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Abstract: Automotive companies are facing major challenges, namely competitiveness and the evolution that characterizes the sector. To ensure their sustainability, companies operating in the automotive industry are concentrating their efforts on reducing waste sources throughout the supply chain by implementing a variety of Lean Management tools. The compliance of the quality management system with the requirements of the international automotive standard IATF 16949:2016 is also a top priority for automotive suppliers. IATF certification is required to operate in the automotive market and enables organizations to meet customer requirements and demonstrate the quality assurance of their systems. This paper analyzes the principles of the Lean Management organizational tools in correlation with the requirements of the IATF automotive standard and determines their synergistic impact on operational excellence. Based on the correlation analysis performed, an original roadmap that will serve as a guide for automotive companies has been developed. The findings show that in order to achieve operational excellence, it is necessary to implement the five Lean Management organizational tools in correlation with the operational requirements dictated in chapter 8 as well as the leadership requirements outlined in chapter 5 of the international automotive standard.

1 Introduction

Faced with the competitiveness and dynamic development of the sector, automotive manufacturing companies aim to optimize the quality of the manufactured products, increase customer satisfaction and improve the overall performance of their systems. Controlling supply chain flows and operations, improving results, and ensuring the effectiveness of quality management systems (QMS) are among the major challenges faced by automotive companies.

Nowadays, Lean Management is one of the most discussed concepts in the literature and the most implemented in industrial environments. Lean Management is based on a set of principles and tools whose objective is to eliminate wastes, optimize flows and improve the efficiency and performance of organizations while involving personnel and creating teamwork spirit [1-4]. Adopted by operational processes within manufacturing companies, Lean Manufacturing eliminates non-value-added activities caused by overproduction, inventory, waiting time, motion, transportation, defects and errors, over-processing and non-utilized talent [5-10].

IATF 16949:2016 is the international automotive quality management system standard intended for automotive companies [11-13]. Through its requirements, the IATF standard promotes continuous improvement and involves automotive organizations in preventing defects and errors as well as reducing wastes and variations in the supply chain [11,14]. The requirements related to management's commitment are defined in the chapter "5: leadership", the resources management is detailed in the chapter "7: support", the operational requirements are defined in the chapter "8: Operation", the evaluation methods are determined in the chapter "9: performance evaluation" and the requirements for improvement are specified in the chapter "10: improvement" [11,15,16].

Operational Excellence (OE) is a systematic approach that encompasses a set of methods enabling organizations to perfect their performance and achieve sustainable results [17-20]. The principles of OE are classified into four categories: "Culture", "Continuous improvement", "Enterprise Alignment" and "Results" [17,18]. The "culture" dimension emphasizes leadership, human resources management and motivation, teamwork spirit and the improvement of working conditions. "Continuous improvement" concerns the improvement of processes, quality assurance and the elimination of wastes. "Enterprise alignment" assesses the organization's vision, policy, and strategy. The "Results" dimension concerns the monitoring of performance indicators and the evaluation of customer satisfaction [18].

Given the diversity of Lean Management tools and the variety of IATF requirements, several automotive companies wishing to reach operational excellence while ensuring the quality assurance of their systems and avoiding wastes in the supply chain are unaware of the approach to follow. In the literature, it was found that no study has investigated Lean Management in correlation with automotive standard requirements and Operational excellence. In this context, this paper aims to demonstrate to automotive companies the impact of the implementation of Lean Management organizational tools in correlation with the requirements of the IATF 16949: 2016 automotive standard on operational excellence. A roadmap, which determines the Lean Management tools to be implemented as priority and the relevant IATF clauses to focus on, has been developed to guide automotive companies in establishing their improvement plan in order to achieve operational excellence.

