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Analysis and Implementation of a Lean Model in Warehouse Management

Abstract

This project aimed to analyze the practical difficulties in storing and moving a high range of products making the process easier and more efficient. The objectives were to improve the use of available space in the raw materials warehouse and ensure the effectiveness, efficiency and reduction of the periods between the transportation from raw materials to production lines.
The work developed focused on improving internal processes, storage practices and internal transportation. In fact, for the production flow to be continuous, the supply must be aligned with the production to ensure that there is no failure of materials.

Keywords

Lean; Warehouse; Sustainable Internal Logistics; Mizusumashi; Discrete Event Simulation.

1. Introduction

The constant technological developments and the globalization of emerging markets have caused global competition to increase, creating unprecedented levels of pressure for manufacturers.

In order to be able to compete with technological developments with emerging markets, the company needed to make its production more sustainable. With the strong bet on sustainability the goal is to improve the efficiency and social responsibility of the company.

The company intended to improve its sustainability practices on a fundamental part of each company, the warehouse. For the warehouse to be efficient and effective, it is necessary that its layout allow the smallest number of moves, simplifying the tasks of the operators.

The warehouse implantation was redesigned considering lean principles thus achieving a higher sustainability index in long term.

Departing from the objective of reducing waste, the internal logistics model was analyzed. Noting that the model was inefficient and ineffective, the various characteristics of the model were analyzed so that it would become more effective and sustainable for the company.

Some of the techniques used to analyze the internal logistics model were discrete simulation, lean principles and a full implementation of a Mizusumashi internal logistic train.

2. Theoretical Foundations

Lean is a management tool that can be applied to any company, system or process. Their goal is to identify critical areas, eliminate their wastes and unnecessary actions/moves so as to subsequently implement measures that result in improvements (Hicks 2007). The waste, which does not add

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value to the customer comes by standard of seven sources (Figure 1): excess of production, inventory, errors and defects, wait, excess processing and unnecessary drives (Rewers, Trojanowska et al. 2016).

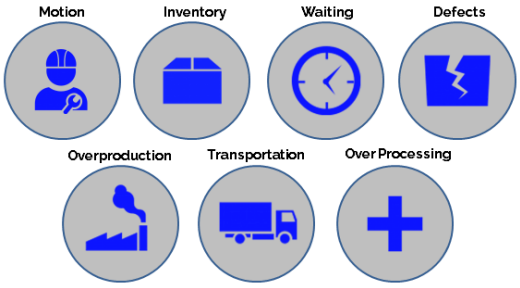

Figure 1. The Seven Wastes of Lean (Chirag 2018).

Storage usually implies high costs as it includes several activities that do not add value (Dharmapriya and Kulatunga 2011). However, this activity plays a key role in the supply chain so any improvement in the warehouse allows a reduction in the costs of the company and the possibility of offering a better customer service (Roodbergen, Vis et al. 2015).

Smith (1998) states that warehouses are a fundamental part of the system of the vast majority of supply chains since they allow to have the product protected and accessible when necessary. The warehouses generate high associated costs, between 2-5% of the total costs of the companies (Frazelle 2002).

Thus, it is necessary to improve the operations of a warehouse by eliminating its inefficiencies (Dotoli, Epicoco et al. 2015). The constant decrease in waste is a participatory process, as such the Kaizen approach (continuous improvement) is a key part in Lean production (Dotoli, Epicoco et al. 2015).

In the TFM (Total Flow Management) model, the Mizusumashi (internal logistics train) is the element that is responsible for the movement of materials and information within the plant (Coimbra 2008).

The purpose of this system is the standardization of materials and the elimination of waste, present in Figure 2. Mizusumashi is one of the most important systems to create internal flow in logistics, functioning as an airport shuttle service (Coimbra 2008).

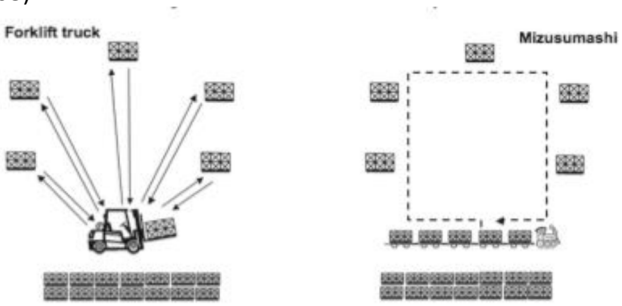

Figure 2. Use of forklift vs. logistics train use (Coimbra 2008).

