

Lean manufacturing maturity level: a case-study applied in the Brazilian auto-parts industry

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Article History:

Submitted: 2021- 09 - 09

Revised: 2021 - 09 - 16

Accepted: 2021 - 10 - 01

Abstract: Lean Manufacturing known as Toyota Production System is a systematic method of waste reduction within a manufacturing system without sacrificing its productivity, assisting on the identification and steady elimination of waste. It has started in Japan and, besides the culture differences, it has arrived in Brazil and is being successfully used in some companies with engagement and commitment through the employees. As lean manufacturing is composed by many different tools that support the sustainability of the continuous improvement and considering the difficulty in assessing the evolution of this system through the operational maturity level, it is important to have a general overview of how methods are implemented and sustained by the organization in order to reach its targets. So far, the purpose of this article was the application of a business process maturity model questionnaire in a Brazilian auto-parts manufacturing company, specializing in interior electronics, which has fourteen methods related to its business system, then ordinate them to facilitate the gap's visualization between them and the company's target. The first step was to understand each method, adapt the Business Process Maturity Model (BPMM) to evaluate the methods maturity, and finally propose a connection between them in order to observe the gaps and help the company to develop an action plan to guarantee that the sustainability of the implementation until all the methods reaches the highest lean maturity level.

1. Introduction

Toyota production system, known as lean manufacturing, has begun its roots in Japan in the 1948's and since then is being followed by many companies around the world as an exemplar technique of waste reduction and, consequently, a maximization of the value to the customer of the product. As lean thinking is spreading itself around the world and in many different industries besides the automotive, leaders have to adapt tools and principles in order to make it work properly.

Considering that lean manufacturing system consists in a collection of tools and methods that assists the identification and elimination of waste, and so, continuous improvement, it is extremely hard to demonstrate and track the evolution of the lean manufacturing methods until it reaches an operational maturity point, especially when the plant has targets to reach.

A relevant point is that even for Toyota, the benchmarking for the lean thinking, the standardized work takes time to reach a sustainable maturity level, demanding a huge involvement and dedication from the employees (Baraldi and Kaminski, 2008), proving that it is necessary patience and focus in order to achieve the goals.

2. Objective

This paper is a case study developed at a German automotive manufacturing company, specialized in interior electronics and related parts for the automotive and transportation industries. The aim of this study was to adapt a Business Process Maturity Model (BPMM) to analyze and evaluate the current maturity status of the lean methods of the organization and ordinate them according to its maturity level, helping the team to have a better visualization of where to focus their improvement efforts to reach the company's target.

It is important to highlight that this concept need to be periodically repeated, always thinking of the continuous improvement process (Kaizen). Also, the achievement of each level depends on the proper actions taken, the environment and the culture. The main idea is to evaluate the current maturity level of the organization's methods and, afterwards, draw up plans to raise this maturity, focusing on the objectives that it wants to reach.

3. Literature Review

Lean manufacturing or lean production is a method for waste minimization (manufacturing without waste) that analyze everything that is not adding value, such as, overproduction, waiting time, inventory, processing, product defects. It helps the company to see what adds value to the final product in order to stay "lean".

The intention of lean manufacturing is to eliminate waste in human effort and inventory, get to the market on time and manage the manufacturing properly to guarantee the quality of the products and attending to the customers' demands in the most economical way (Bhim et al., 2010).

Toyota Production System (TPS) created a concept of Lean Thinking (LT) in order to understand the proper value of any process by characterizing the value-added activities and non-value-added ones, always eliminating waste (Antony, 2011) (Sundar et al., 2014).

In summary, lean manufacturing converges to efficiency, fast productivity at the lowest cost. A set of 14 lean manufacturing tools used by the company in the case-study is described in the following items:

3.1 Value Stream Mapping (VSM)

Value Stream Mapping, or VSM is "the set of all the specific actions required to bring a specific product through the three critical management tasks of any business: Problem Solving, Information Management and Physical Transformation" (Fawaz et al., 2007). On the other hand, VSM refers to the process of mapping the material and information flows, important to coordinate manufacturers, suppliers and distributor activities to deliver products to customers.

VSM allows the performance evaluation of the process under analysis and to identify the occurrence of "looses", or wastes, characterized by tasks that the lean programs denominate as "8 sources of wastes". These wastes are related to overproduction, waiting, unnecessary motion, processing, inventory, defects and underutilization of people (Wahab et al., 2013).

3.2 5S

5S is considered one of the basics and efficient steps of lean manufacturing, focusing on cleaning, sorting, organizing, standardize and providing the necessary base for a continuous improvement environment. Derived from five Japanese words, the 5S are Seiri, Seiton, Seiso,

Seiketsu and Shitsuke, in English, Sort, Set in order, Shinning, Standardize and Sustain (Agrahari et al., 2015).