2 Categorization of Lean Management tools

Lean Management is based on several methods, techniques and tools that are differentiated by their concept, rules and operation mode. Lean Management tools can be divided into four categories:

- Analytical tools: value Stream mapping (VSM) and bottleneck analysis. VSM is a method for mapping material and information flow and identifying the different sources of wastes [5,8,21]. Bottleneck analysis is a technique for production balancing that aims to respond to customer demand [8].
- Operational tools process-focused: Poka Yoke, Kaizen, Smed and Jidoka. The poka yoke is an Error-proofing device to prevent defects and errors [5,22]. Kaizen is based on small steps of continuous improvement performed within short periods of time [5]. SMED enables the optimization of changeover times [23]. Jidoka is a visual warning tool for non-conformity detection [5].
- Operational tools flow-focused: Just-In-Time (JIT) and KANBAN. These tools aim to optimize flows and storage areas in order to meet customer delivery requirements [21,24].
- Organizational tools: 5S, standardized work, Visual management, Total Productive Maintenance (TPM) and Total Quality Management (TQM). 5S enables organizations to take the first step towards continuous improvement. Standardized work is fundamental for operational activities' organization [25]. Visual management supports managers in decision-making [21]. TPM improves the effectiveness and efficiency of business processes [26]. TQM improves the QMS and minimizes defects and errors [27,28].

Lean Management analytical tools and operational tools process-focused and flow-focused enable the organizations to improve their workshops and business processes. Organizational tools enable the improvement all of the company's levels and processes, including management, operational and support processes. Several studies have shown that Lean Management excels in the automotive industry due to high customer demand, high level of competitiveness and customer-specific requirements [6,21,29-31]. In this study, Lean Management organizational tools are considered.

3 The steps of the roadmap's development

The present paper analyzes the impact of the adoption of each Lean Management organizational tool and the compliance of QMS with IATF 16949:2016 requirements on operational excellence. For this purpose, the preselected Lean Management tools were analyzed in correlation with the analysis of the IATF standard requirements. Then, factors and key performance indicators (KPIs) that are positively influenced by the adoption of each tool and the implementation of the relevant IATF requirement were determined and finally, the link between these KPIs/factors and the OE dimensions is established. The considered KPIs were determined according to IATF standard. In the context of quality assurance and customer satisfaction monitoring, IATF 16949:2016 requires organizations to assess internal and external performance. A list of indicators is proposed by the automotive standard in clause 9.1.2.1, which should be completed by each organization according to its activity, QMS content, customer requirements and the complexity of the manufacturing processes. KPIs list include delivered part quality performance, delivery performance, customer disruptions and warranties [11]. Additionally, the IATF automotive standard requires conducting a management review in order to assess the consistency of the QMS with the strategy established by the organization as well as the effectiveness of the QMS and the improvement opportunities to be seized. Management review inputs are defined in clause 9.3.2.1 of the automotive standard. The required KPIs in relation to the operational aspect are: cost of internal and external poor quality, process effectiveness, process efficiency, product conformance, customer satisfaction, maintenance performance, warranty performance and finally actual field failures [11]. Table 1 summarizes the list of internal and external KPIs considered in this article. Internal KPIs concern the organization's internal performance, while external KPIs monitor customer satisfaction.

Based on the correlation analysis performed, a roadmap has been developed in the second section of the present paper. Automotive companies can refer to the roadmap and identify QMS suggested improvements, Lean Management tools and techniques to prioritize, as well as IATF requirements that companies should focus on in order to achieve operational excellence.

Table 1 Determination of internal and external KPIs according to the IATF 16949:2016 standard

KPI type	KPI label
Internal KPI	- Cost of internal poor quality - Process effectiveness - Process efficiency - Product conformance - Maintenance performance
External KPI	- Delivered part quality performance - Delivery performance - Customer disruptions - Warranty - Cost of external poor quality

4 Result and discussion

4.1 Correlation analysis between Lean Management organizational tools and IATF requirements and determination of their impact on operational excellence

The objective of Lean Management is to eliminate wastes, optimize material and information flow, increase customer satisfaction and produce at the best quality-cost-time ratio. This is in alliance with clause 10.3.1 of the international automotive standard, which requires organizations to define a continuous improvement process in order to reduce wastes [11,14]. In this section, the preselected Lean Management tools are analyzed in correlation with the requirements contained in the IATF 16949:2016 standard. Table 2 summarizes this analysis and presents the impact of the implementation of Lean Management organizational tools and the compliance of QMS with the automotive standard requirements on the OE dimensions.

"5S" principle can be linked to clauses 7.1.4.1 and 8.5.4.1 of the IATF 16949:2016 standard. Clause 7.1.4.1 requires organizations to maintain the environment for the operation of processes in a state of order while complying with applicable cleanliness and maintenance requirements [11]. The compliance of the QMS with this requirement and the adoption of the 5S tool enable reduction of industrial accident risks, improve the execution of operational activities, participate in the quality assurance approach and increase productivity, manpower effectiveness and efficiency. Clause 8.5.4.1 requires automotive companies to preserve products' quality throughout the supply chain [11]. The implementation of the 5S tool enables organizations to conform their QMS to this IATF requirement and to ensure the quality of the delivered products by meeting customer requirements. Preserving product quality reduces the internal rejection rate, costs related to reworks and repairs, and the number of customer complaints.

