

IMPLEMENTATION OF LEAN PRINCIPLES TO IMPROVE THE OPERATIONS OF A SALES WAREHOUSE IN THE MANUFACTURING INDUSTRY

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ABSTRACT

This paper deals with the implementation of lean techniques in a sales warehouse in the manufacturing industry. It highlights efforts to improve warehouse operations by eliminating waste using lean tools such as a value stream map (VSM). A current state VSM exposes waste in an existing system. High order picking time, improper storage, delay in vehicle loading, and low space utilization make the warehouse inefficient. Implementation of a U-shaped flow layout in the warehouse improves order picking time, vehicle loading time, and space utilization. A future state VSM shows the new state of operations before implementation. After lean implementation, considerable improvements were observed in vehicle loading, space utilization, and storage. Thus, the efficiency of warehouse operations is increased, resulting in quicker responses to customers' demands.

Keywords: ABC analysis; Layout; Lean manufacturing; Value stream mapping; Warehouse

1. INTRODUCTION

In the modern era, prolonged production runs, unfinished work, and extensive lead times are becoming detrimental. Industries should be flexible enough to meet customers' demands. The main issue faced by manufacturers today is how to deliver high-quality products or services quickly at a low cost. Industries are looking for new tools and techniques to produce goods to compete and survive in the market. One promising method for addressing this issue is the application of lean principles and techniques. Lean manufacturing, simply known as "lean," is a production practice that identifies waste in existing activities and eliminates them so as to achieve continuous improvement and better productivity (Fullerton et al., 2014; Chiabert et al., 2015). The wastes to be eliminated include overproduction, excess inventory, delay, transportation, reworking, and underutilization of people and facilities. Elimination of waste can lead to better connectivity between operations. In addition, it improves the response time to customers' demands, reduces inventory, reduces cost, and improves productivity (Yang et al., 2015). Waste is eliminated using various lean tools, such as 5S, value stream maps (VSMs), and Kanban and Kaizen (Khamis et al., 2009; Arslankaya & Atay, 2015; Jiménez et al., 2015). This paper mainly utilizes VSM and layout changes to solve problems.

VSM is a method to identify non-value-added activities in an existing operation (Venkataraman et al., 2014; Rohac & Janusuka, 2015). It represents activities in a flow chart manner. There are two types of VSMs: current state and future state maps (Abdulmalek & Rajgopal, 2007; Suhadak & Amit, 2015). A current state map is drawn after observing current activities, and it

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helps to identify all wasteful activities. Then, a future state map is drawn to show the effect of eliminating all wasteful activities (Rohani & Zahraee, 2015). VSM helps identify bottlenecks, waste within processes, and the sequence of activities. Compared to other lean techniques, it is inexpensive, easy to implement, quick, and easy to learn.

The literature reveals that implementing lean principles results in better productivity and is very helpful for meeting customer demands. However, to the best of the author's knowledge, the literature regarding implementation of lean principles in warehouse operations is very limited. Hence, in this work, effort is made to improve sales warehouse operations so as to meet customer demands as quickly as possible using lean principles. Warehouses are important areas when dealing with customer demands (Bortolini et al., 2015). They are material handling stations dedicated to receiving, storage, order picking, dispatching, docking, and shipping of goods (van den Berg & Zijm, 1999). Receiving involves scanning the product package and entering it into database, while storage involves storing products in the desired arrangement. Products are picked based on customer orders, stored in a particular area to await delivery, and then scanned in the dispatching area before shipping. Warehouses can be generally classified into three types: production warehouse, distribution warehouse, and contract warehouse (Dotoli et al., 2015). The wastes identified in these warehouses are divided into transportation, inventory, waiting, delay, space, movement, overproduction, and defect wastes. Transportation, waiting, delay, space, defect, and movement wastes are generally eliminated by layout changes, proper working rules, visual management tools, and 5S (sort, set in order, shine, standardize, sustain). Inventory can be made more efficient by adopting proper inventory models such as ABC analysis. This paper considers the sales warehouse to be a symbol for various issues related to distribution of products to customers.