Sort helps to separate what is needed from what is not, removing all the unnecessary items. Set provides locations and quantities (everything in its place and time) for efficient operations. Shine means the cleaning, keeping the workplace easy to work. Standardize the best practices in the work area, implement visual displays and control in order to maintain high standards. Sustain is related to the concept of self-management, each person helping to maintain the sustainability, helping to keep the organization effort in place, getting total employee involvement.

So far, 5S is an essential technique used to bring up the lean culture by developing a successful environment for deploying standards of workplace practices, it emphasizes the concepts of removing wait time and no value added activities.

3.3 Standard Work (SW)

Standard work refers to a way to carry out the job in the shortest repeatable time resulting in effective utilization of resources such as people, machines and material. It is described as a set of analysis tools that result in standard operations, following some process steps as work sequences, cycle time, work-in-process, etc. that helps to control and improve work design, respecting demands and time (Antony, 2011).

This process helps the visualization of the operator movement and material location according to the process layout, contributing to the successful lean implementation of lean manufacturing system. Therefore, it is a principle of waste elimination, ensuring that each job is organized and carried out in the most effective manner, always focusing on quality achievement, regarding the person who is doing the job, i.e., every worker have to follow the same process steps all the time (Fawaz et al., 2007).

3.4 Visual Management (VM)

Visual management is one of the lean techniques that aim to help any person entering a workplace, even those who are not familiar to the process, to understand it. It is a system that improves the performance of the organization by connecting and aligning the information, it is the use of visual aids to make the communication simple.

Visually communicating both the performance and the plan to everyone is an important part to distribute, control, identify deviations, and maintain the schedule. So far, it is structured with given information that helps the communication of the workplace with other people around, transforming the place self-explanatory, self-ordering, self-regulating and self-improving; transform the place independent (Tazel et al., 2010).

3.5 Gemba Walk

Gemba walk is a management concept based on communication, visualization, standardization and continuous improvement. It establishes a structured way to connect the managing level to the shop floor process and employees, allowing information to flow quickly through the organization to the correct level (from operational to management level), according to John Womack (2011), this tool is a unique and natural way to collect information and see, ask, show respect.

In addition, gemba walk empowers all employees to recognize deviations and pragmatic problem solving solutions as well as initializing and implementing improvements; creating structure and environment to promote lean process and achieve results faster and sustainably (Womack et al., 1990).

Simplifying, this concept means "going to the place of activity looking for muda or waste", and it has become a way of life in a lean workplace, where everyone is responsible to identify waste and inefficiency, eliminate it and keep continuous improvement (Imai, 1997).

3.6 Jidoka

Jidoka, or intelligent automation, means having a culture and the appropriate system in place that immediately enables the identification of deviations, and then take pertinent actions, such as stopping the line or process in order to avoid further failures and losses.

The central principle of Jidoka means "automation with human touch" to prevent the propagation of defects, eliminating errors during processing and flow of production (Ghinato, 2000). It also consists in delegating to the person responsible for the work, the autonomy to stop the process when detecting any abnormality; it means that, as soon as defects are detected in the process, the intervention is necessary to perform the correction, avoiding the propagation of them (Steven, 2003).

3.7 Problem Solving

Problem solving is a step by step approach to investigate, correct and document the root cause of internal and external non-conformances associated with products and processes, ensuring that the problems will be sustainably solved and preventing recurrences. It is also important to mention that the employees have to understand and detect problems, since they will be the "managers" of their own problem solving process, as they are more involved with the process itself, helping to permanently correct and improve the products and processes (Miranda et al., 2003).

This tool is considered the act of defining a problem, determining the cause of the problem, identifying, prioritizing and selecting alternatives for a solution and implementing it. The organization needs to have practice for process improvement, especially to create problem solving capability among employees to make it sustainable (Puvanasvaran et al., 2008).

3.8 Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) is a method to obtain the best performance from equipment, using adequate maintenance techniques and involving all levels of the organization to reduce maintenance efforts. It focuses on maximizing efficiency of a production system during the whole life cycle, increases equipment performance eliminating breakdowns, and avoiding unplanned breakdowns (Pinto et al., 2016).

Furthermore, this methodology aims to increase the availability of existing equipment and, consequently, reducing the necessity of additional investment. Also, it was designed to maximize equipment effectiveness by establishing a productive maintenance system for the entire life-cycle of the equipment (planning, use, maintenance, etc.) with the involvement of all workers at the company, contributing to the continuous improvement activities (Mwanzaa and Mbohwa, 2015).

