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Procedia Manufacturing 41 (2019) 1095–1102

Procedia MANUFACTURING

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8th Manufacturing Engineering Society International Conference

iLeanDMAIC – A methodology for implementing the lean tools

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Abstract

Organizations focus must reside in their constant desire for improvement in order to satisfy their clients as a result of high-quality products, thus maximizing their profits through a waste reduction in the flow production. Lean thinking allows organizations to identify and eliminate wastes within the organization. The use of lean tools is considered a simple, efficient and cost-effective solution to achieve productivity and profit. DMAIC (Define, Measure, Analyze, Improve, Control) is a problem-solving methodology that improves processes, allows defect reduction and reduction of process variability, allowing companies to continuously improve their efficiency and performance. In this work, a combined methodology iLeanDMAIC based on Lean Tools and DMAIC was developed, aiming to help organizations to easily and accurately solve their problems. It includes a case-study implementation on an organization of the sector of wood products. We were able to successfully validate this methodology and to show its efficacy in enhancing production. Results using iLeanDMAIC allowed a reduction time in changeover in the assembly machine (from 39 min to 17 min), presenting this a 44% gain on manufacture. iLeanDMAIC can help organizations thrive against their competitors, make their business more cost-effective and efficient.

Keywords: Obeya Room, Jidoka, DMAIC, Lean Tools, Six Sigma, VSM, SMED, A3 Problem Solving, TPM.

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Peer-review under responsibility of the scientific committee of the 8th Manufacturing Engineering Society International Conference.

1. Introduction

The present work aims to develop a model integrating the lean tools with DMAIC, termed as iLeanDMAIC. In order to validate the methodology here developed, iLeanDMAIC was implemented in a sector wood company.

Nowadays, especially in global markets, it is increasingly important for companies to work proactively to stay competitive and therefore survive to the constant change. To achieve this, companies must be continually involved in increasing their customers' satisfaction through high-quality products, maximizing their profit by eliminating the waste that may exist along with the production flow. The Lean philosophy enables organizations to identify and eliminate waste through the application of various tools. The policy of eliminating waste results in a reduction of production times, making it possible to meet deadlines, thus increasing productivity in organizations [1-6]. The 6 Sigma methodology is based on DMAIC, which is based in a 5 cycle-stages of analysis and improvement of processes, allowing the reduction of defects and the reduction of process variability.

This work intends to be a proposal for problem-solving through the DMAIC methodology and an interconnection using Lean Tools. First, we identified which Lean Tools should be applied in each phase of the DMAIC. Then, according to the results provided, we can achieve the best solutions to enhance production. To have a more meaningful understanding of iLeanDMAIC, we conducted a case-study implementation, which will consist of a survey of the initial situation and subsequent implementation of the DMAIC cycle with Lean Tools.

2. Literature Review

In association with the TPS (Toyota Production System), Lean Thinking was born to optimize processes, reduce waste create value. The TPS house is supported on the concepts of: (1) Standard Work, which represents the normalized work, allowing the reduction of the variability of the procedures and also to improve the Quality and flexibility [7]; (2) Kaizen, concept of continuous improvement; and (3) *Heijunka*, mixed production system – level production [8]. Just-In-Time (JIT) refers to the ability to implement pull production, allowing to obtain what is intended, only in the desired quantity and time. The concept of *Jidoka*, is a Japanese term whose translation *"automation with a human touch"*, which allows the reduction of employees in the control of machines [9]. At last, but no less important, there are other tools that help lean Thinking [10]. Lean manufacturing improves business performance and could be described as the elimination of wastes on organizations [1].

The use of Lean Tools is considered a simple, efficient and low-cost solution to achieve productivity and profitability, always focusing on the elimination of waste [3]. Some lean tools are now described:

Table 1. Some lean tools

Lean Tools	Description
Daily Kaizen	A tool that aims to develop teams by holding Daily meetings so that they become more autonomous and able to improve processes and the work area [11,12,13]. Through the frequent Kaizen meetings, the teams remain connected which provides a greater and better level of control and efficiency, and also through the analysis of performance indicators, allowing the continuous improvement of these [12,13].
Visual Management	Tools that enable indication of the current performance; allows an easy, wick and clear visualization of the state and conditions of production processes; improves the performance of the organization by identifying the next problem to be solved; and also knows to predict, plan, control and optimize the flows of tasks [14,15].
Yokoten	*Yokoten* is a Japanese word that means "sharing the best practice" [16]. *Yokoten* was created by Toyota Motor Corporation which wants the entire organization to have horizontal information and knowledge of information [16].
Gemba Walk	*Gemba*, a Japanese word that represents the place where activities really happen. *Gemba Walk* allows to know the reality of the organizations, through first-hand observation and the involvement with the employees who execute the processes, allowing to identify in a more efficient way what can be improved [11,17].
SMED	SMED – *"Single Minute Exchange of Dies"* tool defined as a set of "methods that lead to rapid tool change *(Setups)*" [10].
VSM	*Value Stream Mapping* (VSM) tool that can represent the entire value stream of the organization [18]. Through VSM it is possible to identify the activities that do not add value to later eliminate them [19].
WID	*Waste Identification Diagram* (WID) is as an alternative representation, to more easily identify wastes along the value stream [20].

Six Sigma methodology emerged in 1980 due to the successful implementation case in Motorola Company [21] and has since been implemented in numerous companies such as Ford, Allied Signal, Sony, Kodak or Texas Instruments [22]. Six Sigma focuses on the non-occurrence of defects, for this, it is necessary that the processes are carried out within the pre-established limits and its quality strategy is focused on the customer [23]. This methodology makes use of DMAIC cycle for solving-problem [24,25]. DMAIC is a 5-phase cycle: ***D**efine, **M**easure, **A**nalyze, **I**mprove*, ***C**ontrol* [5], that allows identifying and eliminating parameters that affect the efficiency of a process [26]. The following table presents the description of each of the stages of the DMAIC:

Table 2. Stages of the DMAIC

Phases	Description
Define	In this phase, the focus of the study is determined.
Measure	Collection of necessary data of the problem to measure the performance of the process [5,27,28,29].
Analyze	At this stage, it is analyzed: root causes of the problem and sources of variation; variance between the planned and the achieved; effects of problems/ solutions; customer need [5,25].
Improve	Identifying the root causes, it is at this stage that solutions to the problem are developed gaining improvements in the process applying a set of tools to eliminate the defects and accelerate the processes [5,27].
Control	In the control phase, a commitment should be made to monitoring and improvement actions [5]. The improvements are internalized and institutionalized through controls [30]. The objective of this phase is to ensure that the improvement does not disappear over time by documenting all information on process changes and through control measures ensuring that defects do not occur again [29].

3. Methodology

iLeanDMAIC is a methodology that aims to solve problems in organizations, in order to reduce waste and make the organization more efficient and competitive. This methodology, as the name itself indicates, is based on the DMAIC cycle with Lean Tools. Benitez [31] applies a checklist with tools through the DMAIC to determine priority actions. Domingues [32] considers the DMAIC cycle "an organized and sequential method that allows the identification of problems and their resolution, aiming at the continuous improvement of processes". The successful implementation of the approach has not been fully investigated; there are some empirical studies that documented how the Lean and DMAIC approaches, or Six Sigma can be interacted [33].

Currently, there is still not a lot of knowledge on the integration of the DMAIC methodology with Lean Tools [32]. Some benefits of implementing Lean Tools are: reducing transition time; simplification of the flow of materials; reduction of waste time; better machine performance; process that are more transparent and easier to control; WIP reduction; productivity increase; stock reduction; lead time reduction; training reduction of cycle time; improving efficiency; cost reduction; quality improvements [29].

Each stage of the DMAIC cycle has a certain function, and it is intended that this methodology uses several lean tools to assist in the execution of these functions in order to solve the problem. Next, the methodology is presented in tabular form, which lists the Lean tools that can be implemented in each of the phases of the DMAIC cycle. It is important to note that some Lean tools can be implemented in different phases.

Figure 1. iLeanDMAIC Methodology

4. Results – Case Study

A case study will be presented for validation of the methodology iLeanDMAIC. For that, iLeanDMAIC will be implemented in an organization of the sector of other wood products. The Company chosen is involved in the production of wooden objects for various applications.

4.1. D - Define

In the first phase (*Define phase)* of methodology, the VSM (Figure 2) was used, to understand the present situation and to identify an opportunity for improvement.

