities are identified, such as waiting Time to print labels, waiting Time to distribute labels, waiting Time to put labels on their emplacement, waiting Time to request material from WH, waiting Time to record values measured and waiting Time for C/O. The non-value adding activities are analyzed to determine their impact on the overall process	Non-value adding activities are improved such as removing Time to distribute labels, Time to put labels on their emplacement, Time to record values measured and optimizing Time to print labels, Time to request material from WH and Time for C/O. Opportunities for improvement are prioritized based on their potential impact and ease of implementation.
Implement Changes	Opportunities for changes are identified, using lean to eliminate waste of time and non -value adding activities, using Six sigma to improve the overall process and using industry 4.0 by introducing CAO cutting system	Changes are implemented in the cutting area, including changes to the flow of materials, information, and using CAO system. Progress is monitored and adjustements are made as necessary.
Monitor Progress		The progress of the changes is monitored over time to ensure that they are achieving the desired results.

The Table 3 describes the different steps involved in using a VSM to identify non-value adding activities in the cutting area, prioritize opportunities for improvement, and create a plan for implementing changes. By following these steps, we will improve overall productivity in the cutting area. Six Sigma can be used to reduce variability and defects in the production process. Statistical process control has been used to monitor the process and identify variations (Titmarsh et al. 2020; Santos et al. 2021).

A statistical study was conducted to optimize the change of machine configurations. The study evaluated three configurations, namely Seal Applicator, Terminal (Applicator and Spool), and Wire Spool (Alhuraish et al. 2016). The Seal Applicator took the longest time to be changed, approximately 10 minutes, followed by the Terminal, which took approximately 5 minutes to change, while the Wire Spool was the quickest to change, taking only 2 minutes.

The study aimed to minimize the number of Seal Applicator changes, followed by the Terminal, and finally the Wire Spool. Optimization was performed for each machine configuration, and the statistical analysis allowed for the identification of the most efficient configuration change sequence with the implemented of CAO system to collect data, analyze it, and make optimizations about the production process.

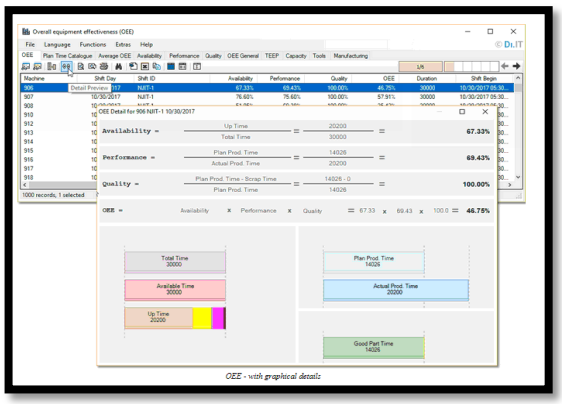

Fig 3. Real time collecting data and record OEE of Cutting machine

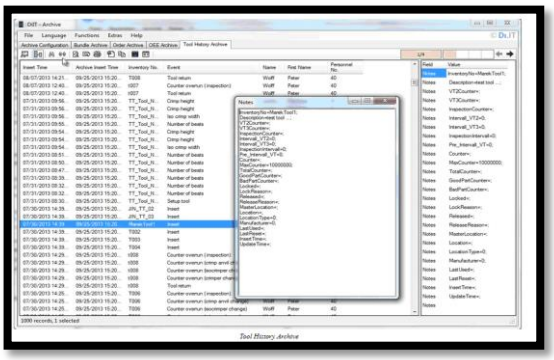

Fig. 4 Configuration optimization

with CAO optimization we can reduces setup cost and efforts to a minimum and makes sure that we meet our order deadlines. Taking account of each machine's features and capabilities, required and available resources, as well as current setup states, the CAO V12 automatic planning tool finds the optimum order distribution and sequencing for a smooth and highly efficient workflow that also ensures that we are on schedule.

The view "Optimization" is a planning tool for cost-efficient production in the Cutting Area. Supported by powerful functions, we can easily find a good sequence and schedule orders with drag and drop to machines that can build them. In a more complex production situation, we can use the automatic planning and optimization feature available as an extension to CAO V12.