3.9 Frontloading

A method helps on the product or process development reaching an agreement on solutions in an early phase and close to customer needs by putting preparatory work and early consumption of resources. It is the foundation for flawless execution thought the program is analogous to the shop floor maximization of measurement.

Frontloading is also defined as changing identification method, finding and solving problems during the first phases of the product development process (Martínez et al., 2011).

3.10 Lean Clever Automation (LCA)

Consists on techniques to minimize and automate handling in respective operations in a simple and cost-efficiency way. Lean Clever Automation use the gravity force to automate the movement of parts from one station to the other. So the basic principle is to avoid expensive automation systems minimizing the required investment (Kolberg and Zühlke, 2015).

The main characteristic of this method is to focus on lowest maintenance efforts, optimizing invest volume in order to improve flow in repetitive process, as production. As consequence, it achieves more flexibility by less complexity and provides a better floor space utilization, since it focuses on simple, space-saving, clever and economical resources for operations.

3.11 Lean Product Design

Lean productive design focus on understanding and considering the internal needs of the company, in order to ensure manufacturability of the product by application of design specifications and simultaneous engineering according to product life cycle, focusing on understanding and considering the needs of the company.

This method helps to enhance product design for robust, safe and simple production processes, ensuring safe, rapid and reliable launch. As consequence, it helps to reduce time to market, complexity and variants in production, saving costs and increasing the quality (Gautam and Singh, 2008).

3.12 Network Collaboration

It is a way to establish collaborative cross-functional networks between various departments within the organization, in order to act to solve situations that require collaboration of anyone able to help, i.e., interactions run vertically and laterally.

Network collaboration contributes on achieve fast decisions and efficient solutions, improving the adaptability and agility to business changes in the organization. It also demands participation and engagement from the people involved (Ahuja, 2000).

The relevance of this method is having better comprehensive solutions, as the different views are considered, including all interfaces and process partners, it connects colleagues with a common interest in the same subject, collaborating for a greater knowledge exchange, besides motivating a good networking through the best practices.

3.13 Policy Deployment

Deploys a vision followed by a strategic plan through the organization, it is a strategic planning/ management methodology involving the full commitment necessary to achieve the common goals. It helps the organization to share vision and goals that are connected to daily business, integrating all the employees through the contribution they provide, by using interactive feedback and communication.

Policy deployment directly links the vision and daily business of the company, embracing all the employees and also makes sure that all the implementation plans are synchronized (Tennant and Roberts, 2001).

The methodology implementation starts with the vision (ideal stage) of the internal and external situations, then moves to the tangible vision, starts the initiatives and projects to achieve that, find the necessary metrics and responsibilities, moves to the tactical implementation plan, and finally, implement that proposal.

3.14 Workplace Design

Organizes and arranges a workplace to improve the overall flow, increasing employee`s safety, ergonomics and customer needs. It develops or improves workplaces by lowering the overall process time and effort of tasks and processes (Chafin, 2007).

The principal points considered while applying this method are the ergonomic, avoiding injuries or disorders to the employees; human-machine interface, ensuring that the workplace is appropriate to work; value and flow, by designing clean and obvious streams; and other general aspects, creating a useful and effective work environment.

4. Methodology

The Business Process Management Model (BPMM) is a theoretical model that provides a needed standard for evaluating the capability and maturity of business processes and compares the maturity level of an organization's existent practices with the industry standard, helping the company to set priorities in order to improve its product or service operations using the developed strategy given by the BPMM analysis (Lee at al., 2007).

This model provides a standard roadmap for assessing process maturity and guide business process improvement; it illustrates the evolution of an improvement sequence that orients the organizations as they move from immature, inconsistent business activities to

mature, disciplined processes. It is important to emphasize that if an organization does not understand the process, it cannot see it in a cross-functional way, and it is only possible to measure the performance of functional areas separately, affecting performance measurement, quality monitoring, cost, problem resolution, and others.

The business process maturity model taken as the basis in this paper was the Business Process Maturity Model (BPMM) maintained by OBJECT MANAGEMENT GROUP, INC (BPMM, 2018) with some adaptations, since this model uses a Business Process Management view within the life cycle of a process that starts from its discovery and continues until its implementation, in order to make the institution able to implement a technological process management solution.

The maturity scale is similar to the process maturity model of Capability Maturity Model Integration (CMMI) Institute and it is applicable for product development, service provision, procurement and methods as well. The achievement of each target depends on the transformation actions of the process, the environment and the culture of each institution.

The idea was to evaluate the current maturity of each method of the organization, order them according to its level, helping the gaps visualization, so then, in the future, the company can draw up plans to raise this maturity, focusing on the objectives given as target.