The objective of this work is to provide lean solutions to improve warehouse operations. Using lean tools such as VSM, wastes are identified. Methods for eliminating wastes are decided and a future state VSM is drawn. The solutions mostly involve layout changes drawn in Autodesk inventor. A class-based storage system using ABC analysis is developed to reduce travel waste.

2. METHODOLOGY

Of the available lean tools, such as 5S and Kanban and Kaizen, VSM is selected for this work as the others are not as helpful for identifying wastes in a process. Its advantages, such as its ability to find bottlenecks, easy implementation, and simple learning curve, make it an ideal way to solve problems in a warehouse. The methodology of this work is divided into three phases: study of an existing system, development of lean solutions, and results (Tyagi et al., 2015). In the study of an existing system, the problem area (i.e., sales warehouse) is identified. For evaluation of the current state of the system, a detailed study is performed. Time and motion studies are used to monitor each warehouse operation. From these studies, a current state VSM is drawn. Wastes that hinder smooth operation of the warehouse are identified from the VSM. In the development of lean solutions phase, solutions for eliminating wastes—changes in layout and inventory arrangement—are developed. The new inventory arrangement is based upon ABC inventory analysis; products are arranged according to the customers' contribution to product sales. The warehouse layout is changed from an L shape to a U shape, which minimizes the travel distance and time required for operation.

A future state VSM is drawn to show the future state of warehouse and progress of operations based on the lean solutions. In the implementation stage, the developed lean solutions are implemented. The result phase mainly consists of evaluation and analysis of the new state. During this evaluation, the results of implementation of lean solutions are monitored using time and motion studies. Analysis is performed to determine whether the lean solutions are successful.

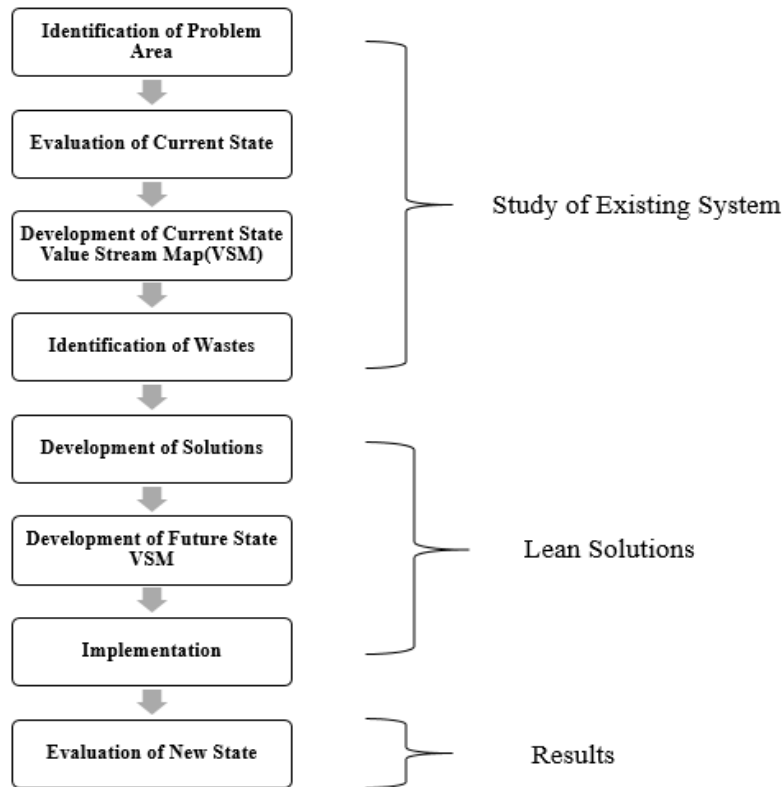


Figure 1 Methodology

3. CASE STUDY

This paper describes the application of lean techniques in a sales warehouse of a reputed manufacturing company in India. There are five value streams with which products are associated: actuators, boosters, compressors, anti-lock braking systems (ABSs) and valves. The products, which are packed in carton boxes and pallets, enter the warehouse from the assembly line.