2.1. As-Is State

In the initial study show that the warehouse has a low efficiency rate in the loads and discharges of raw materials because of the lack of discharge pier. In addition, in the warehouse there is also a lack of storage locations and when they are in block they can damage the raw materials.

Moreover, to add to the storage problems there were identified too many unnecessary moves. For instance, at the time of picking because the sites are not defined based on the rotation of the product and because there is no standardization in the functions, the warehouse materials flows present significant inefficiencies. Being that all the operators do everything now, and the picking process is still manual there is a lot of variability in operations durations.

Further to these problems the deliveries are slow and inefficient as they are carried out using forklifts, thus requiring several trips and always returning in emptiness.

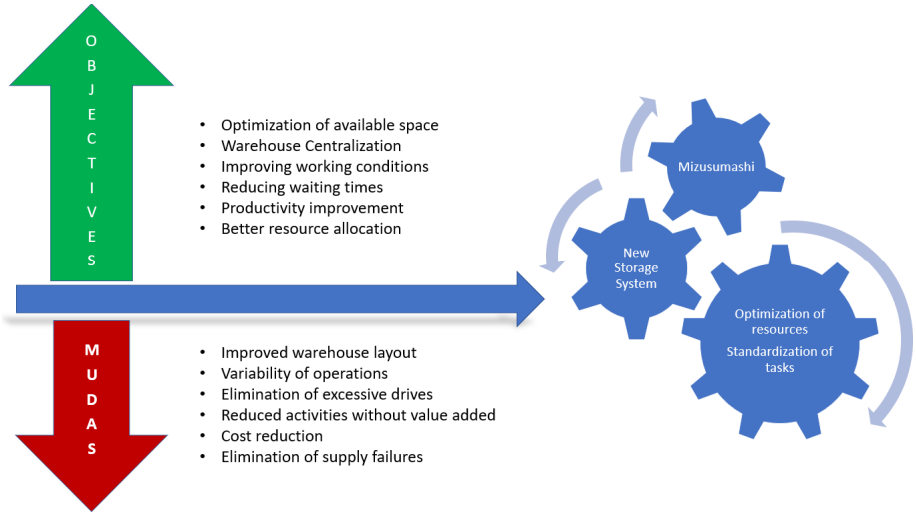

Figure 3. Overview picture of this project.

2.2. Vision

The vision for the warehouse goes through integrating a dock of loads and discharges in the warehouse as well as a definition of a new layout of the warehouse. With these solutions, it is intended that the storage capacity will increase and that the number of drives for picking is reduced. The suggested changes will allow the creation of a more efficient and more sustainable warehouse management policy.

To oppose existing wastes in raw materials deliveries, the vision is to implement an internal logistic train called Mizusumashi to reduce delivery times, reduce the costs of the operation and allow reallocation of resources for value-added activities.
By using this system, the aim is to obtain a more efficient operation, reduce supply failures and increase its capacity at operational level.

2.3. Proposals Assessment

The solutions proposed for the warehouse went first by selecting a new storage method for high-speed products.

According to the specialists, for high-rotation products and with certain restrictions (at the level of weight and height and being supplied on pallets of wood) the best system to implement is the Drive-In and Drive-Through system. This system is composed of vertical metallic columns with rails to withstand the loads and store on several floors with the forklifts circulating inside the structure orderly to place the loads. The selected method was the Drive-In system.

The choice of this system will allow that the high-rotation raw materials are all in one space and that this space is as close as possible to the shipping area. Thus, achieving increasing efficiency and reducing excess movement.

A new design was then made for the conventional storage system inside the warehouse as well as a new plan for the allocation of raw materials to their new locations. For the elaboration of the locations, the rotation and the peaks of stock of each product beyond its technical characteristics were studied.