The proposed model is divided into five levels of maturity (initial, manageable or repeatable, standardized, predictable, and optimized), each level represents how the methodology is implemented in the company and how close to the target it is. By ordering these stages, it is possible to define the improvements undertaken at the next stage, by helping the identification of deficiencies and guiding the improvements in logical, incremental steps.

Level 1 - Initial

The organization typically does not provide a stable environment for the method development, management is not consistent and it is hard to predict the results. As an implication, it can cause bad quality, uncertain, uncoordinated and unstructured information.

The main characteristics of the first maturity level are: punctual approaches; individual efforts; various non-consolidated methodological approaches, tools and techniques; limited scope of BPM initiatives; minimal development of employees; low dependence on external BPM expertise; and high level of manual intervention and "putting out fires" practices.

Level 2 - Manageable (repeatable)

At this level, the company ensures that all the requirements are managed, the methods planned, executed, measured and controlled, and making sure that all the status are visible to management at specific points.

Discipline helps to ensure that the existent practices are maintained even during the crisis's moments, and proper management enables the reproduction of the procedure in order to increase the quantity of people involved with it.

The main characteristics of the second level are: first methods are documented; recognitions of the BPM importance; more involvement from executives and top management; a main reason to explore BPM; an extensive use of the methods; first attempts on using structured methodologies and common standards; increase of the dependence on external expertise; methods attending the specified standards and requirements; the results are more predictable.

Level 3 - Standardized (defined)

At this point, methods are well characterized and comprehended, been described according to the standards, procedures, tools and methodology. The standards procedures are documented through the organization, including management standards, integrated with coherence.

The organization's management sets targets based on this standard and ensures that these goals are followed appropriately, also, training programs implemented to ensure that staff and managers have the same knowledge and skills required to fulfill the roles assigned to them.

The main characteristics are: focus on managing the early stages; use of the elaborated tools; combine different methods and tools; comprehensive and formal BPM training; reduced reliance on external expertise; basic activities are performed according to well-defined methods, following the standards adopted by the organization; relations between the methods are defined; uses of measurements to help on management.

Level 4 - Predictable (quantitatively managed)

The capabilities enabled by the standardized methods are exploited and returned to the work units. The performance is managed statistically during the execution of the entire

workflow by understanding and controlling the variation, so the results are still predicted, even in intermediate stages.

When the organization achieves this level of maturity, the benefits on having it heavily embedded in this improvement strategy, will be finally been enjoyed and helpful.

The main difference between this level and the previous one is that in level 4, the performance of the methodology is quantitatively know and controlled. Other characteristics are: stabilized standards; good acceptance of all the methods; huge knowledge of the tools from all the employees; almost non dependence from the external support.

Level 5 - Optimized

Actions for proactive and opportunistic improvements seek innovations able to close gaps between the organization's current capacity and the capacity required to achieve its business goals. So far, as the entire company is focused on continuous improvement, it is possible to assume that it has finally achieved the level five of maturity.

Lessons learned are disseminated and the optimization of fast and innovative processes depends on the participation and empowerment of the workforce, aligned to the targets and values of the organization and its business. The improvement becomes part of everyone's activity, leading to a continuous improvement cycle.

The main difference from level 4 and 5 is that this level has a permanent improvement oriented to the strategic objectives of the organization. As mentioned, the BPMM questionnaire used in this paper was an adaptation from the OMG model, and it can be viewed at the Table 1. It is important to note that it is a very simple questionnaire, which the only possible answers are YES or NO.

Succeeding the questionnaire application and obtaining the maturity level of each method, it is possible to have a clearly visualization of the method's stages by compiling all the information in one graphic (Figure 1). In addition, as the proposed model considers five different levels, in order to have the overall information regarding to the maturity level itself, it was used the average among them to indicate the maturity of the method.

Table 1 - BPMM questionnaire. Source: Adapted from OMG (BPMM, 2018).