"Standardized work" principle is linked to clause 8.5.1.2 of the IATF 16949:2016 standard, which requires organizations to establish standardized work instructions, including workstation safety rules and to ensure that instructions are communicated to the concerned personnel [11]. Standardized work enables organizations to reduce industrial accident risks and produce on time, parts at the required quality level. Productivity, delivery time, rejection rate and manpower efficiency and effectiveness are all improved when the work is standardized.

"Visual management" is linked to clause 5.3.1 of the automotive standard, which involves management in designating the personnel responsible for monitoring customer satisfaction [11]. Customer scorecards are one of the "Visual management" applications. Based on customer scorecard data analysis, the management can improve the organization's policy and strategy and make the right decisions at the right time. By analyzing the collected data from customer portals and implementing corrective actions in case of non-achievement of targets, automotive companies optimize their processes effectiveness and improve their external KPIs.

TPM is explicitly required in the IATF Automotive Standard in clause 8.5.1.5 [11]. Maintenance management is more efficient when the objectives are defined in coherence with the organization's strategy and when the deviations between the monitoring results and the predefined targets are constantly analyzed and corrected. TPM ensures quality at the source and improves internal and external KPIs. Organizations with reliable manufacturing equipment produce in accordance with customer requirements, improve maintenance performance and improve the effectiveness of operational processes. Costs related to corrective maintenance and loss of productivity are minimized when TPM is implemented.

TQM method principles are linked to clauses 5.1.2, 10.2.3, 10.2.4, 10.2.5 and 9.2 of the IATF standard. Clause 5.1.2 requires management's commitment to customer-focused approach [11]. As a leader, the management promotes the employees commitment and supports them in operational management activities. The quality policy, the objectives and the strategy are reviewed by incorporating all the necessary actions to continuously satisfy the customer. A QMS focused on customer satisfaction prompts all processes to improve their operations and ensure the quality of the delivered products. All external KPIs are improved when the organization focuses on meeting customer requirements. Clause 10.2.3 requires organizations to implement a process for problem-solving [11]. The implementation of this clause ensures a good collaborative climate by involving multidisciplinary actors in the process.

Table 2 Synthesis of the correlation analysis between Lean Management organizational tools and IATF requirements and determination of their impact on OE

Lean Management tool	**Related IATF 16949 :2016 clause**	**Impacted factor/KPI**	**Concerned OE dimension**
5S	7.1.4.1 Maintain the premises in a state of order	Working environnement	Culture
		Operational process efficiency and effectiveness	Results
		Quality assurance	Continuous improvement
	8.5.4.1 Product quality preservation	Quality assurance	Continuous improvement
		Delivered part quality performance, Operational process effectiveness, Cost of internal poor quality	Results
Standardized work	8.5.1.2 Standardized work instructions	Working environnement	Culture
		Quality assurance	Continuous improvement
		Delivered part quality performance, Process effectiveness, Operational process efficiency	Results
Visual management	5.3.1 Management involvement in designating the personnel responsible for customer satisfaction monitoring	Strategy and policy	Entreprise alignement
		Process effectiveness, Delivered part quality performance, Delivery performance, Customer disruptions, Warranty, Cost of external poor quality	Results
		Process improvement	Continuous improvement
TPM	8.5.1.5 Implementation of a documented TPM process	Management of maintenance by target	Entreprise alignement
		Quality assurance	Continuous improvement
		Cost of internal poor quality, Process effectiveness, Product conformance, Maintenance performance, Delivered part quality performance, Delivery Performance	Results
TQM	5.1.2 Management's commitment to the customer focus concept	Commitment and Leadership	Culture
		Strategy and policy	Entreprise alignement
		Quality assurance, Process improvement	Continuous improvement
		Delivered part quality performance, Delivery Performance , Customer disruptions, Warranty, Cost of external poor quality	Results
	10.2.3 Problem-solving methodology	Multidisciplinary working group	Culture
		Cost of internal poor quality, Process effectiveness, Operational process efficiency, Product conformance, Maintenance performance, Delivered part quality performance, Delivery performance, Customer disruptions, Warranty, Cost of external poor quality	Results
	10.2.4 Error-proofing devices	Quality assurance	Continuous improvement
		Cost of internal poor quality, Process effectiveness, Product conformance, Delivered part quality performance, Delivery performance, Cost of external poor quality	Results
	10.2.5 Warranty management	Warranty, Cost of external poor quality	Results
	9.2 Internal audits management	Quality assurance, Process improvement	Continuous improvement
		Strategy and policy	Entreprise alignement
		Cost of internal poor quality, Process effectiveness, Operational process efficiency, Product conformance, Maintenance performance, Delivered part quality performance, Delivery performance, Customer disruptions, Warranty, Cost of external poor quality	Results

