Study of the Impact of Lean Management Tools and the IATF Automotive Standard on Product and Process Quality Management

Oumaima EL AFFAKI[1], Mariam BENHADOU[1] and Abdellah HADDOUT[1]

[1] Industrial Management and Plastics Forming Technology Team, Mechanics, Engineering and Innovation Laboratory LM2I, ENSEM, Hassan II University, Casablanca, Morocco

Abstract. Faced with competitiveness and constant evolution in the sector, companies operating in the automotive industry focus their efforts on controlling the quality of manufactured products and manufacturing processes, eliminating waste, and improving performance results. Compliance of quality management systems with the automotive standard requirements is one of the major challenges facing automotive companies. IATF certification is required by the automotive market and is considered proof of the assurance of management systems. This article aims to demonstrate to automotive companies how to improve product and process quality management by implementing Lean Management tools and ensuring compliance with IATF requirements. To achieve this purpose, the concept of Lean Management and its tools in correlation with the requirements of the IATF 16949 automotive standard have been analyzed, and their synergistic effect on product and process quality management has been determined. A correspondence matrix, which will act as a guide for automotive suppliers, has been developed to determine the degree of impact of each pair (Lean Tool, IATF clause) on improving product and process quality management. This study has demonstrated that the implementation of Lean Management organizational tools and operational tools that are process-focused in conjunction with the requirements of the IATF significantly improves both product and process quality management. As for Lean Management operational tools that are flow-focused and analytical tools, their implementation in synergy with compliance with IATF requirements produces a high positive impact on process quality management.

Keywords: automotive sector, IATF, Lean Management, quality assurance, quality management.

1 Introduction

Faced with the constant evolution of the sector, automotive companies focus their efforts on ensuring the quality of the manufactured products, controlling the value

chain, responding to customer requirements, and continually satisfying their needs. To ensure their sustainability, companies operating in the automotive industry, whatever their rank in the logistics chain, pay particular attention to the elimination of waste, the management of the quality of products and manufacturing processes, as well as the compliance of their Quality Management System (QMS) with the requirements of the international automotive standard IATF 16949:2016.

Recognized as a universal management method, Lean Management is focused on eliminating waste, improving the effectiveness and efficiency of different processes, optimizing flows, involving staff, managing commitment, and seizing opportunities for improvement while establishing a spirit of teamwork. The concept of Lean began in the automotive sector at the Japanese manufacturer Toyota; it derives from its production system called Toyota Production System. The success achieved by Toyota has attracted the attention of other automotive manufacturers and suppliers as well as other sectors of activity [1-11]. IATF 16949:2016 is the international standard for the automotive market, which determines the requirements relating to the QMS applicable in the design, production, assembly, installation, services, and products relating to applications in the automotive sector [12]. QMS certification in accordance with IATF requirements is considered a license to operate in the automotive sector [13-15].

Given the diversity of Lean Management tools, the variety and complexity of IATF standard, several automotive companies ignore how to improve their product and process quality management while eliminating waste through the supply chain and conforming their QMS to IATF standard requirements. In this context, the objective of this article is to demonstrate to automotive organizations the impact of the implementation of Lean Management in correlation with the IATF 16949:2016 automotive standard requirements on the improvement of product and process quality management. In this study, we also propose a correspondence matrix that will guide automotive companies in establishing their progress plan.

2 Literature review

2.1 Lean Management

Today, Lean Management has become a fundamental approach serving companies that aim to improve their performance, increase customer satisfaction, and remain competitive in a changing environment. Lean Management is based on the definition of value for the customer, the identification of the value chain and the mapping of all the stages of the processes, the identification and elimination of non-value-added operations (overproduction, inventory, waiting time, motion, transportation, defects and errors, overprocessing and non-utilized talent), the organization and creation of a continuous flow without unnecessary interruptions, and finally, the implementation of a pull system in order to produce according to real customer demand [1, 8]. There are many Lean Management tools; each one is characterized by an objective, an approach, and a methodology. Analytical tools such as bottleneck analysis and Value Stream Mapping (VSM) make it possible to map flows, optimize operations, and improve the overall performance of the value chain. Lean Management operational

tools that are process-focused, such as Poka Yoke (PY), Kaizen, Single Minute Exchange of Dies (SMED), and Jidoka, contribute to the improvement of activities and the optimization of operations. Operational tools that are flow- focused such as Just-In-Time (JIT) and Kanban, allow the optimization of flows and delivery times. As for organizational tools such as 5S, Work Standardization (WS), Visual Management (VM), Total Productive Maintenance (TPM) and Total Quality Management (TQM), they contribute to improving the overall performance of organizations by optimizing the operation of different processes and improving their efficiency [3, 6].