Level 1
Are the approaches punctual?
Are the efforts are individual?
Is there more than one methodology approach?
Is there more than one applicable tool?
Do the searching techniques change frequently?
Is the process mapping restricted to your coordination / sector / advisory / section / subsection?
Only a few people participate in the process mapping initiatives?
Are initiatives only done in your area without external support?
Is there much non-systematized work?
Are there problems that occur frequently?
Level 2
Are there any documented processes?
BPM is not important to your organization?
Do your superiors support or participate in the ongoing initiatives?
Is there a purpose for BPM initiatives?
Is there a tool with the mapped process repository?
Is there a structured methodology for the method?
Are standards common to all?
Are queries in the area responsible frequent?
Are the services offered delivered to specified standards and requirements?
Are there methods that are planned and managed?
Are the results predictable?
Are the sub process and activity not well defined?
Not all methods are associated with macro methods?
Level 3
Are all the organization's basic methods already mapped?
Are there automated methods in the tool?
Are there processes based on risk management?
Are there processes published or available on the intranet?
Is there formal and continuous training in BPM?
Is there any assessor or fixed department focus on supporting the BPM initiatives?
Are the basic activities executed according to a well defined method and following the adopted standards?
All the methods are associated, at least, with one macro methods?
Are there effective indicators on the methods execution?
Level 4
Is there any assessor or fixed department to report before doing any modification?
Are there any technological control mapped process?
Is there any financial control?
Does the process pass through other departments and involve more than one area?
All the methods, requirements and critical success factors are documented?
The methods and tools are widely known and accepted?
All the initiatives follow the same methodology and are approved by the same area?
Is the organization focused on process management?
Is there any detailed performance measurement ?
Is the detailed performance measurement periodically and systematically fulfilled and analyzed?
Is it easy and reliable to predict the performance?
Are there any methods to define and quantify the quality of the products or services?
All the questions above are executed in a quantitative way for all the process?
Level 5
Is the process management institutionalized and part of the daily activities?
Does the performance measurement have a clear responsible?
Is the measurement done and executed by the entire organization?
Are the process memory cycle executed in a systematically way?
Is the organization managed focused on the methods?
Are the methods aligned with the organization's strategy?
Does the strategic planning demand any changes on the process?
Are there ways to provide feedbacks regarding to the method's performance?
Are the improvement actions and innovations oriented by statistical data and client's feedback?
All the organization's process is mapped?
Does the mapped process have a date to start the improvement cycle?
At the strategic planning, are the impacted methods defined and part of the improvement cycle?

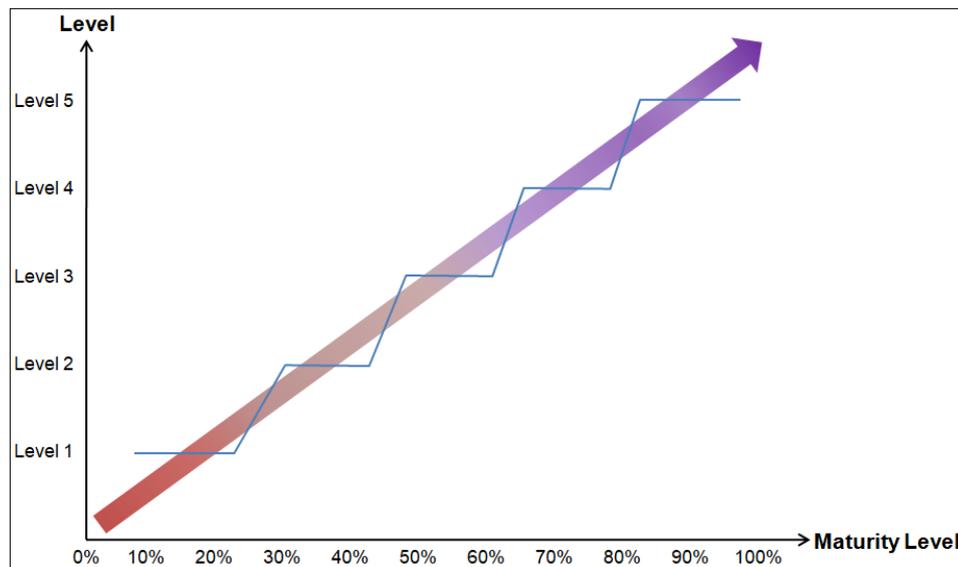


Figure 1 - Graph of the maturity according to the level.

Source: Authors.

It is also important to mention that the ideal maturity level of each tool, would be the highest level as possible, since having all these methodologies well implemented, standardized and optimized would be the "ideal scenario" for every company. But obviously that it is something really hard to achieve, especially when dealing with daily situations that need to be prioritized to not harm or lose the customer.

The company studied in this paper, has the maturity level target as, at least, minimum of 80% and ideal average around 85% for each method. And, as mentioned before, this is a very hard target to achieve, but not impossible.

So far, by applying the BPMM questionnaire and analyzing the data collected, it would be possible to have a better view of the results and compare them to the organization's ideal maturity level of each method and, finally, analyze the gap between them.

As mentioned, the BPMM model is divided into 5 maturity levels, and each level represents how the organization transforms itself as the methods are implemented and improved. The Table 2 represents a summary of each level, as the related score obtained by the average of the five levels.

Table 2 - Level description and associated scores. Source: Adapted from OMG (BPMM, 2018).

