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Warehouse operations logistics improvement in a cork stopper factory

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Abstract

In a market that is increasingly competitive, the success depends on the efficiency levels of the implemented processes, highlighting the importance of the operations related to the warehouse management in the logistics flow. This research focuses on the improvement of management and logistic flows within a Portuguese cork stopper production factory. The primary goal is to maximize the warehouse stocking capacity and to improve logistics operations associated to that. By using procedure mapping techniques, data analysis, and direct time monitoring, it was possible to identify non value added times, as well as the associated causes and impacts, inadequate planning, and sizing of the warehouse layouts that were causing significant negative impact in terms of efficiency management. Using lean thinking philosophy, several improvement suggestions were presented to mitigate the problems identified.

Keywords: Lean Warehousing, Layout, Action Research, Cork Stopper Factory, Logistic.

1. Introduction

The global business environment has been changing rapidly and profoundly these past few decades. Market has become increasingly more complex, requiring companies to become more and more competitive. The overall supply chain process and its improvement are directly influenced by the role played by warehouse, whose performance depends on its management and the strategy with which the warehouse is managed according to capacity, organization, and the process procedures followed by the warehouse operators. The primary goal of a warehouse is to manage the movement and storage of the goods in the most efficient way while also providing flexibility in the resources management [1].

In the last five years, the company production values have doubled, which led to a necessity to improve the production and maximize its resources in order to meet the increasing demand. The developed work focus on reduce/eliminate most problems using the action research methodology, in order to increase operation efficiency, focusing on reworks, decrease lack of stocking space (107% average warehouse occupation) and the picking tasks (could represent until 55% of total warehouse costs). It was possible to identify many wastes in all announced problems.

In order to respond to this demand, it is necessary to apply the best strategies for improvement. Lean management – that originated in the Toyota Production System - aims to identify waste and to eliminate it. This is possible by following the five principles of Lean [2]. The first consists in defining the value for the costumer, and, has a consequence, eliminating from the process all that is not necessary - defined as waste. The second maps the value stream that identifies how value is created in order to create and maximize production flows capacity – the third principle. The pull system stipulates that the flow of

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products should be pulled only by costumers' requests - the fourth principle. The fifth and final principle consists in seeking perfection as a result of continuous improvement.

The process improvement methods help industry to cut process costs and achieve competitive advantage. Therefore, improvement - even in small repetitive procedures - will contribute to increase the productivity of the industry.

Lean approach has proven to be very effective when it comes to eliminating non-value-added processes, especially in "lean warehousing,". This leads to significant improvements in a warehouse, such as eliminating the need for over-processing, decreased lead time for costumers, better understanding of the process and inventory reduction [3].

This work is developed in a make-to-order (MTO) cork stopper factory - in the finished goods warehouse - located in Portugal.

The remainder of this paper is organised as follows:

Section 2 introduces a brief literature review on pertinent matters such as lean warehousing. The main objective is to acquire knowledge, understand previews applications of lean warehousing, and its real impact on warehouses. Section 3 presents the work methodology (Action Research - AR) followed and used as basis in the present study, consisting of five stages: diagnosis, action planning, implementation, evaluation, and monitoring.

Section 4 presents the case under study, with a contextualization of the problematic and a description of the current situation. Subsequently, the study carries out the analysis of possible improvement opportunities, as well as plans its implementation. Section 5 – results - consists of collecting results and quantifying gains upon the implementation of the changes proposed. Section 6 – conclusions – highlights the main achievements.

2. Literature Review

The growing trend towards a greater variety of products and short response times emphasizes the importance of efficient logistics operations. The activity developed by logistics involves the entire organization, from the management of raw material to the delivery of the final product [10].

Lean production pull-systems consider inventory a waste in any organization, thus production is triggered through costumers' orders, opposed to the traditional production concept push-systems which is based on inventory [4]. From a Lean perspective, value is created when a specific operation or a particular process brings together crucial aspects, namely, whether the customer is willing to pay for the product/service and whether it is done correctly at the first execution. On the contrary, waste occurs when a productive system fails to achieve its goals [5]. According to lean thinking there are seven types of waste: transportation, inventory, motion, waiting, overproduction, over-processing, and defects [6]. The growing need for improvement in the supply chain performance has conducted the concentration of warehouse management to be on the reduction of non-value adding activities, and maximize the use of available warehouse resources [7].