2.2 International automotive standard

Through its requirements, IATF 16949:2016 encourages automotive organizations to develop a QMS capable of providing continuous improvement, the prevention of quality defects, as well as the reduction of waste and variations throughout the supply chain and to meet the requirements of their customers. IATF 16949:2016 has canceled and replaced the latest version of ISO/TS 16949:2009, which represents the 3rd version of the international standard that defines QMS requirements for the automotive market. To harmonize the different QMS evaluation systems and consolidate the requirements of the different manufacturers in a single reference system, IATF 16949:2016 was created in October 2016, after consultation and participation of several automotive manufacturers, suppliers, auditors, certification bodies, and global automotive industry associations. IATF 16949:2016 emphasizes in its latest version the risk approach and contingency plans, the involvement of management in the monitoring of process performance, the management of products with specific characteristics, safety and regulatory requirements, the design and development of the manufacturing process, the control of non-compliant products, as well as the development of the supply chain through the monitoring and development of suppliers of different tiers [12, 13, 15].

3 Methodology

The purpose of the present study is to answer the following research question: To what extent do the implementation of Lean Management tools and the compliance of QMS with IATF 16949:2016 requirements improve product and process quality management? To achieve this purpose, this article analyzes the correlation between Lean Management and the international automotive standard requirements and determines their synergistic impact on the improvement of product and process quality management. The principles of each Lean Management tool and method have been analyzed, and their correspondence with the relevant IATF clause has been determined. The present study considers the most implemented tools of Lean Management in the automotive sector that are required directly or indirectly by the IATF standard. The developed correspondence matrix synthesizes the correlation analysis carried out and

determines the synergistic impact on improving product and process quality management. The impact of each pair (Lean Tool; IATF clause) is determined according to the contribution of the latter to the improvement of performance indicators relating to the product or process. The considered Key Performance Indicators (KPIs) were determined according to the requirements of the IATF automotive standard contained in clauses 9.1.2.1 and 9.3.2.1 relating to the evaluation of customer satisfaction and the conduct of the management review, respectively [12]. We classify KPIs into two categories. The first category concerns product quality management and includes the performance indicator evaluating the conformity rate of manufactured products. The second category includes process effectiveness and efficiency, maintenance performance and delivery performance, these KPIs concern process quality management. Table 1 presents the KPIs considered to determine the impact of each pair (Lean tool; IATF clause) on improving product and/or process quality management. The rating used to determine the degree of impact of each pair (Lean tool, IATF clause) on product and/or process quality management is as follows: "0" means no impact, a minor effect is translated by "+", a medium effect by "++" and a major effect is marked by "+++".

Table 1. Determination of product and process KPIs according to the IATF 16949:2016 standard

KPI label	**Impact on Product/Process**
Product conformance	Product
Process effectiveness	Process
Process efficiency	
Maintenance performance	
Delivery performance	

4 Results and discussion

In this section, a correspondence matrix has been developed between Lean Management tools and the requirements of the automotive standard, and the impact of the latter on product and process quality management has been determined. Table 2 presents the developed correspondence matrix.

Lean Management is based on tools and methods that aim to eliminate waste, optimize operations and flows, and reduce costs while ensuring the quality of the manufactured products. This is in alliance with clause 10.3.1 of the IATF automotive standard, which requires automotive organizations to implement a documented process of continuous improvement once manufacturing processes are stable and capable [3, 12].

The concept of the 5S tool is linked to clauses 7.1.4.1 and 8.5.4.1 of the international automotive standard [3]. The implementation of the 5S tool and compliance of the QMS with clause 7.1.4.1, which requires maintaining premises in order, contribute to improving the quality of products and manufacturing processes. Indeed, the organization of workstations and the elimination of contamination sources enable

organizations to preserve the quality of the products, carry out operations in good conditions, and improve the effectiveness of operational processes and the efficiency of manpower. On the other hand, automotive organizations are required by clause 8.5.4.1 to preserve the quality of products from their reception, throughout the manufacturing processes, and until delivery to customers [12]. The adoption of the 5S tool and compliance of QMS with this requirement enable automotive companies to guarantee the quality of manufactured products throughout the automotive logistics chain and thus satisfy their customers.