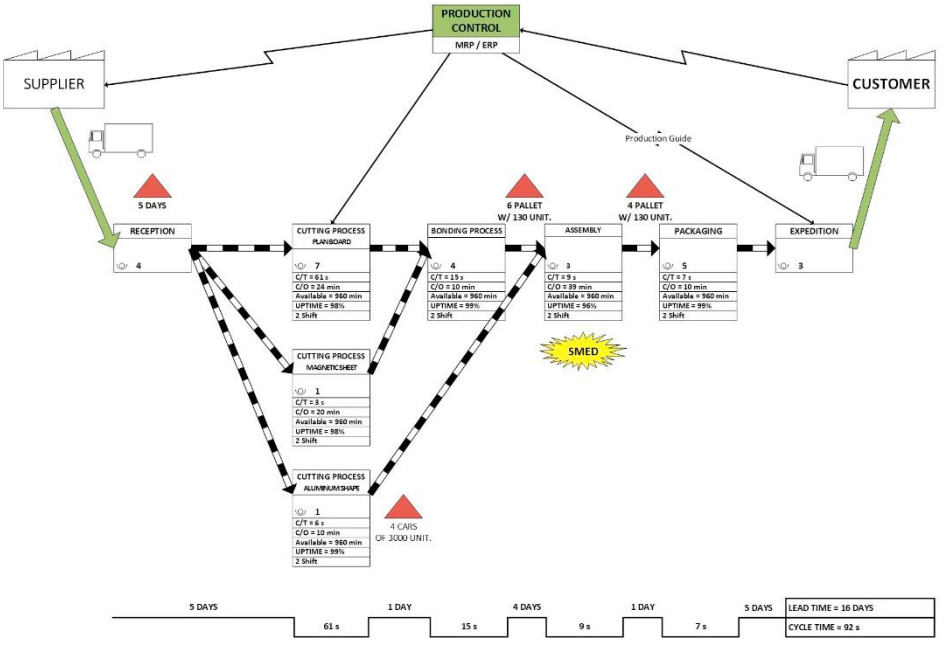

Figure 2. VSM of the present situation

Through VSM it was possible to conclude that there is a high accumulation of WIP (Work-In-Progress) between the assembly and packaging sectors. Namely, the WIP in the assembly is stopped until some employer collects to proceed to the next production process – assembly. It was also verified that the C/O (Changeover) of the assembly process takes 39 minutes. The changeover of this machine reveals an insufficiency of resources since the people who carry out the task were not properly trained and sensitized for the problem. This was precisely the problem detected on the Define phase of the DMAIC cycle, and where our study will be focused on.

4.2. M - Measure

Simultaneously, it was also used in *Measure phase* to analyze some lean metrics (Table 3).

Table 3. Lean metrics of company's initial state

Lean Metrics	Data:
Lead Time – Time required for a product to go through the entire value stream from start to finish [18].	16 days
Cycle Time (C/T) – elapsed time between two pieces produced in a given workstation [18].	Assembly: 9 s.
Takt Time – how often a part is to be produced, based on the demand of customer needs [3,20].	Demand = 8904 units /month Takt time = 1,13 min.
Changeover (C/O) – the time it takes to switch from one type of product to another [18].	39 min
Number of shifts	2
Available – working time available – working time in the process shift	8h / shift = 960 min
Uptime – the percentage of time a machine is available for productive work	96 %
Number of operators	3

As the value of Takt Time represents the customer demand rate, it allows us to conclude that the company has to produce 1 unit every 1,13 min to respond to customer demand.

4.3. A – Analyze

Moving to the *Analyze phase*, we analyzed the OEE of the machine identified in the VSM on the assembly process. With this analysis, we found that the changeover time was slow.

The unplanned stop had a high percentage of changeover – 38%, which means that the machine was stopped for about 157 hours. Given this value, in the next phase of DMAIC – *Improve phase* – we decided to implement the lean tool that would allow improvement in the process of changeover of setups – the SMED tool. With this tool, we could reduce the time of setup, considered not productive time.

4.4. I - Improve

The SMED was one of the lean tools adopted in the *Improve phase*, with the goal of reducing changeover time. The implementation of SMED took the following steps:

- Step 1 – Data collection: In this step, the profile changes in the machine were filmed. It is important to mention that the time also depends on the operator who performs, since a more experienced worker would have better performance. Through the filming it was possible to measure the times that the operators spent to perform each of the tasks, using the chronometer.

