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Implementation of Lean Methodologies in the Management of Consumable Materials in the Maintenance Workshops of an Industrial Company

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Abstract

During the course of the 21st century, companies have constantly had to adapt to change. The solution resides in increasing operational efficiency, quality and productivity, while simultaneously reducing costs and establishing the waste-free organization. The objective of this work lies in the implementation of lean methodologies in the management of consumable materials in the maintenance workshops of an industrial company by adjusting/reducing the volume of materials and reorganizing their placement. It further explores the potential to eliminate waste and create value-added tasks in the maintenance activities involved. The development of this work allowed for an improvement in the organization of the consumable material cabinet through the implementation of 5S methodology, as well as a reduction in the time required to locate the consumable material by using visual management (in the order of 70%). Improved control of stock was also achieved through the reformulation of *kanban* (approximately 30%); a reduction in the time required to replenish material in the consumables cabinet was ensured by means of the *mizusumashi* (with an expected improvement of 50%).

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Keywords: Maintenance, 5S methodology, Visual management, Operations improvement, Lean tools.

1. Introduction

The current market is subjected to constant alterations which require prompt flexibility and adaptation to address the changes at hand [1]. The purpose of lean philosophy is to expedite a company in order to make it more active and dynamic, thus enabling it to address future challenges, eliminate waste and promote a culture of steady improvement in all areas of activity, on a daily basis, and amongst all the employees involved [2, 3]. Maintenance activities aim to enhance reliability, safety, availability and quality in organizations, equipment and buildings. In the

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course of the last decades, organization management has considered the role of maintenance to be a necessary "evil" in terms of expenses and time [4]. The costs of the maintenance activities represent, after the energetic expenditure costs, the largest portion of a company's budget [5] and weighs heavily on the costs associated to operation. One has thus seen a steady increase in the use of maintenance services which has, in turn, led to a greater financial burden in company budgets. The increase in requirements to optimize costs and the availability of equipment means that a balance must be struck between the budget restrictions demanded by managers and the service quality expected by the users of the equipment [6]. The work described in this article was developed at a Portuguese brewery. Its main objective was to implement lean methodologies in the maintenance area. This article is divided into five sections: section 1 consists of the introduction; section 2 presents a review of literature pertaining to lean methodologies and lean maintenance; section 3 consists of the methodology used to undertake the work at hand; section 4 provides a description of the practical work; section 5 contains the quantification and analysis of the results obtained and, lastly, section 6 presents the contributions of the work involved and the final conclusions.