The principle of visual management is related to clause 5.3.1 of the IATF automotive standard, which requires management to designate personnel responsible for monitoring customer satisfaction and analyzing customer scorecards [12]. Customer dashboards primarily provide performance results for delivered parts as well as delivery performance. The analysis of data collected from customer portals and the implementation of necessary corrective actions for unachieved quality objectives allow automotive organizations to improve the efficiency of their processes and contribute to the quality assurance process for manufactured products.

Clause 8.5.1.2 of the IATF 16949:2016 standard explicitly requires automotive organizations to adopt standardized work, develop work instructions, and communicate them to relevant personnel [12]. Standardized work ensures that all products are manufactured in the same way and controlled according to predefined specifications, reducing the risk of error or quality defects. Standardization also helps improve the effectiveness and efficiency of operational processes by establishing optimal working methods.

TPM is explicitly required in clause 8.5.1.5 of the international automotive standard [9, 12]. Maintenance management with the TPM method allows organizations to improve the reliability of their production equipment, improve maintenance performance as well as the efficiency of operational processes, and ensure the manufactured products' quality.

The principle of TQM is linked to clauses 5.1.2, 10.2.3, 10.2.5 and 9.2 of the international automotive standard [3, 16]. Clause 5.1.2 requires management commitment to customer focus [12]. By establishing a customer satisfaction-oriented QMS, organizations respond to the requirements of their customers relating to the manufacturing of products and the functioning of processes. The problem-solving is required in clause 10.2.3 of the IATF standard; in fact, the adoption of a problem-solving methodology to analyze the quality defects and dysfunctions of different processes contributes to improving the quality management of products and processes. As for warranties' management, it is required in clause 10.2.5. By eradicating problems detected by final customers, product conformity is ensured, and product quality management is improved. Clause 9.2 of the IATF automotive standard requires automotive organizations to conduct manufacturing process audits, product audits and QMS audits [12]. The deviations noted during the various audits should be exploited by the organizations with the aim of improving the quality management of products and processes as well as the entire management system.

The VSM is an analytical and visual tool for identifying non-value-added operations, areas to be improved, and operations to be optimized [17]. Its principle is relat-

ed to clause 7.1.3.1 of the automotive standard, which requires adopting an approach to improving factories, equipment, and installation by optimizing flows and exploiting space [12]. Adopting VSM and complying with QMS requirement 7.1.3.1 enable organizations to identify different sources of waste, optimize workflows, and improve operational processes' effectiveness and efficiency. On the other hand, bottleneck analysis is an analytical technique that aims to streamline production flows and resolve the constraining causes to achieving the requested customer rate. The principle of this tool was associated with clause 8.2.3.1.3 of the IATF standard, which requires carrying out a feasibility study to ensure the organization's ability to keep up with the requested customer rate over time. The feasibility study and bottleneck analysis improve the effectiveness and efficiency of operational processes as well as delivery performance by minimizing waiting times and meeting customer requirements for lead times.

The principle of the Kaizen tool is linked to clause 7.3.2 of the IATF, which requires automotive suppliers to motivate and empower personnel to achieve continuous improvements. This approach encourages employees to actively participate in resolving quality issues and other dysfunctions detected, which enhances the management of product and process quality.

Automotive organizations are required by clause 10.2.4 to implement error-proofing devices in order to control the risks of quality defects and process errors and to reduce the resulting costs [12]. The implementation of Poka Yoke and compliance of the QMS with this requirement contribute to improving the quality management of products and processes.

SMED is a fundamental Lean Management tool that aims to reduce change time by carrying out part of the operations upstream of the change and by optimizing and standardizing working methods. The SMED principle is associated with clause 9.1.1.1, which requires organizations operating in the automotive sector to monitor and measure manufacturing processes and maintain documented information relating to significant process events such as tool changes. Adoption of the SMED tool and compliance of the QMS with this requirement reduces lead time, improves operational processes' efficiency, and allows organizations to satisfy customer demands relating to delivery schedules.