3.1. Study of Existing System

Figure 2 shows a model of the existing state of the warehouse created using Autodesk Inventor. Packed products come from the assembly line. There are two docks in which parts are loaded.

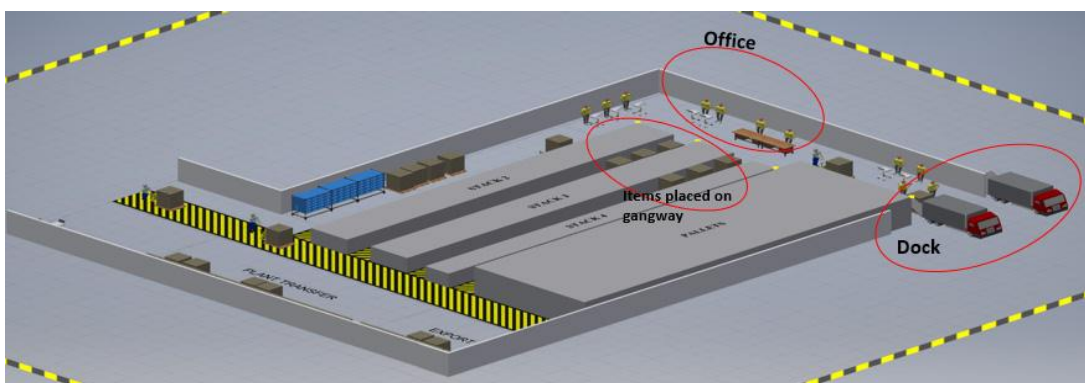


Figure 2 Existing layout

The warehouse has an L-shaped layout in which the receiving area and dock are on different ends. Order picking is performed after vehicle arrival, causing delay in vehicle loading.

Material stacking based on the value stream increased picking time. Picked products placed on gangways obstructed motion. From the collected data, a current state VSM was drawn. Figure 3 shows the current state VSM.

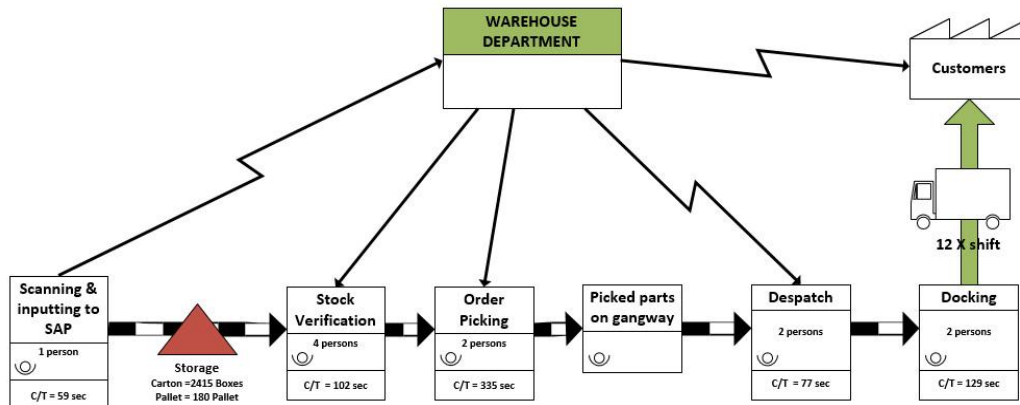


Figure 3 Current state value stream map

Scanning, storing, stock verification, order picking, dispatching, and docking are the main operations of the warehouse. The cycle time for each operation is determined by time study. The figure clearly shows that order picking requires the most time (335 s) and thus is a waste that must be reduced. After order picking, items are placed on the gangway, obstructing movement of materials. Table 1 shows the identified wastes, and its location.