- Step 2 – Distinction of internal tasks of external: After the tasks and their respective times were collected, an analysis was made to classify the tasks as internal or external. The former being considered tasks that must be

performed with the machine stopped, and the latter are tasks that can be performed with the machine on. In this specific situation, all activities are internal. However, when it is possible, the internal activities must be transforming into external ones, in order to improve the setup process.

- Step 3 – Convert Internal to External Tasks: After the distinction of tasks, it is intended to convert the internal tasks into external ones.
- Step 4 – Reduction of Internal Tasks in External: The improvements were performed on the longer tasks. Furthermore, other proposals for improvement were also been considered, namely: Add a person in the changeover process: The assembly process consists of 3 people, but the changeover process was only done with 2. The figure 1. (a) shows the initial state balancing with 2 people, where the total time for the changeover was 38 min and 50 s. In order to reduce the time, it was decided to carry out the changeover with 3 people, as can be seen in the figure 1. (b). This balancing and implementation of visual management tools allowed a decrease of total time changeover to 16 min and 59 s.

At this phase, it was also implemented other Lean Tools such as 5S and Standard Work.

4.5. C – Control

Finally, in the Control phase of iLeanDMAIC, the SMED was again performed to verify if the changeover was improved. A VSM was designed to certify that the overall process was improved through the lean tools implemented in the previous phase.