Material storage is an essential component of any supply chain. The costs related to storage represent between 20% and 30% of logistic costs [8]. Therefore, this is one of the most relevant levels in the supply chain [9]. However, the use of warehouses for stock and the movement of materials are essentially activities that do not add value to the product. This is a consensual concept among professionals in the field. Despite this, both activities represent important operations in the supply chain playing a critical role in production efficiency, in final customer satisfaction, and in the fulfillment of the company's value proposal [10]. Both customer service and logistics costs can be improved through proper use of the warehouse [11].

The main activities developed in warehousing are as follows [12]:

- Receiving – offloading and inspecting goods to ensure the quality of delivered orders.
- Put-away – storage of the received goods.
- Picking – pulled by costumers' orders, this operation consists of collecting and preparing for dispatch.
- Dispatch – once an order is completed, it is ready for delivery.

Lean philosophy application to warehouse activities can result in substantial enhancements, such as improving efficiency and efficacy procedures, reduction of processing time and lead time for costumer, and control inventory diversity [10,12]. There is a large variety of lean improvement techniques that can be applied to warehouses, such as material flow analysis, application of the 5Ss, Kanban, VSM, and visual management. Some cases of improvement achieved through the implementation of Lean techniques were studied in order to understand the real impact of this approach. A study carried out in a retail warehouse developed a localization storage system that allowed the improvement of picking tasks, the improvement of the warehouse operations, as well as the stock management. This lead to the reduction of unproductive time by 93% to 100%, and the increase of preparation capacity by 63% [13]. According to Garcia [14], the key to reduce non-value added steps in the warehouse and to enable significant improvement is the application of value stream mapping crosswise. The lean improvements implemented in this warehouse study reduced order processing time by 50% and lead time by 25% [14]. Mahajan [2] presents a research study that uses a continuous improvement lean tool to identify the seven *mudas* of lean principles. By analyzing the spaghetti diagram that minimizes wastes process, it was possible to reduce the corrugated packaging material trough increasing the material handling productivity and increasing efficiency associated to the movement of materials [2]. A study conducted by Salhieh et al. [15], aiming to explore the impact of waste reduction practices on operational efficiency concluded that, in warehouses, the highest implementation of waste reduction practices is likely to lead to higher operational performance [15]. Detty and Yingling [16] present a study developed at an electronics factory, in which by implementing Lean Production it was possible to reduce finished goods stock, transports, occupied space, human resources and procedure time [16]. Chakravorty [17] applied A3 reports in a successful improvement project in aircraft maintenance and repair operations. The systematic approach allowed the successfully implementation of the project – emphasis on the efficiency of

lean tools [17]. A study developed at a warehouse for improving the efficiency of warehouse functions and reducing the stock quantities, carried out the installation of warehouse management system to support stock inventory and its location, also allowing to analyze relevant key performance indicators [18]. Another research, having established the importance of warehouse management, developed a study at a wholesale distributor warehouse, applying lean warehousing techniques and allocation tools in order to improve working conditions and reduce downtime and distances. As a result, it was possible to reduce the distance traveled in the warehouse by 22% as well as making the working area more efficient [19,20].

There is a prevailing acceptance among researchers that lean contributes to improve warehouse operational performance, especially when it comes to cost reduction and significant improvement of productivity and lead time. Lean provides warehousing operations with a competitive edge by ensuring better stock control, improved picking accuracy, and lower storage. Eliminating waste from the warehouse activities, constitutes a resource that improves warehouse operational performance [21].

3. Research methodology

When it comes to continuous improvement, it is crucial to identify existing problems that are in the way of a more efficient and effective outcome. In order to do that, the understanding of the current scenario is very important - via direct observation leading to the identification of the problems and seeking suitable solutions to mitigate the negative aspects identified.