Table 1 Waste identification

Sl. No.	Waste	Location
1	Delayed scanning	Receiving area
2	Delay in movements	Gangway
3	High vehicle loading time	Dock
4	Unnecessary movement during storing and order picking	Storage area

The observed wastes are delayed scanning, obstructed material flow, improper storage, delayed storage, high order picking, and delayed vehicle loading. Improper storage directly causes high order picking time and delayed vehicle loading.

3.2. Lean Solutions

In this phase, solutions for the identified wastes are developed. Table 2 shows the wastes, their locations, and ways to eliminate them.

Table 2 Waste solutions

Sl. No.	Waste	Location	Solutions
1	Delayed scanning	Receiving area	Move scanning area nearer to gangway
2	Delay in movements	Gangway	Two-way gangway
3	High vehicle loading time	Dock	Marshal yard
4	Unnecessary movement during storing and order picking	Storage area	U-shaped flow layout using ABC analysis

The delay in scanning is due to the 7.5 m distance between the scanning area and products. Thus, the operator has to move 15 m for each scanning and data entry activity. To reduce scanning time,

the scanning area is moved nearer to the gangway. The new distance between the scanning area and products is 1 m.

Material obstruction mainly occurs due to the clash between inward and outward flow and can be solved by a two-way gangway. By following the directional arrows, the clash between inward and outward flow will be reduced. Figures 4a and 4b show the current gangway and two-way gangway, respectively.

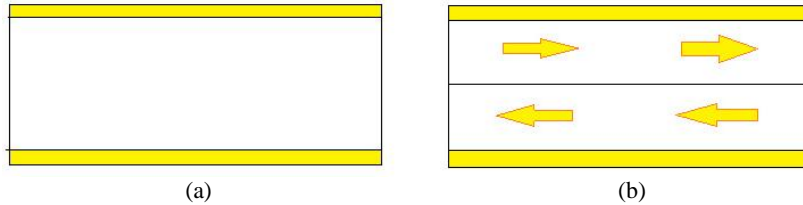


Figure 4 (a) Current gangway; and (b) two-way gangway

High vehicle loading time is another waste that should be eliminated. In the previous layout, shown in Figure 2, order picking was done only after a vehicle entered the docking area. In total, it takes nearly 63 min to load the vehicle. Nearly 20 vehicles come to warehouse per shift. But, in the current scenario, it is possible to load only 12 vehicles. Also, picked products were placed on the gangway, obstructing flow. To solve this, a marshal yard was implemented, as shown in Figure 5.

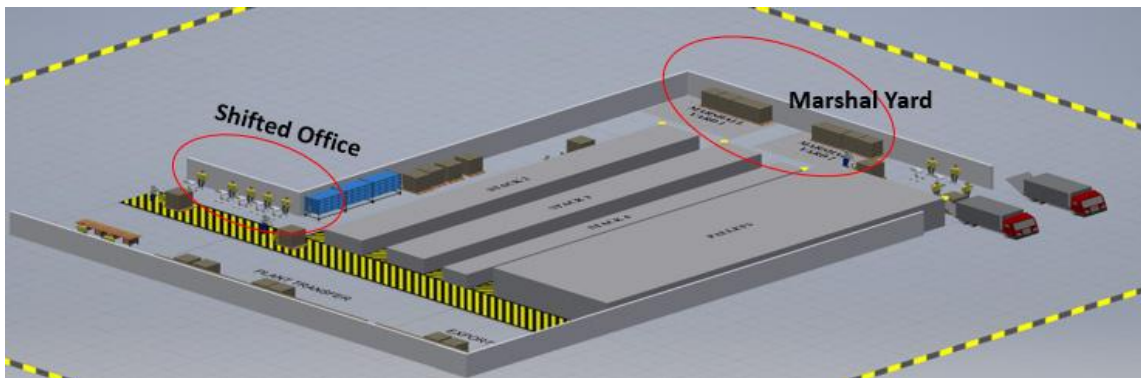


Figure 5 Marshal yard implementation

In order to reduce vehicle loading time, the new layout includes two marshal yards so that order picking is done at least 1 hour before a vehicle arrives. As a result, vehicle loading takes only 16 min.