2. Review of literature

Lean thinking aims to identify and eliminate waste by doing away with activities which consume resources and add no value to the final product [7]. Lean philosophy and tools enhance continuous improvement across a wide range of industrial activities and services. Originating from industrial production, lean philosophy and its tools encompass areas such as maintenance, quality, logistics and planning. They are also used in the service sector in hospital facilities, banks and universities. Several studies present examples of successful cases of the implementation of lean thinking in the sectors of industry and services [8, 9, 10, 11]. In a study undertaken in the area of maintenance, the implementation of lean thinking allowed for the identification of different types of waste in the maintenance sector of a company, and how these were reduced or eliminated by using lean tools. The principal contributions were the minimization of human error, analysis and elimination of unnecessary maintenance activities, reduction of the time spent on repairs and an increase in autonomous maintenance [12]. At a vehicle dismantling company, the implementation of lean thinking led to the conclusion that 70% of the tasks added value, 20% of these added no value but were necessary, and 10% constituted sheer waste [13]. At another company in the automotive industry, the implementation of SMED (Single Minute Exchange of Die) methodology – complemented by other lean tools such as 5S, visual management and standard work – allowed for the reduction of waste inherent to tool changes on the assembly line. This contributed to a reduction of 58,3% (210 minutes per week) of the time spent on setups [14]. At an aluminium foundry, a study demonstrated the benefits of creating a dashboard, whose layout was based on the principles of visual management, *kaizen* and TPM (Total Productive Maintenance). This board enabled improved performance in the production areas, enhanced the sharing of information and communication, and promoted a culture of continuous improvement in the *gemba* [15]. In another study undertaken in the area of Logistics, results are presented for a project which sought to explore opportunities for improvement in the management of raw materials through the implementation of lean tools such as 5S, Poka-Yoke, standard work and visual management. This set of improvement activities was translated into savings for the company, which were estimated to be equivalent to 6 245 €/annum [16]. A study carried out at a company in the cardboard box production sector presents the benefits ensuing from the use of tools such as SMED, 5S and visual management. These led to an average reduction of 47% in the time required for machine setup, which corresponded to a profit of 10 114 €/month [17]. At a thermoelectric plant, the implementation of 5S methodology in the spare parts system resulted in a significant cost reduction, which led to a profit of approximately 250 000 €/annum [18]. In the service sector, a study was undertaken at the São João Hospital in Portugal to improve the supply system of clinical and pharmaceutical material. The implementation of a *kanban* system consisting of two-compartment boxes, as well as the reconfiguration of the layout of the general warehouse through 5S, allowed for the simplification of the *picking* system. Besides enabling nursing staff to spend more time with patients, the new system led to a decrease in expenses associated to medication stock, from 5 million to 3 million Euros. It was thus also possible to reduce the space required to store medication in the warehouse area by 70% [19]. Another study describes the importance of the role played by lean maintenance in improving the productive process. The strategies and projects implemented made several contributions, such as an increase in the availability of equipment (20%-55%), as well as a reduction in maintenance costs (40%) and greater satisfaction amongst employees (4%) [20]. The implementation of a lean production system involves the participation of all the parties involved in the practice of continuous improvement through the detection of opportunities for improvement and the enhancement of processes and people. The process of continuous improvement changes the role played by people, who are now considered to be the most important asset within an organization [21]. In *lean* thinking, costs constitute the consequence of practices, systems and processes in an organization and can only be reduced when improvements are implemented [22]. Taiichi Ohno, the founder of Toyota production (TPS, *Toyota Production System*) identified seven types of waste in production operations, which were also applied to maintenance activities. According to Taiichi Ohno [21], excess production is considered to constitute the most harmful type of waste, since it leads to all the other types of waste referred. With regard to maintenance, the waste generated by excess work is seen to produce the most adverse results, exactly for the same reasons. An eighth type of waste was later added to the other seven which had already been identified (see Table 1), the waste resulting from the failure to use human potential [23].

Table 1. Waste in Maintenance [23, 24].

Waste	Description/Examples
Excess work	• Maintenance carried out more often than required; • Components replaced too soon.
Waiting time	• Delays; • Diverse waiting times; • Interruption of activities due to shortages in materials and/or parts; • Time wasted in locating materials, parts and tools.
Transport and movement	• Movement of people and mobile workstations equipped with tools and materials for no valid reason.
Reworking	• Need to repeat what was initially incorrectly done; • Need to execute additional tasks due to a lack of manpower or qualifications.
Inadequate management of materials and spare parts	• Failure in access to the right material at the right time.
Incorrect data management	• Collection of unnecessary data; • Collection of indispensable data and which are not treated.
Negligence in the implementation of equipment	• Careless handling of equipment.
Failure to use human potential	• Failure in communicating with technicians and operators to obtain feedback and thus improve processes.

3. Methodology

The approach used throughout this study initially consisted of acquiring a greater knowledge of *lean* thinking and *lean* maintenance by consulting scientific articles and books. One subsequently identified the problems related to the area of maintenance and the operation of the workshops at the company under study, and planned the approaches which would address the problems in question. The organization of the cabinets used for consumable materials emerged as an opportunity for improvement. This was considered to generate a great impact on the efficient operation of the workshops and on the maintenance activities as such, occurred in the workshops. Firstly, a list of all the references already available in the cabinet was drawn up. With the assistance of the maintenance technicians, one also determined which references were not used or inactive, and then set up a list of material which still had to be added to the cabinet. One then proceeded with the logical organization and suitable identification of the material found in the consumable material cabinet. Finally, one quantified and analyzed the results obtained, and identified the waste which had been reduced or eliminated as a result of the development of this study.