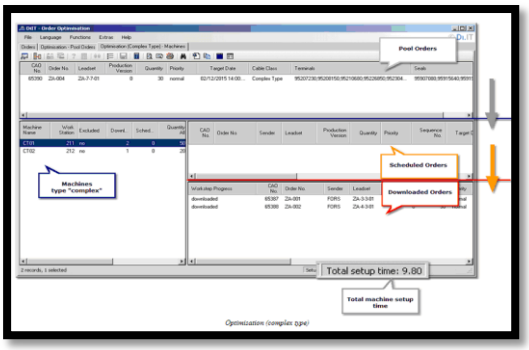

Fig. 5 Measurement parameters in real time recording

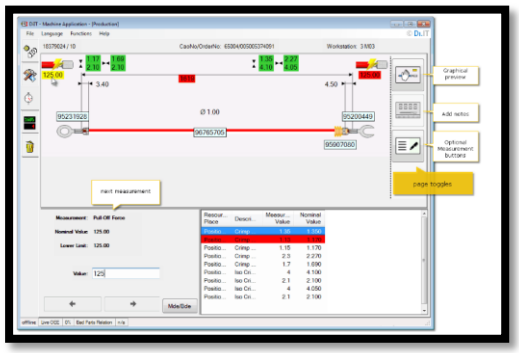

Fig. 6 Material Change Detection in CAO

To improve the quality and traceability, all resources that are setup and changed over by the operator need to be identified and confirmed with a scan operation. In addition, rule-based measurements can be enforced.

All information from the setup event, changed over resources and the measurements taken, are logged permanently in the system. This can minimize the wrong setups and minimize as well the scrap rate & IPPM.

In 2021, the OEE objective was set at 62.5%, and the actual OEE achieved was 61.19%, with a negative gap of -1.31%. In 2022, a solution was proposed and implemented to improve the OEE. The OEE in 2022 was 63.12%, with a positive gap of 0.62%.

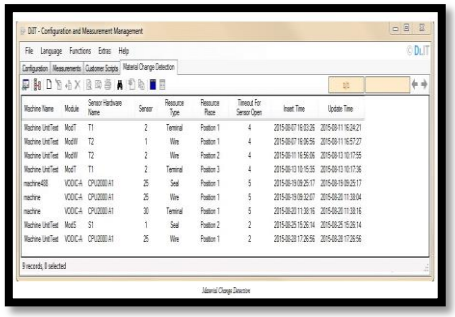

Fig. 8 Results and Objectives meets

Table 4. Overall Equipment Effectiveness in 2022

Year	Real	Objectif	Gap
2022	63,12%	62,50%	0,62%

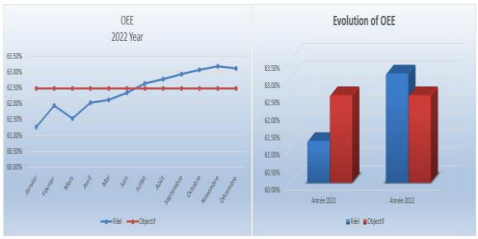

Fig. 9 Reel and objective evolution of OEE

The results show that the solution proposed in 2022 had a positive impact on the OEE of the company. The gap between the objective and the actual OEE in 2021 was negative, indicating a need for improvement. The positive gap in 2022 shows that the solution was effective in improving the OEE. It is also worth noting that the OEE switched from a negative gap to a positive gap starting from July 2022, which indicates that the solution was implemented successfully.

Table 5. Scrap rate gap in 2022

Year	Real	Objectif	Gap
2022	1,34%	1,32%	-0,02%

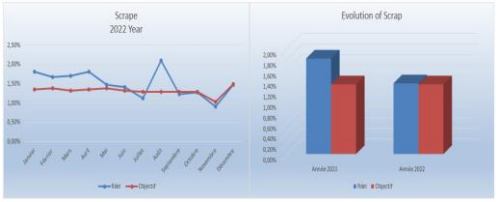

Fig. 10 Scrap evolution

In 2021, the objective was to achieve a performance of 1.32%, but the actual performance was 1.81%, resulting in a gap of -0.49%. This indicates that the target was not achieved, and there was a significant gap between the expected and actual performance. However, in 2022, with the implementation of proposed solutions, the actual performance improved to 1.34%, with a gap of 0.02%. This indicates that the solutions implemented had a positive impact on the

performance and helped to bridge the gap between the objective and actual performance.