The analysis of internal and external dysfunctions enables automotive companies to minimize poor quality costs, improve the processes' operations and manpower efficiency, reduce the non-conformity rate and improve the external KPIs. The problem-solving methodology can be used to solve the different processes' dysfunctions and thus contributes to the improvement of their operations. Clause 10.2.4 requires organizations to develop a documented process to manage Error-proofing devices [11]. These devices enable organizations to control the risks of process errors and quality defects and reduce the costs related to scrap, rework, and repairs, as well as the costs related to customer complaints. These devices improve processes' effectiveness by enabling them to achieve quality objectives. Clause 10.2.5 requires automotive companies to develop a warranty management process [11]. This allows organizations to eradicate problems detected by end customers and thus minimize the costs of external poor quality. Clause 9.2 of the IATF Standard requires organizations to conduct QMS audits, product audits and manufacturing process audits [11]. Audits assess the organization's performance and determine the improvement opportunities to be seized. Based on audit deviations, the management reviews the quality objectives, the pre-established strategy and the quality policy. Analyzing deviations and implementing the necessary actions enable automotive organizations to improve their internal and external KPIs.

4.2 Development of a roadmap for automotive companies to achieve operational excellence

In this section, a roadmap intended for automotive companies to achieve operational excellence is developed. This roadmap is based on the results of the first section of the present paper, which focuses on the correlation analysis between Lean Management organizational tools and automotive standard requirements and their impact on operational excellence. OE assessment is the first step of this process; it enables organizations to determine their OE maturity level and identify gaps. After the diagnostic, organizations can refer to the developed roadmap to establish their action plan. The latter would contain the Lean Management tools and the IATF requirements to be implemented as a priority. Once the action plan is implemented and deemed effective, a reassessment is necessary. Figure 1 summarizes the improvement process.

The developed roadmap is presented in figure 2, organizations can refer to it in order to prioritize actions, identify the levers on which they should focus and define their needs for resources and competences. An organization which has noted deviations related to the "culture" dimension should focus on the requirements contained in chapters "5: leadership", "7: support", "8: operation" and "10: improvement" and implement 5S as a priority, standardize the work and adopt TQM methods. The improvement of the "culture" dimension is conditioned by a work environment that promotes the operation of the various processes in good conditions, the establishment of a customer-focused spirit, the standardized work, and finally by the adoption of a problem-solving methodology.

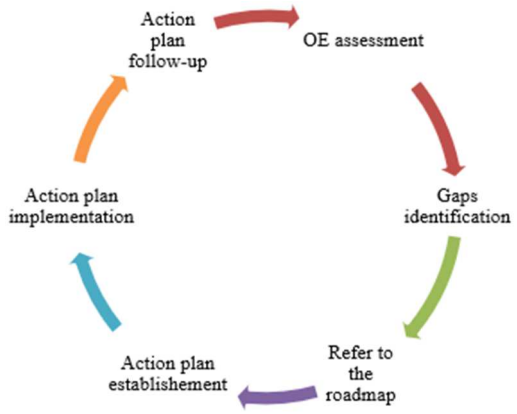

Figure 1 Operational excellence improvement process in automotive companies

In order to achieve OE through the "Continuous improvement" dimension, automotive organizations should implement the five Lean Management organizational tools and conform their QMS to the IATF requirements contained in chapters "5: leadership", "7: support", "8: operation", "9: performance evaluation" and "10: improvement". Particular attention should be given to operational management; organizations should organize their production workshops, preserve the product quality through the supply chain, standardize the activities, implement Error-proofing devices, conduct internal audits and adopt the TPM. The assignment of organizational roles and the management's commitment to a customer-focused approach are essential for this OE dimension. For organizations that have identified gaps related to the "Enterprise Alignment" dimension, their action plan should be based on the requirements related to chapters "5: leadership", "8: operation" and "9: performance evaluation" of IATF standard. Visual management, TQM, and TPM should be implemented as a priority. In order to align the operational work with the organization principles, the management's commitment to customer orientation is fundamental, the roles should be assigned, the TPM adopted and the internal audits conducted and their results exploited.