4. Improvement in the management of consumable materials in the maintenance workshop

The maintenance workshops contain various types of equipment (for example, column drilling machines and bench grinders), a workbench, a cabinet for the storage of consumable material and spare parts, a welding bench, a bench with a sink, tool trolleys or kits and waste containers (for example, for general industrial waste, technical plastic, cardboard, metal scrap, amongst others). Most of the workshop users are maintenance technicians at the company, although a few are subcontracted workers. When the filling lines are serviced, there is a much greater affluence of workshop users, who are both internal maintenance technicians as well as subcontracted workers. The workshops thus need to be well structured in order to provide the best conditions for the users in question to carry out their tasks more easily. Consequently, clear instructions must be provided for the handling of equipment, as well as for aspects dealing with safety, hygiene, organization, storage and the specific places reserved for each type of material.

4.1. Identification of problems

Communication with the workshop users at the company (maintenance technicians and operators) provided feedback concerning the problems and difficulties they are often confronted with, and which impact negatively on the execution of their tasks. Table 2 presents the problems detected with regard to the functioning of cabinets for consumable material in the workshops.

Table 2. Identification of problems.

Problems	Description
Difficulty in locating material.	Not all of the materials are stored in a specific place, neither are they identified.
Shortage of material in the cabinets.	Not all of the materials are coded and there is no definition as to the minimum replacement of stock (kanban).

4.1.1 Difficulty in finding the material required

Shortage of materials causes events of unforeseen downtime, in which the unavailability of a specific component might imply great losses, and may even jeopardize people and the premises itself. Cabinets in the workshops contain large quantities and varieties of consumable materials (for example, screws, nuts, washers and all the materials which are usually required for maintenance activities). On analyzing the contents of the cabinets, several problems were detected, such as: old stock of material which is no longer used; illogical organization of consumable material (for example, the grouping of consumable material according to common characteristics); inadequate replenishment of stock (known as *mizusumashi,* the staff responsible for the replenishment of required material, they do not seem to carry out this task often enough; the same can be said about the drawers' kanban of the consumable material cabinets found in the workshops); shortage of material which is essential for everyday use; and material without a specific storage space in the cabinet. The maintenance waste identified through the implementation of lean methodologies consisted of: improper management of materials and spare parts, which is translated into events of inadequate supply, i.e. the required material is not provided at the right time; waiting time due to the interruption of activities caused by shortages in material and/or parts, or time wasted when trying to locate materials; transport and movement, when operators have to go to other workshops or to the general warehouse on purpose to obtain the required material.

4.1.2 Shortage of material in cabinets

When the consumable material cabinet was reorganized, one found material that was often used for machines but which had not been coded by the SAP (corporate software) system, and which had no associated *kanban* either. Since this material was not coded by the company's computer system, it was rather difficult to request, and thus led to other types of waste, such as: the inadequate management of materials and spare parts; transport and movement; and waiting time, when material had to be located or requested from the general warehouse.

4.2. Proposals for improvement

The cooperation with the maintenance teams allowed reaching a consensus about the measures required to improve the operation of the consumable material of cabinets. Table 3 describes the proposals for improvement presented to address the problems mentioned in section 4.1 of this article.

Table 3. Proposals for the improvement of the detected problems.

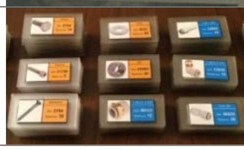
Problems	Proposal for Improvement.
Difficulty in finding material.	Organization of the consumable material cabinet.
Material shortages.	Creation of kanban for the minimum amount of replenishment stock required.