LEVEL	DESCRIPTION	SCORE
1	The organization typically does not provide a stable environment for the method's development.	0 - 20%
2	The methods are planned, executed, measured and controlled. Local procedures are stable.	21 - 40%
3	The methods are well characterized, comprehend and described according to standards and procedures. The standards exist and are well defined.	41 - 60%
4	The quantitative and qualitative management of the method's performance. The results are predictable and real-time corrections. Continually and proactively improvements.	61 - 80%
5	The entire organization is focused on continuous improvement and the lessons learned are disseminated.	81 - 100%

5. Case study

The case study was developed in an auto-parts German automotive manufacturing company, specialized in interior electronics and related parts for the automotive and transportation industries. The company has approximately 190 plants all around the world, and even if the Lean methods are mandatory to all of them, the Lean maturity level differs according to its location.

In this case study, the plant analyzed is located in Guarulhos, São Paulo, Brazil, which concentrates the production of the interior automotive parts, involving a team of approximately 400 engineers focused on local development of specific products in order to attend the client demand.

The company's business system focus on lean methods to set the mindset of always look for improvement opportunities through the daily work, ensuring simple structures and efficient and effective workflows for the complete value chain. This system is based on fourteen methods that support their objective in generating sustainable value for all stakeholders.

As mentioned, the fourteen supported methods are: 5S; Frontloading; Gemba Walk; Jidoka; Lean Clever Automation; Lean Product Design; Network Collaboration; Problem Solving; Value Stream Design; Standard Work; Visual Management; Policy Deployment; Total Productive Maintenance; and Workplace Design.

So on, after understanding all the methods and the BPMM concept for evaluation of the maturity level of a process, the continuous improvement team contributed to the development of this paper. They explained the meaning of each method for the company, gave the proposed

targets, and provided all the necessary information for the BPMM questionnaire, applied in each different method, so it was possible to measure the maturity level individually.

Once obtained the results of each questionnaire, it was possible to have an overview of the maturity level of each method, according to the score reached in every level of maturity, by taking the average between all the levels and finding a value to represent the maturity level of the method itself.

At the beginning of each year a target is set for the plant, in this case, the expected target for each method is 85% of maturity. It is up to the plant to measure and make sure that all the objectives will be achieved by the end of the year, or by the time that the plant receives the outside audits.

6. Results

The BPMM original questionnaire was adapted so that it could be used in the measurement of the maturity level of the methods instead of the processes, providing the necessary standard for evaluating the capability and maturity and comparing it with the organization's target.

Through the questionnaire application a roadmap was generated according to the percentage level (1-5) of each method, which was compiled as the average between them, providing a general maturity level, as shows at the table below (Table 3).

Table 3 - Results from the average of the BPMM questionnaire.

Method	Maturity Level
Value Stream Mapping	3%
Policy Deployment	29%
StandardWork	31%
Front Loading	44%
Lean Product Design	49%
Gemba Walk	52%
Jidoka	54%
Visual Management	57%
Workplace Design	61%
Problem Solving	67%
5S	69%
Lean Clever Automation	76%
Network Collaboration	79%
Total Productive Maintenance	81%

Source: Authors

Subsequently, it was possible to compare the values to the organization's ideal target by using a roadmap that simply identifies where the main gaps are, and which method need more attention (Figure 2), it shows that none methods have achieved the goals yet.