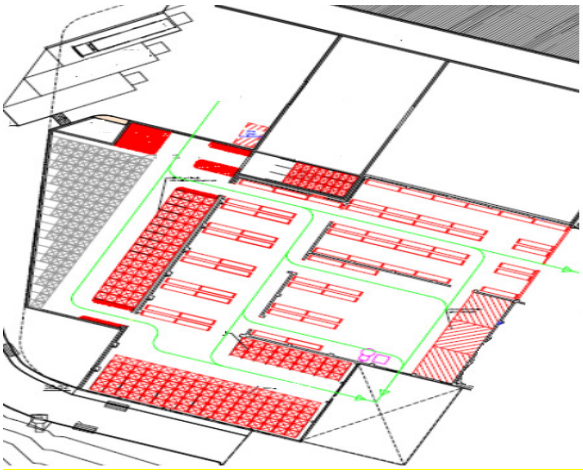

Figure 4. The image represents the new layout of the warehouse.

The Figure 4 demonstrates the changes made to the warehouse layout. With the inclusion of the loading and unloading pier, the drive-in for the most rotating raw materials in easy-to-access areas near the dispatch zone.

In position to make a careful analysis of the internal logistics model, we developed spaghetti diagrams of the courses performed, the time of each course and a total distance analysis traveled per week.

After an analysis of all the measured parameters, it was verified the best solution passed through the implementation of a Mizusumashi to improve efficiency and reduce transport costs thereby improving the sustainability of the company as well.

After being selected the model to be implemented, several simulations were made, namely the route to be used, the hours of deliveries and the locations of the stations, having always in mind to increase the efficiency and effectiveness of the process.

Moreover, all kinds of materials to be transported and the restrictions that they could bring at the time of choosing the type of trailer were also considered. In addition, simulations were made to know the ideal number of trailers needed to be able to carry the needs of the production lines with the smallest number of drives.

Following were selected the types of trolleys that best adapted to the model considering their limitations. The last step went through with the choice of the Mizusumashi tractor that best suited the amount of trolleys that this logistical train would have to tow.

After the definition of all the components of the Mizusumashi, the equipment was chosen to maneuver the raw materials in the delivery and collection stations of raw materials.

To validate the study made for the internal logistic model a set of simulations were feature of Delmia's discrete Quest simulation tool.

Four scenarios were studied using four discrete event simulations. In all four simulations, the work schedules of the warehouse employees as well as their daily breaks were analysed. In addition, the existing annual costs with the equipment, the fuel costs and the cost of the workforce were calculated to obtain the cost in function of the working hours.

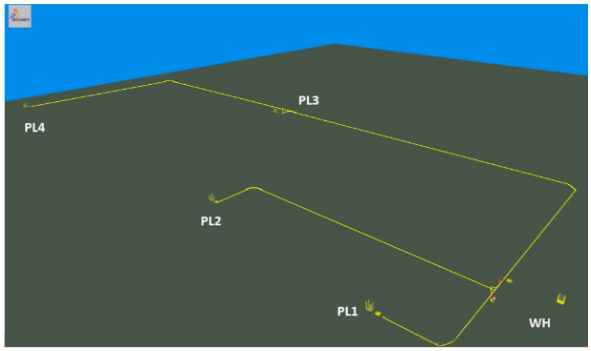

Figure 5. Path for the Existing model and Mizusumashi model

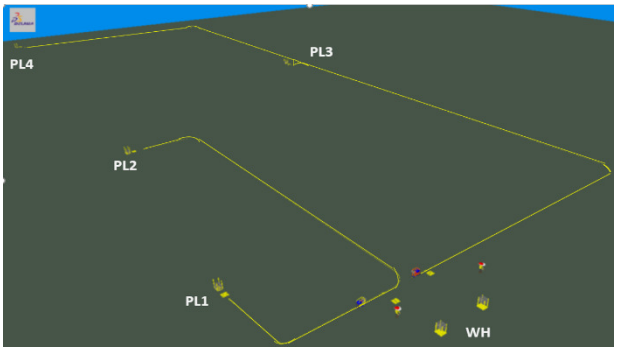

Figure 6. Path for the Mixed model and Mixed model optimized

The first scenario, (the layout path is represented in Figure 5), represented the existing internal logistic model. This scenario was built in order to verify the improvements obtained when compared with the other scenarios.