By means of 5S and *kanban*, one was able to determine a methodology of visual management which ensured that all materials were suitably identified, each in its designated location, and ready for immediate use. Table 4 presents a general overview of the implementation of the improvement proposals presented for the functioning of the consumable material cabinet. The stages comprising the work undertaken are detailed as follows:

- Sort (*seiri*) – Firstly, a list was drawn up of all the materials already in the consumable material cabinet. With the assistance of the maintenance teams, one then screened the material in question. This allowed one to identify obsolete materials which had been used for machines that were no longer in use at the factory, and which were subsequently returned to the general warehouse. One was thus able to create space for the addition of new and frequently used materials which, because they had not been stored in the workshops until this moment, had to be requested from the general warehouse.

- Shine (*seiso*) – After the screening process, the cabinets were cleaned thoroughly, as they were rather dirty.
- Set in order (*seiton*) – Based on the list of consumable materials, one sorted the material according to type, size and/or main characteristics. Larger material was placed in a cabinet which had bigger drawers.
- Standardize (*seiketsu*) – In order to prevent the storage of surplus material in the drawers, one established a minimum quantity of replenishment stock (*kanban*). In order to do so, the larger drawer modules were replaced by smaller ones, so that the cabinet was visually standardized (showing labels with explanatory images for each of the materials, specifications and SAP codes). More space was also created for the storage of additional material. Plastic strips were added to the drawer slots to act as dividers, and *kanban* in order to separate stock in use from backup stock. The new modules and drawers, from which old material had been removed, were identified once again and now show the name, material size and the respective SAP code.
- Sustain (*shitsuke*) – In order to maintain conditions for the effective functioning of the cabinet, one had to ensure that material was replenished. By means of the *kanban* system, one was able to guarantee that the material required was always available in the drawers, thus preventing stock failures. By using the list and labels already produced for the external identification of materials, one was able to create a *kanban* for all the materials, with a respective illustration of the material in question, its main specifications and the minimum quantity of replenishment stock.

Table 4. Implementation of improvements for the consumable material cabinet.

5S	Description	Picture
Sort (seiri)	Screening and return of material to the general warehouse.	
Shine (seiso)	Cleaning of cabinets.	
Set in Order (seiton)	Logical organization of material according to type and size.	
Standardize (seiketsu)	Standardized cabinet with explanatory identification and specification of materials through visual management.	
Sustain (shitsuke)	Kanban for each cabinet drawer. This also acts a drawer divider, thus providing two compartments (stock in use + backup stock).	

As one can observe in Figure 1, the identification of material required was rather complicated before this intervention; this was chiefly due to the time wasted in determining which drawer corresponded to the material sought. This often led to extremely stressful situations, during which the operator desperately opened all the drawers, and even mixed all the material in the drawers, thus producing a scenario of a total disorganization in the cabinet. Through the implementation of 5S, which was complemented with visual management, and is presented in Figure 2, the user is now immediately able to identify the type and size of the material required. Figure 3 presents the *kanban* corresponding to each type of material, which thus ensures the efficient functioning and sustainable use of the cabinet, and presents information such as the SAP code and the minimum quantity of replenishment stock.

Fig. 1. Module without identification.

Fig. 2. Logically organized module with identification (5S + visual management).

Fig. 3. Module with kanban.

In brief, the solution involved reorganizing the consumable material cabinet by implementing 5S, complemented by visual management. The 5S stages (sort, set in order, shine, standardize, and sustain) allowed for the logical organization and placement of material in the cabinet. Visual management enabled one to create an intuitive method of identification, observed in Figure 4 and Figure 5, where one can see the impact of the lean methodology implementation.

Fig. 4. Before: the consumable material cabinet.

Fig. 5. After: the consumable material cabinet.

The use of the *kanban* tool allowed for an improvement in the sustainability of the consumable material cabinet. The request for material occurs when the stock in use runs out and backup stock must be utilized, which is shown in Figure 6. When the *kanban* are collected weekly, the *mizusumashi* replenishes the backup stock before depletion occurs of the stock still in use. Stock failures are thus prevented, ensuring that sufficient quantities of material are always available in the cabinet drawers.