Overall, continuous improvement is a result of cycles of observation, planning, implementation, analysis and monitoring, reviewing, and reassessing towards a new phase of the cycle. In order to reach the proposed goals, it is essential to develop critical analysis of the problem, steered by methodical guidance - well-structured procedures that define how to approach each stage of the problem analysis, as well as the implementation of the proposed solutions.

The methodology applied in this study is action research (AR) - a sequential analysis of events and approaches by problem solving amounting to actual research in action, as opposed to a research about the action. The strategy presented by this methodology applies knowledge in action trough theory building and testing in action. The action part in this methodology implies and improvement-direct change, to eliminate waste and improvement into a more efficient process [8].

The approach requires co-operation between the researchers and the work teams involved – a significant asset - considering the real applications of the solutions proposed by this research [6]. Action research's first key requirement is a symbiotic relationship between the intervenient – the researcher - and the organization.

This methodology allows to co-work with scientific knowledges and company knowledges, in order to reach the goals, such as wasting elimination and to make the process more efficient, always having improvement in mind.

First stage: data gathering and analysis for diagnosing the problems. At this stage, the researcher will understand warehouse logistics dynamics and identify the potential problems and methods to address the problem. The research data gathered is used to generate further knowledge on the nature of the problem, its causes, and impact. The application on a range of techniques can also widen the suite of available options for action.

Second stage: Action planning - define corrective actions by determining what needs to change and how, considering the resources available. This is followed by a planned and structured intervention, with clearly defined procedures.

Third stage: Implementation - actions are enforced based on the plans made in the previous stage, considering all the key members of the organization involved, restrictions and constraints. After the implementation stage, it is necessary to evaluate the outcome of the action – to understand the positive and negative impact of the changes, so that the next cycle may benefit from the experience of the completed cycle. This stage is very important because it is the key to learning for improvement.

The fifth and final stage is monitoring and standardization of the improvement achieved. Monitoring is a meta-step that occurs throughout every stage of AR and is essential to achieve continuous improvement (Fig. 1).

Given the nature of the methodology, the above-mentioned stages are likely to overlap throughout the process. Through the multiple stage cycles, it is possible to improve and attain further knowledge. The reflection analysis on the actions will lead to new understanding and open new areas of inquiry. This iterative process shapes the basic structure for continuous improvement [9].

Within the scope of operations´ management, action research practices aim to find solutions to the problems faced by the organization, becoming at the same time a project within the firm. When applied to management problematics structures, action research becomes an opportunity for creativity and exploration - a goal of this study.

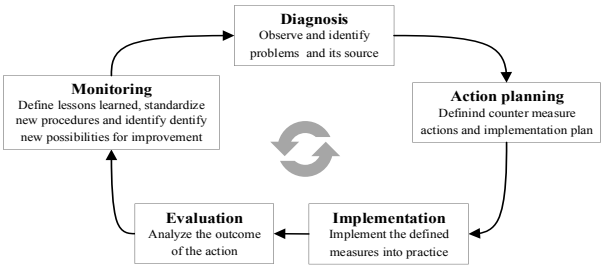

Fig. 1. Action research cycle and implementation guidelines

4. The case study

The present study was carried out at make-to-order (MTO) cork stopper factory finished goods warehouse, aiming to improve the efficiency of the operations developed, maximizing as well the available resources. Finished goods logistics is essential for the supply chain, not only for the

impact on the cost structure but also for the impact on customer service.

The factory under study has been working for 20 years with little changes made in these two decades in the finished goods warehouse. Due to increasing demand, evolution of technologies, decreasing of operations efficiency, and lack of stocking space, improvement became ultimately necessary.

One of the greatest challenges identified was the small budget flexibility - due to large previous investments in the factory. Thus, before considering a more extreme solution, it was important to identify opportunities for improvement within the financial resources currently available. In the context of the project conducted, the four following warehouse operations were studied:

- Packing material stock;
- Order storage after packing;
- Order picking;
- Finished product expeditions.