Jidoka relies on the visual alert when a problem or a quality defect occurs in the manufacturing process. Jidoka has been linked to clause 8.5.1.1, which requires developing a control plan including the reaction method when a non-compliant product is detected, or a failure and instability of the manufacturing process occurs. Jidoka and the reaction plan, which must be defined on the control plan, have a complementary effect; they contribute to the reduction of quality defects by ensuring the intervention at the right time by the personnel responsible for product conformity, and they also make it possible to reduce waiting times, thus improving the operations' efficiency and the deliveries' performance.

Table 2. The correspondence matrix between Lean Management tools and the automotive standard requirements and the determination of their impact on product/process quality

	IATF Clause																	Product Quality	Process Quality
Lean Tool	5.1.2	5.3.1	7.1.3.1	7.1.4.1	7.3.2	8.2.3.1.3	8.5.1.1	8.5.1.2	8.5.1.5	8.5.1.7	8.5.4.1	9.1.1.1	9.2	10.2.3	10.2.4	10.2.5	10.3.1		
5S				X													X	++	+++
											X							+++	0
VM		X															X	++	++
WS								X									X	+++	+++
TPM									X								X	++	+++
TQM	X																X	++	++
													X					+++	+++
														X				+++	+++
																X		+++	0
VSM			X														X	0	+++
Bottleneck Analysis						X											X	0	+++
Kaizen					X												X	+++	+++
PY															X		X	+++	+++
SMED												X					X	0	+++
Jidoka							X										X	+++	++
JIT										X							X	0	+++
Kanban										X							X	0	+++

Considered a pillar of Lean Management, JIT makes it possible to minimize stocks and avoid overproduction by producing on a pull flow. JIT and Kanban are closely linked; to implement a pull flow and deliver to customers just-in-time, automotive suppliers adopt Kanban, which is a visual system that ensures the production of the right quantities of products at the right time [18-20]. The concepts of JIT and Kanban are linked to clause 8.5.1.7 of the IATF automotive standard, which requires automotive companies to verify that the production scheduling applied enables organizations to fulfill customer demands regarding JIT deliveries and to implement an information system that ensures the availability of production data at key stages of the process according to an order-driven flow. The adoption of JIT, the implementation of the Kanban system, and the compliance of the QMS with requirement 8.5.1.7 of the automotive standard have a positive impact on delivery performance and contribute to the improvement of processes by increasing their efficiency.

According to the correlation analysis carried out between Lean Management and requirements of the IATF 16949:2016 standard, and the developed correspondence matrix, we note that the implementation of Lean Management organizational tools in correlation with the requirements of the IATF significantly improves product and process quality management. The implementation of Lean Management analytical tools in synergy with the IATF requirements has a high impact on process quality management. Lean Management operational tools that are process-focused in conjunction with the automotive standard requirements produce a positive effect on product and process quality management. And finally, the implementation of operational tools that are flow-focused in correlation with the compliance of QMS with IATF requirements have a positive impact on process quality management. On the other hand, the IATF 169949:2016 standard encourages automotive organizations to develop a QMS oriented toward continuous improvement and favors the prevention of defects and the reduction of waste [3, 12]. Indeed, the correspondence matrix developed illuminates the link between Lean Management and the international automotive standard and underlines their interdependence, thus affirming the purpose and intent of the IATF 16949 automotive standard.

5 Conclusion

To guarantee their sustainability and preserve a dominant position within the sector, automotive organizations focus their efforts on eliminating waste, ensuring the quality of manufactured products, controlling the quality of processes, and implementing effective and mature quality management systems. In this paper, a correlation analysis is carried out between Lean Management tools and the requirements of the international automotive standard IATF 16949:2016, and the synergistic result of their combined implementation on the quality management of products and processes is determined. At the end of this study, a correspondence matrix was developed that will serve as a guide for automotive companies wishing to improve their methods of man-

aging the quality of their products and processes. The correlation analysis carried out and the correspondence matrix developed are part of the originality of this article.

The results of the present study showed that the implementation of Lean Management organizational tools in conjunction with the requirements of the IATF standard and the adoption of Lean Management operational tools that are process-focused in synergy with compliance with the IATF requirements significantly improve the product and process quality management. As for Lean Management analytical tools and operational tools that are flow-focused, their implementation in correlation with compliance with IATF requirements has a positive impact on process quality management. In perspective, empirical research is planned involving automotive companies located in Morocco to confirm the outcomes of this article and quantify the synergistic impact of Lean Management and the international automotive standard requirements on the improvement of product and process quality management.

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