The second scenario (uses the same layout path represented in Figure 5), depicts a model of deliveries using a Mizusumashi with the ability to carry five pallets at a time returning empty to the warehouse.

The third scenario, (the layout path is represented in the Figure 6) describes a mixed model, which include the farther production lines of the warehouse. The Mizusumashi train supplies the nearest production lines (PL) through a forklift, which returns empty to the warehouse.

The fourth and final scenario, (also uses the layout path represented in the Figure 6) is an improvement of the mixed model, and in this case, the Mizusumashi train return bringing materials to the warehouse.

2.4. Result Analysis

The new warehouse design significantly increases the number of locations available to store raw materials. The new layout design intended to improve the access to the storage locations reducing the likelihood of damaging the pallets or the raw materials itself.

To conclude, more centralization has been accomplished by allowing the most rotating raw materials to be in single place. Thus, reducing the number of movements of operators and equipment at the time of storages increasing the efficiency and effectiveness of the process.

After the realization of the four scenario simulations, it was possible to see that the existing model was not sustainable since it was the model that moved the smallest number of articles with the greatest number of moves and consequently at the highest cost. Thus, it was found that the model was neither efficient nor effective.

From the current model to the Mizusumashi model it was possible to obtain a significant reduction in the distance travelled weekly (almost 80%) and in the transport costs (near 50%). However, the solution would not be sustainable if there was an increase in the level of orders of the production lines.

The mixed model allowed an increase in the level of moving products (doubled) against the current model, thereby showing the increase of this the model sustainability in the medium-long term. This mixed model scenario reduces both the distances travelled and the transport costs (close to 53% for both).

With the last studied model, the improved mixed model, the results shown a three times increase of the weekly transport capacity and at the same time, and a reduction of the distance and costs by 49%.

In order to compare all the scenarios it was necessary to quantify the average cost per unit transported. Since the four models move different quantities and have different costs, a measure was required to compare the effective improvement of each simulation against the initial model.

The first Mizusumashi model presented an overall reduction in the costs of 81%. The mixed model achieved a reduction of almost 77% and finally the improved mixed model scored a reduction in total costs of 83%.
In face of these results, we can conclude that all simulated models present improvements comparing with the initial scenario. However, the scenario that achieves the highest flexibility is also, what scores the lowest cost. In the light of this data, the model chosen by the company management was the improved mixed model, which allows the highest cost reduction.

3. Conclusions

The main objectives of this project were to improve sustainability of the existing storage system first by designing a new more efficient layout, followed by the implementation a new storage and retrieving system project. This new approach aimed in making the warehouse daily operation more efficient, more dynamic, more centralized, and at the same time, reducing the movements and efforts by the operators. In addition to this endeavor, the present work proposed to design a new logistics supply model between the raw materials warehouse and the production lines. This model foster to reduce transport costs, the movements between the warehouse and the manufacturing premises, and ensure that there is no excessive stock in the production borderline, sending only the required quantity for each manufacturing order at the time needed. All of these efforts aimed to improve the company sustainability with the respect to social, environmental and economical axis.

References

Chirag (2018). The 7 wastes of Lean, leanmanufacturingsecrets.com.

Coimbra, E. (2008). The Total Flow Management Model. *KAIZEN FORUM*, Global Edition.

Dharmapriya, U. and A. Kulatunga (2011). New strategy for warehouse optimization–lean warehousing. In *Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management*.

Dotoli, M., N. Epicoco, M. Falagario, N. Costantino and B. Turchiano (2015). An integrated approach for warehouse analysis and optimization: A case study. *Computers in Industry* 70: 56-69.

Frazelle, E. (2002). *World-class warehousing and material handling*. McGraw-Hill New York.

Hicks, B. J. (2007). Lean information management: Understanding and eliminating waste. *International journal of information management* 27(4): 233-249.

Rewers, P., J. Trojanowska and P. Chabowski (2016). *Tools and methods of Lean Manufacturing-a literature review.*

Roodbergen, K. J., I. F. Vis and G. D. Taylor Jr (2015). Simultaneous determination of warehouse layout and control policies. *International Journal of Production Research* 53(11): 3306-3326.

Smith, J. D. (1998). *The warehouse management handbook*, Tompkins press.