Considering the necessity of redesigning the warehouse organization, this study consists of four main topics, namely warehouse layout, material allocation and rack capacity resizing. The proposed solutions aimed at improving mainly the warehouse productivity, operations efficiency and increase storage capacity.

This project development was based on the five stages of action research. First: observation for understanding the present scenario. Based on data analyses, local observation and production mapping, it was possible to identify problems and waste needing elimination. Second: proposal of solutions to the organization and design of a plan for implementations, based on lean techniques, followed by a third stage - implementation. Afterwards, results were evaluated and monitored in order to understand the real impact of improvements implemented.

4.1. Diagnosis

The first aspect analyzed was the warehouse occupancy rate. The factory produces MTO exclusively. Stocking space are needed for storing finished goods until clients can order them to be dispatched. Transportation management is reliant on various factors: order size, delivery frequency, destination, and market value density, which must be well balanced. The ratio between the first three factors and the fourth determine the rational cost of transportation - the higher the first three and the lower the fourth, the more cost effective the transportation will be. It is also important to consider that more economical means of transports are usually the slowest. This is one of the main factors that leads to a lower stock rotation, and greater space need. Considering that 70% of market sales have daily transport solutions, it is not expected that at least half of the products remain more than two days in storage. When it comes to other markets, the permanency needs vary a lot, and it can go from two weeks to a month, depending on various factors.

The storage systems are based on rack shelves, with two levels, and the storage unit is pallets with 1.0 x 1.2 m^2. At this point, the total storage capacity was 266 pallets positions.

Based on 24-month inventory time series, it was possible to conclude that the average occupation rate was 107%, as presented in Fig. 2.

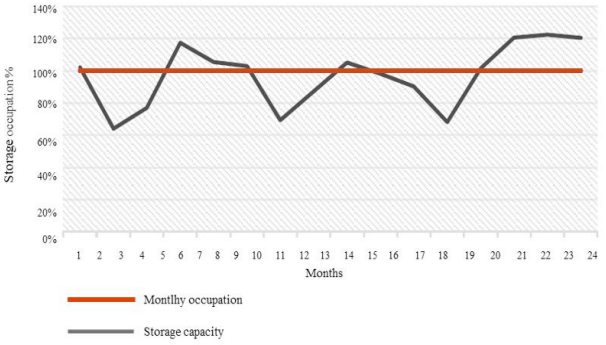

Fig. 2. Monthly warehouse storage analysis

It was possible to conclude that the monthly storage needs are higher than the warehouse storage capacity.

Besides the storage capacity, the working areas are also object of analysis, being a subject of high importance, because if the space is not suited for the working needs, the efficiency of the operations is seriously compromised.

In order to understand the real needs of the current situation, two indicators were analyzed: a) average transport waiting time before loading and b) area for order preparations for daily expedition.

The average time waited by the transportation trucks before loading is an important indicator, as it reflects the organization of warehouse operations. Transportation is arranged through outsourcing and there is normally a set time frame for every transportation to arrive. The warehouse operators know at the beginning of each workday which orders are going to be dispatched and by which means of transportation.

After analyzing the registers of transportation arrivals for the period of a month, it was possible to conclude that the average waiting time between arrival and loading start was of about forty minutes, and the average loading time per pallet was of two and a half minutes.

There are two docking loads available in the warehouse.

As for the first indicator, the space available for order preparation had a capacity of 20 pallets, and the main value area at the loading dock was occupied with a 25 m^2 dusting filter, as it can be seen in Fig. 3.

In addition to the finished orders awaiting dispatch, there are also two other types of storage in the warehouse: returned items (reverse logistics), meaning orders that were for some reason returned by clients, and packaging material. Regarding the reverse logistics, it represents about 20% of the occupied space, and as the space allocated to those items was not sufficient for the existing needs, this led to an unsuccessful attempt to follow the determined organization.