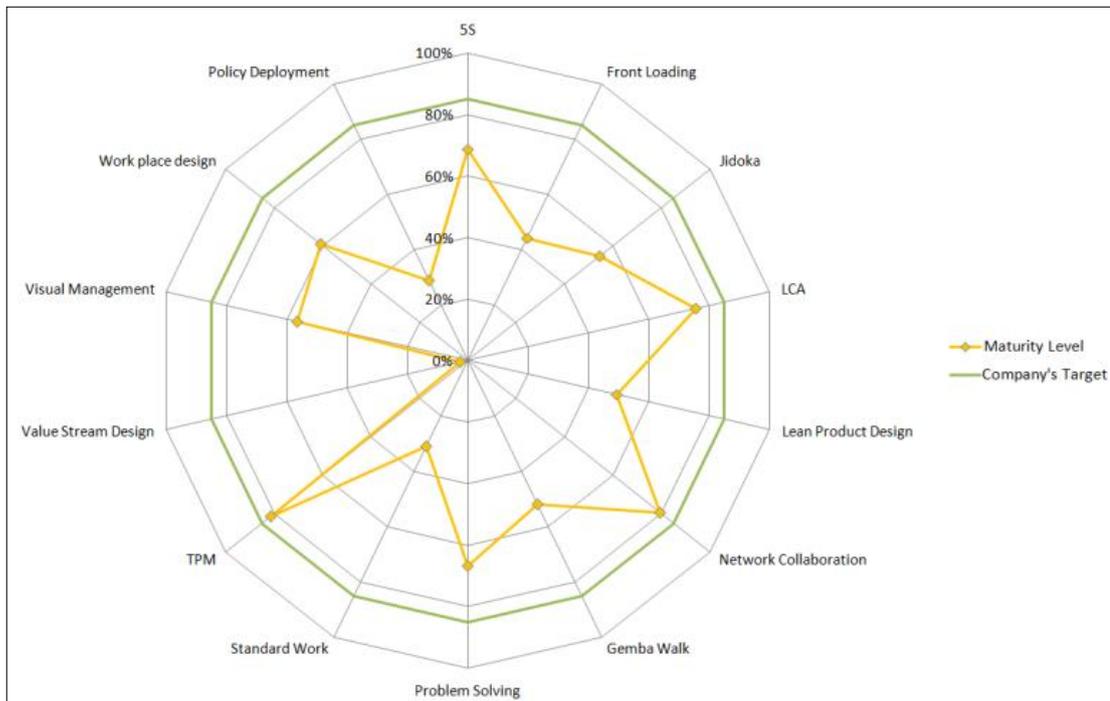


Figure 2 - Chart comparing the results of the maturity measurement and the Company's target.
Source: Authors

Finally, all the information was compiled to the level vs. maturity graph, analysis that helped the company to see the methods that have lower maturity and those with higher levels, facilitating the elaboration of the action plan to attack the most critical numbers, without losing the sustainability of the highest ones (Figure 3).

By analyzing the Figures 2 and 3, it is possible to affirm that none of the methods have yet achieved the ideal maturity level expected by the company. However, some of them are really close to, while other ones are still too far. As can be seen, LCA, Network Collaboration and TPM are less than 5% from the minimum expected target, showing that if they are continuing to be improved, it will be achieved very soon.

In the meanwhile, Workplace Design, Problem Solving and 5S are about 20% away from the minimum target. In this case, some action plans need to be taken in order to get them improved and, perhaps that would be enough to achieve the minimum score. However, methods like VSM, Policy Deployment, SW, Front Loading, Lean Product Design, Gemba Walk, Jidoka

and VM are over 40% away from the minimum score, and considering that some of them are basics lean tools, they need to be urgently analyzed and acted in order to achieve at least half of the minimum score, i.e., 40%. After that, be treated to reach the 80% score and so on.

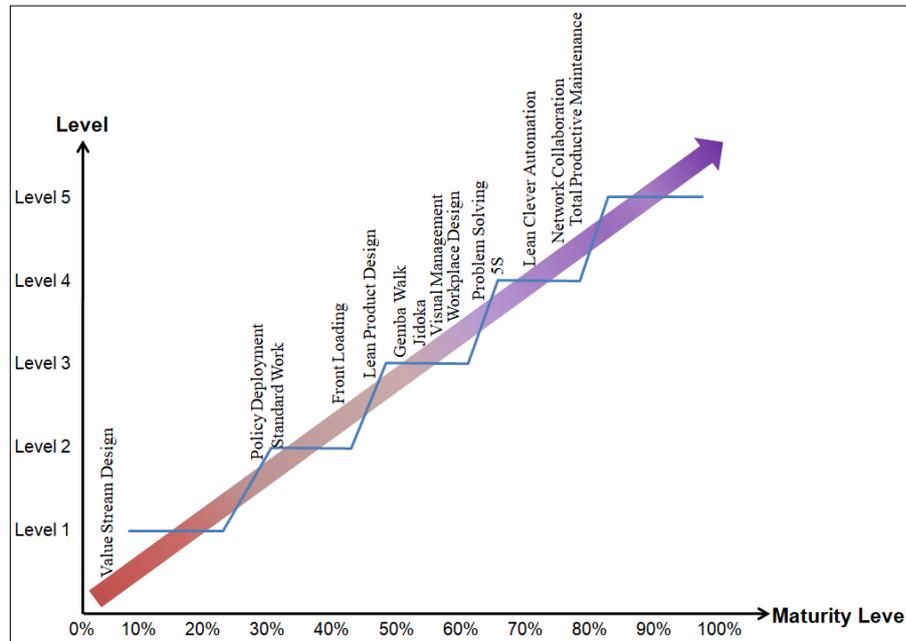


Figure 3 - Graph of the methods maturities.
Source: Authors.

The Figure 5 is an adaptation from the Figure 4 and can be used as an example of how to solve the gaps and slowly achieve the maturity level using a PCDA cycle. Also, it is important to note that every new level achieved needs to be standardized and sustained, guaranteeing the maturity of the reached level.