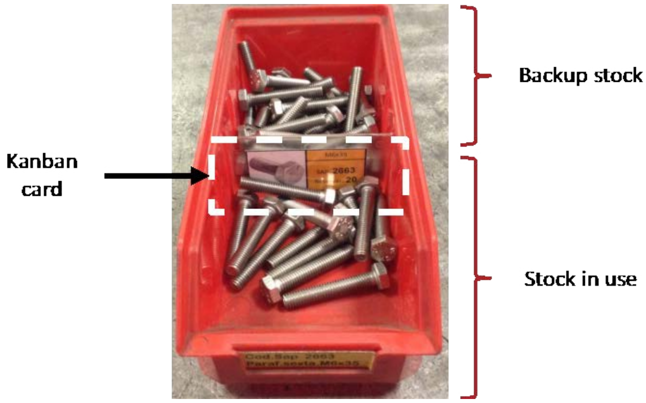


Fig. 6. Drawer with kanban implementation.

The addition of new material, which was not registered in the system, was coded in the SAP. When changes were made to the consumable material cabinet, the material which had not been coded in the SAP had to be requested and acquired through external purchasing, and was only then obtained from the general warehouse. This process did not ensure that material was available when required.

5. Analysis of results

Once the interventions had been implemented, measurements were carried out to quantify and validate the impact of the improvements undertaken. Table 5 presents a reduction in the time spent (in seconds) by technicians when looking for material in the consumable material cabinet during the course of several random samples. Table 6 presents the number of *kanban* which had to be reformulated due to incorrect information. This often resulted in a failure to replenish the material in question, or in the replenishment of quantities larger than the space available in the drawers. Consequently, after the abovementioned alterations were implemented, a suitable and correct replenishment was ensured of material in the cabinet.

Table 5. Sampling of the time spent (in seconds) by technicians in the consumable material cabinet.

Samples	1	2	3	4	5	6	7	8	9	10	Average (s)
Before (s)	49	42	37	35	50	46	40	42	33	52	43
After (s)	11	9	13	12	11	8	13	8	14	7	11

Table 6. Number of reformulated kanban.

Number of total *kanban*	252
Number of reformulated *kanban*	71

This study resulted in a 70 % reduction of the time required to locate consumable materials (decrease in time from 45 seconds to between 10-15 seconds, approximately). In addition, one saw an improved control of stock quantities, due to the reformulation of a minimum quantity of stock replenished, for 71 of the 252 existing *kanban* (approximately 30%). Finally, one estimated a reduction of at least 50% in the time required by the *mizusumashi* to replace material and *kanban* in the drawers.

6. Conclusions

This study sought to improve the state and operation of consumable material cabinets in the maintenance workshops, with a view to optimizing and addressing the problem of the search for material by the maintenance technicians at the factory. This objective was met through the reorganization of the placement of material in the cabinet and its identification by means of explanatory images. The quantities of material to be replenished for each of the drawers were also reformulated. One was able to eliminate/reduce several types of waste, such as the inadequate management of materials and spare parts; prior to intervention, the material required was seldom available at the right time. One was also able to reduce lengthy waiting times, which resulted either from interruptions in activities due to the lack of material and/or parts, or time spent looking for materials. Moreover, one succeeded in minimizing the waste generated by transport and movement when going on purpose either to other workshops or to the general warehouse to obtain the material required. One thus saw an increase in the availability of materials, as well as a greater reliability in the replenishment of stock. The visibility of the state and quantity of material was also improved, with smaller quantities of accumulated stock and less space taken up by material. There was, furthermore, a significant reduction in the costs associated to consumable materials. Due to the results and feedback provided by the technicians, the work executed in this study was also implemented in other workshops at the company. It was thus demonstrated that the application of lean methodologies represents a simple inexpensive approach, which produces results that constitute an advantage, and which facilitate everyday activities for both workers and companies.

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