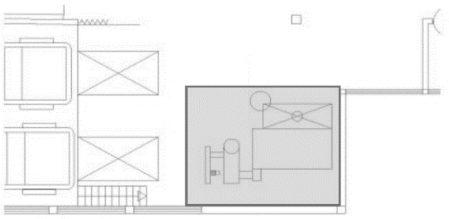

Fig. 3. Docking load nearby area occupied with dusting filter

The packing material is also stored in pallets, which are stored in the racks. There is one pallet space occupied for each different packing type, and there are 22 different references of packing materials, 13 boxes, and nine pallets. Considering that there are references that are more frequently consumed / accessed, and that requires more available stock, the packing materials occupies a total of 32 stocking pallet positions.

This analysis identified a set of improvement opportunities that could be implemented at the warehouse for optimization and improved efficiency.

In addition to this, the working expedition area was not appropriate for the operations - here there were too many unnecessary documents and there was no standardized. the workstation' organization was carried out.

4.2. Improvement proposal 1

After analyzing the rack storage, it was possible to identify an improvement opportunity for increasing the total capacity of storage. The racks pillars do not end alongside the shelf - they continue for an additional 27 cm in height, as illustrated by Fig. 4. This constitutes a restraint of the space available for storage and a waste.

The shelfs are 2,70 m wide and each pallet only occupies 1,1 m, accounting for 10 cm for maneuvering and safety concerns. If the remnant of the middle pillars was cut off, this would amount to a possible gain of 31 additional stocking spaces. In order to maximize the space, it was ascertained that the widest side of the pallet is placed in lengthwise.

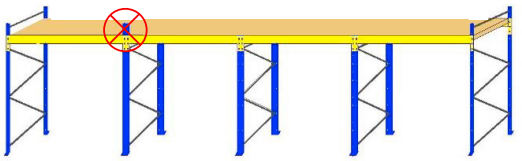

Fig. 4. Racks storage space improvement

4.3. Improvement proposal 2

Having a suitable expedition preparation zone is essential, not only to improve organization, but also to minimize loading times and travelled distances.

Relocating the dusting filter was the most necessary improvement when it comes to gaining space, since it was located in the privileged area of the loading dock. For that reason, this situation was the subject to a trade-off study, to find a possible scenario able to allow this space to become free.

After analyzing some possible scenarios, it was concluded that the filter was only working at about 20% of its capacity, and that the other existing filter could absorb this work, deeming this filter obsolete. The relocation of the filter had a cost of 2.000 €, which was recovered by the enabled decrease of energy consumptions to up to 1.250 €/year.

4.4. Improvement proposal 3

Since there are a lot of packing references that are probably not used as often as others, it was studied the data gathered and analysed from the last 3 years, regarding the consumptions of each reference. This allowed to conclude that there are three references that are not consumed or retrieved by clients within a year, thus taking up the space of a pallet for that length of time, probably unnecessarily. This means that there is absolutely no need to occupy a storage space with only this packing references. That being said, it was proposed that a new organization of the packing material needs to be implemented considering the occupation of only 28 positions, which allowed to win 4 positions (before were 32). This study also enabled to reduce obsolete packing stock by 2.500 €.

Visual management is a very important tool when it comes to visually organizing the working stations. In order to control the stock management, guiding arrows signaling were installed to limit the maximum and minimum stock, according to Fig 5.

Fig. 5. Visual management

4.5. Improvement proposal 4

In addition to clarifying operation procedures and tools, the 5S application to a working station enabled the identification of misplaced objects and / or if tasks were being carried incorrectly. Organized work is the first step for normalized and effective operations. Firstly, all the existing material in the working station was sorted and accounted for. Subsequently, it was introduced a definition strategy for organizing/placing tools and documents according to their use frequency, importance, and picking/usability process. Workstations were divided according to market and transport categories and according to the documents needed for each case. Cleanliness also contributes to standardized behavior, which was the next step. This was followed by an update of cleaning standards and organization standardization. Finally, maintenance of these procedures is a crucial step, that must be kept at all times, and that must be supervised and inserted into the organizational culture promoted by the company.

4.6. Result appreciation and assessment

After the warehouse has been organized, the warehousing operations efficiency has been increased as well as the information flows, contributing for a better company's performance.