Finally, automotive companies that have noted gaps related to "Results" dimension should implement the five Lean Management organizational tools. The requirements contained in chapters "5: leadership", "7: support", "8: operation", "9: performance evaluation" and "10: improvement" should be analyzed and considered by the organization during the establishment of the action plan. To improve internal and external results, operational management and management's commitment are fundamental. In addition to the improvement axes of the "Continuous improvement" dimension, the "Results" dimension focuses on the problem-solving methodology and the warranty management.

OE dimension	IATF Chapter	Main requirements	Lean Management tools
Culture	5: leadership 7: support 8: operation 10: improvement	- Environment for the operation of processes - Standardized instructions - Customer-focused approach - Problem-solving	- 5S - Standardized work - TQM
Continuous Improvement	5: leadership 7: support 8: operation 9: performance evaluation 10: improvement	- Environment for the operation of processes - Quality preservation - Standardized instructions - Organizational roles - TPM process - Customer-focused approach - Error-proofing - Internal audit	- 5S - Standardized work - Visual management - TPM - TQM
Entreprise Alignment	5: leadership 8: operation 9: performance evaluation	- Organizational roles - TPM process - Customer-focused approach - Internal audit	- Visual management - TPM - TQM
Results	5: leadership 7: support 8: operation 9: performance evaluation 10: improvement	- Environment for the operation of processes - Quality preservation - Standardized instructions - Organizational roles - TPM process - Customer-focused approach - Error-proofing - Internal audit - Problem-solving process - Warranty management	- 5S - Standardized work - Visual management - TPM - TQM

Figure 2 Roadmap for automotive companies to achieve operational excellence

According to the developed roadmap, the requirements contained in chapters “5: leadership” and “8: operation” are fundamental to improving the four dimensions and achieving OE. In fact, chapter 8 requirements guide automotive companies in the operational management of their workshops and enable them to meet customer requirements. Furthermore, leadership is the cornerstone of any improvement process; a committed leader motivates the employees by developing their skills and potential, which will necessarily contribute to the success of improvement projects and the achievement of operational excellence. Referring to the developed roadmap, results show that "culture", "Continuous improvement" and "Results" dimensions are influenced by the effective implementation of the requirements contained in chapter "7: support". The latter determines the requirements related to human resources management, the improvement of their skills, as well as the process for motivating and empowering them. In fact, as mentioned by the authors [27,32], the human factor is the key element of success;

companies with committed and competent personnel achieve the expected results, succeed in implementing their culture and manage effectively the continuous improvement projects.

5 Conclusions

To follow the evolution of the sector and stand out from competitors, automotive companies put special focus on the control of the value chain, the assurance of their QMS and the results of their performance. The effective implementation of the various Lean Management tools and techniques enables automotive companies to improve their performance and optimize flows and processes by making them more effective and efficient. In this paper, Lean Management organizational tools that are 5S, standardized work, Visual management, Total Productive Maintenance and Total Quality Management were analyzed. Based on the correlation analysis between these tools and the requirements contained in the international automotive standard IATF 16949:2016, a roadmap is developed on which automotive companies can rely on to establish their improvement plan in order to achieve operational excellence. The roadmap determines the Lean Management tools to be prioritized in the lean project implementation as well as the IATF requirements to be integrated into the quality management system and implemented as a priority. The correlation analysis and the developed roadmap are among the original features of the present research. The performed analysis has shown that, to achieve operational excellence, organizations should focus in particular on the requirements contained in chapters "8: operation" and "5: leadership", in addition to the five Lean Management organizational tools. From this perspective, an empirical study is in progress involving local automotive companies in order to validate the results of the present article and determine the synergistic effect of Lean Management and the international automotive standard on operational excellence.

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