The analysis also shows that starting from September 2022, the scrap rate has significantly decreased and is now below the objectives. This indicates that the solutions implemented have helped to improve the quality of the product and reduce waste. The reduction in scrap rate also has a positive impact on the financial performance of the company, as it reduces the cost of production and improves the bottom line.

4 CONCLUSION

The study highlights the importance of monitoring the OEE of a company and implementing solutions to improve it. The proposed solution in 2022 had a positive impact on the OEE, and the results show that the company is on the right track towards achieving its objectives. Further analysis and monitoring of the OEE will help the company to identify areas of improvement and to maintain a high level of efficiency in its operations.

In conclusion, the analysis shows that the solutions proposed and implemented had a positive impact on the performance and scrap rate of the company. It also highlights the importance of continuously monitoring and analyzing performance to identify areas for improvement and implement effective solutions.

5 AUTHOR CONTRIBUTIONS

A.E. Author: Conceptualization, Methodology, Writing-Original Draft Preparation; Y. A. Author: Data Curation, Validation, Writing-Reviewing and Editing; A.B. Author: Validation and supervision.

6 CONFLICTS OF INTEREST

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest on the manuscript.

7 REFERENCES

Salunkhea O., F. Berglunda. 2022. Industry 4.0 enabling technologies for increasing operational flexibility in final assembly. International Journal of Industrial Engineering and Management (IJIEM), Volume 13, No 1, 38-48.

Larsson, J., and J. Wollin, 2020. Industry 4.0 and Lean –Possibilities, Challenges and Risk for Continuous Improvement. MBA Thesis, Karlskrona, Sweden.

Koren Y., X. Gu, and W. Guo, 2018. "Reconfigurable manufacturing systems: Principles, design, and future trends. Frontiers of Mechanical Engineering, Vol. 13, no. 2, pp. 121–136.

Kumar P. 2021. Integration between Lean, Six Sigma and Industry 4.0 technologies. Int. J. Six Sigma and Competitive Advantage, Vol. 13, No. 1-3, pp. 19-37.

Ballestero F., and J. G. Aranda. 2020. The use of disruptive ICTs for improving environmental sustainability and competitiveness. Sostenibilidad Para La Compet. Vol 1, 135-146.

Schneider P. 2018. Managerial challenges of Industry 4.0: an empirically backed research agenda for a nascent field. Managerial Science, Volume 12, pp. 803-848.

Varela L. et al. 2019. Evaluation of the Relation between Lean Manufacturing, Industry 4.0, and Sustainability. MDPI - Sustainability, 11(5), pp. 1-19.

Mittal K. K. et al. 2017. Configuration selection in reconfigurable manufacturing system based on reconfigurability. Int. J. Logistics Systems and Management, Vol. 27, No. 3, pp. 363-379.

Gan T. S. and M. Grunow. 2016. Concurrent product and supply chain design: a literature review, an exploratory research framework and a process for modularity design. International Journal of Computer Integrated Manufacturing, vol. 29, no. 12, pp. 1255– 1271.

Verma V., and K. Mittal. 2016. Lean manufacturing system for air cleaner assembly cell. Int. J. Logistics Systems and Management, Vol. 23, No. 3, 315-317.

Skalli D. et al. 2023. "Industry 4.0 and Lean Six Sigma integration in manufacturing: A literature review, an integrated framework and proposed research perspectives". Quality Management Journal, Volume 30, pp. 16-40.

Tortorella G. and al. 2020. Towards the proposition of a Lean Automation framework: Integrating Industry 4.0 into Lean Production. Journal of Manufacturing Technology Management, V 32 (3), 593–620.

Santos B. P. et al. 2021. The Synergic Relationship Between Industry 4.0 and Lean Management: Best Practices from the Literature. Management and. Production Engineering Review, Vol 12, Num 1, pp. 94–107.

Alhuraish I., C. Robledo and A. Kobi. 2016. Impacts of Lean Manufacturing and Six Sigma. Proceedings of the 22nd ISSAT International Conference on Reliability and Quality in Design August 4-6. Los Angeles, California, U.S.A