Firstly, in order to implement these improvements, it was carried out the development of a sorting activity, so that item returns, small and big orders were separated, since that due to the lack of space all of these were mixed within the same spaces. The initially poor organization of tasks, such as the picking list not following a logic order or the operators constantly revisiting the same aisles, contributed strongly for time waste in tasks such as transportation, re-work, motion and waiting – all of these also largely contributed to the decrease of efficiency of the operators.

The final layout was defined as follows in Fig. 6.

Fig. 6 – Final layout

The blue coloured zone represents the preparation zone, now with a capacity for 35 pallets. Relocating the dusting filter machine allowed to gain 25 m^2, that translates in space for 15 pallets on the preparation zone. The yellow zone was reserved for small and heavy rotation orders, in order to reduce transportation waste. The green zone was reserved for returns (upper level) and packing material (ground level). The red zone of the warehouse is used for all the other orders. The storage areas were calculated taking into account a monthly rotation ponderation, grouping the higher rotation items together and closer to the expedition area, in order to decrease the number of moves as well as the travelled distance.

Overall, the improvements proposed can be resumed to:

- Organized workstation which contributes to operation efficiency, decreasing the probability of errors;
- Improving rack storage space;
- Increasing of preparation zone;
- Implementing new organization system in the warehouse.

5. Results

The work developed had as foundation continuous improvement and lean tools. This enabled the analysis and identification of several waste situations and of improvement opportunities for its mitigation.

The biggest constrains encountered was firstly the budget limits and secondly the mind set of the operators, conditioned by their old habits and tools.

Based on the structure proposed by the action research methodology, we began by developing a critical observation process that enabled the team to diagnose and identify several points wastes. We began by collecting the data that was subsequently subject to analysis. It is important to enhance the positive contribution and the active engagement between the researcher and the organization. This allowed both to understand the real needs of those who work on the shop floor, and in what sense those needs meet the organization's goals. Based on the opportunities identified, solutions for implementation were presented to the company. Upon the conclusion of that stage, the results were evaluated, and work procedures were standardized, in order to implement continuous improvement culture.

Visual management and implementation of 5S in the working stations also contributed to increasing the efficiency and decreasing operation times, as well as helping to prevent errors and re-work needs.

In order to maintain the improvements achieved, it is very important to maintain discipline in an organizational culture of continuous improvement, always considering that in order to achieve results the organization has to adapt the continuous improvement methodologies to its resources and goals.

Through these methods, it was possible to identify waste and achieve critical improvements.

When it comes to storage space, the improvement proposed allowed an increase of 12% capacity, meeting the needs of stocking according to the last 24 months' inventory. 5S was applied to the general warehouse, which helped sorting through some obsolete materials.

It was possible to increase the area allocated to preparation to 35 spaces, and to improve a prime zone for loading transportation, significantly decreasing the transportation distances. The elimination of the dusting filter also allowed a reduction of power costs up to 1.250 €/ year.

The definition of storage reserved areas also contributed to a reduction of transportation distances. The distance traveled by operators was reduced up to 23% when compared to the initial scenario, before intervention. These improvements also had a substantial impact on the waiting time between arrival and the beginning of the loading process by those in charge of transportation.

6. Conclusions

This research has shown that continuous improvement can be achieved through measures that do not require an excessive amount of investment. In total, it was spent 3.500 € applying all the solutions proposed, as the time spent on studying and implementing the measures was 4 months.

This study was promoted by the increase of production, that doubled in 5 years, the highest rate ever recorded in the 25 years of the company's history, which led to the need to maximize the production capacity and the resources available.

The storage space was increased by 12% due to the improvements implemented. Moreover, the area allocated to preparation was enlarged to 35 spaces, and to improve a prime zone for loading transportation, significantly decreasing the

transportation distances. Also the elimination of the dusting filter allowed a reduction of power costs up to 1.250 €/ year.

In order to maintain the improvements achieved, it is very important to maintain discipline in an organizational culture of continuous improvement, always considering that in order to achieve results the organization has to adapt the continuous improvement methodologies to its resources and goals.

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