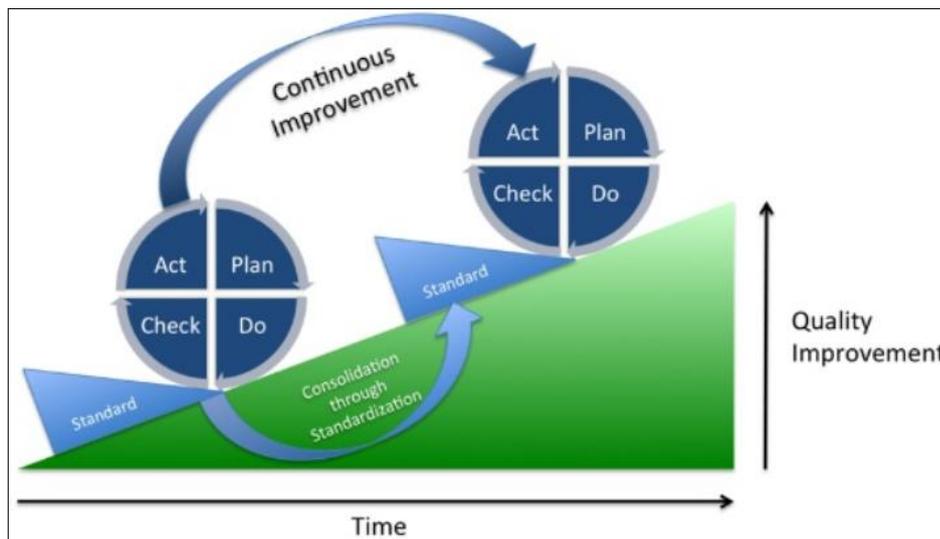


Figure 4 - Graph of the PDCA cycle.
Source: Authors.

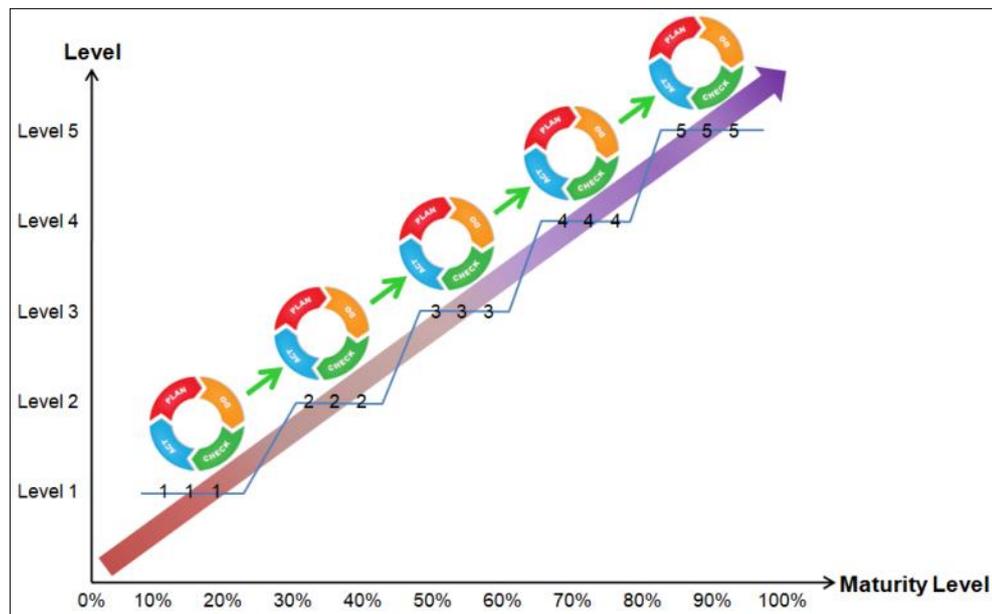


Figure 5. Graph of the PDCA cycle through the maturity levels.

Source: Authors.

7. Conclusions

The presented paper helped the visualization of the maturity levels of all the methods used by the company, after the application of the BPMM questionnaire through all. It also assisted the company to identify the main gaps and which tool needs more attention and be acted immediately.

From the data collected one important tool that showed the lowest score, VSM, should not present such a low score, since it is one of the basic and initial lean manufacturing tool. Therefore, a recommendation would be an immediate action to improve the VSM score, by focusing on that first level implementation and sustainability, and after that start to look at the other big gaps showed at the analysis.

The adaptation and use of the BPMM model helped to develop this article and evaluate the maturity status of the lean methods of the organization, by organizing it according to the scores obtained and, putting them in a graphic by their average scores. It helped the visualization of the gaps and also the weakness points, which provided to the company an overview of where they should act first. So far, it proved that the objectives of this paper were achieved.

For the future studies, a suggestion could be a support to the company in the development of action plans to reduce the score gaps between the methods used, and also, assistance on the main target achievement.

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