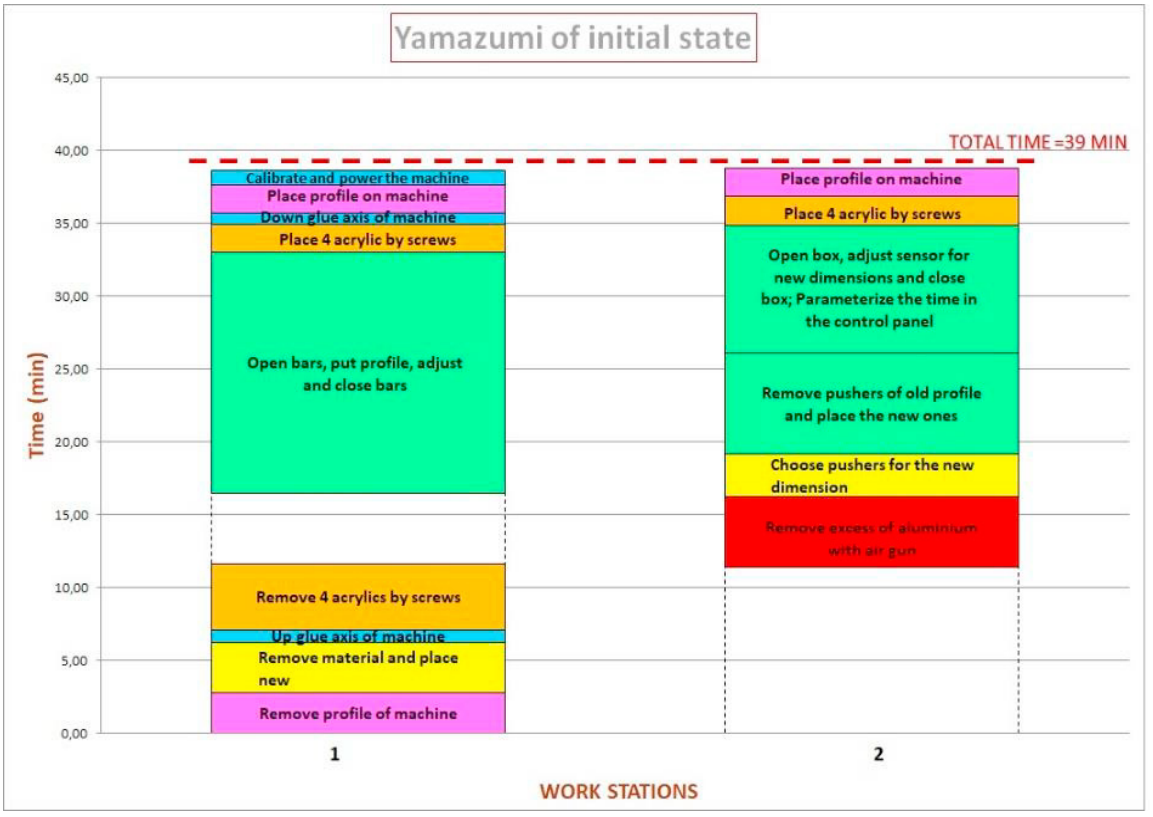

Figure 3. Initial State

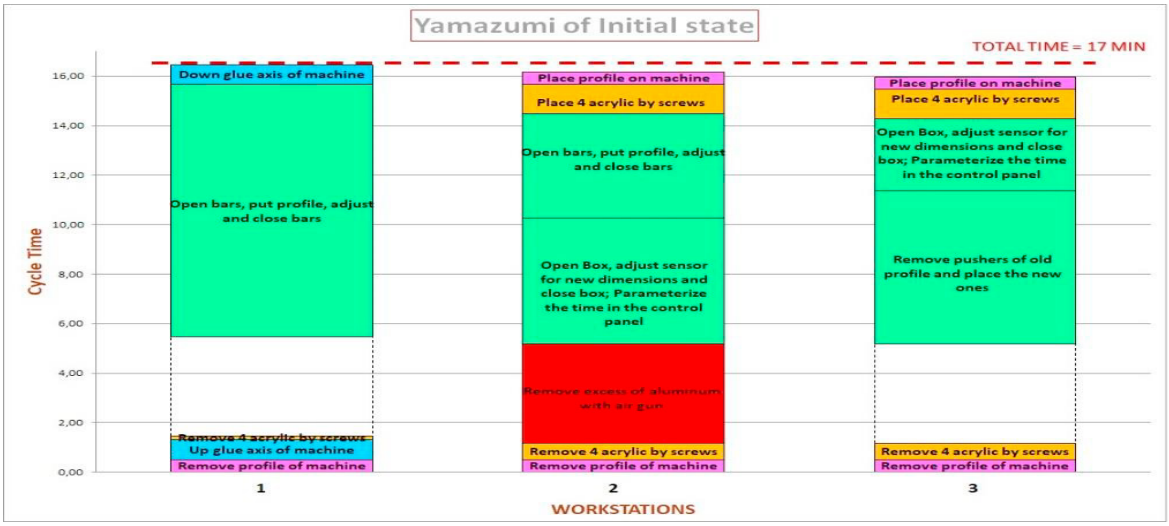

Figure 4. Current State.

5. Discussion

The main contribution of this work is to allow organizations to solve problems in an easier way, through the use of a table that relates the DMAIC methodology with Lean Tools, iLeanDMAIC. This methodology proved to be possible to solve problems in an easier way, so that it improves the performance of the organizations, having been validated the same with a case study. Given the promising results from the application of the integration of Lean Tools with DMAIC, we proceeded to a study in an organization. In this Company, a problem was identified, namely the high lead time because the changeover of a certain process was high. Through the implementation, a 44% time reduction was achieved in the process setup identified as a bottleneck (39 minutes to 17 minutes). Reducing setups allows the value stream is more efficient, enabling a greater performance of the equipment and the Takt Time matches the demand required by customers. Through the results of the solutions implemented with iLeanDMAIC, it was possible to reduce the flow time of a given product. The problem identified was high changeover in the assembly process. Through the implementation of SMED, it was possible to reduce the changeover of the process, making the productive flow more efficient. With a reduction of changeover in the assembly machine from 39 min to 17 min. having a gain of 44%.

6. Conclusion

With this practice, the organization is able to respond to market expectations and present itself competitively in relation to other organizations. While it's clear the benefits of implementing this methodology in the organization, this requires specialized personnel to use and understand the proper tools in search of problems. As well as, it requires that they be able to define modes of action for their resolution. Often companies do not understand the usefulness of this type of philosophy, which leads to a waste of resources that make them obsolete in the market in the face of adversity and its competitors. In addition, the resistance to change on the part of the companies could be a problem to the application of this methodology. In fact, companies must be able to willing to make the necessary changes to solve problems. In this study, the methodology was only validated in the sector of other wood-works. However, their positive applicability is expected in other sectors. Being a dynamic methodology, it offers a multiversity of applications. That is, it is expected to identify and solve problems in any type of organization, effectively and efficiently. As future work, it is suggested to implement the methodology in other organizations. In addition, a more in-depth study of their impact on organizations is proposed, including the collection of more detailed information on the effect of applying this methodology. Following this project would require the collection of values related to the gains obtained through improvements to the organization.

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