Unnecessary movement during storing and order picking is the next waste that is targeted. Figure 2 shows the current layout, in which material flows in an L shape. The dock and receiving area are at different ends of the warehouse, meaning that each product has to travel 67.5 m before loading. Thus, much manpower is wasted moving the parts.

In the new layout, the flow has a reverse U-shaped layout and items to be stored are classified into three categories based on ABC analysis. This layout provides excellent cross-docking as the cross-docking distance is reduced to 30 m (previously 67.5 m). “A” items should be placed nearer to dock area, while “B” and “C” items should be stacked afterwards. Figure 6 shows the U-shaped flow layout.

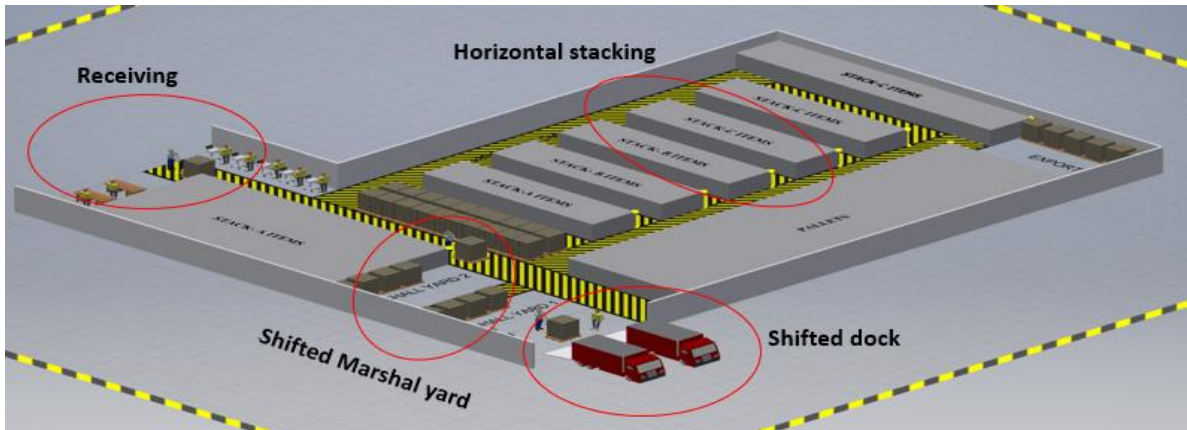


Figure 6 U-shaped flow layout

ABC storage analysis is used to reduce order picking time. It is a method of storage categorization in which items are classified into three classes: A, B, and C. Figure 7 shows an ABC analysis graph of the sales value of products sold to customers.

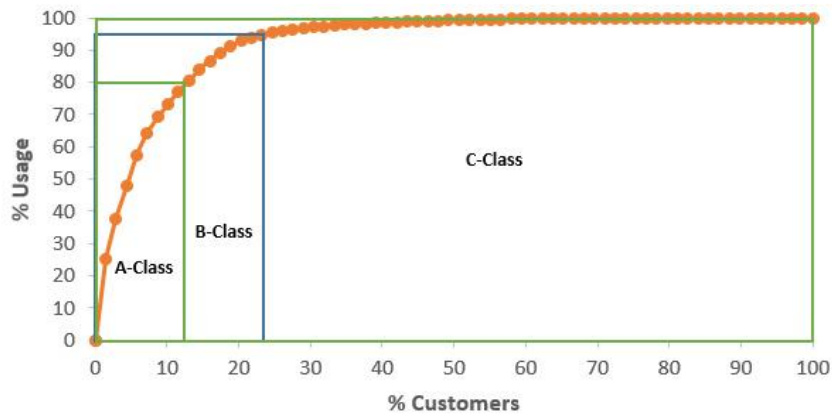


Figure 7 ABC analysis

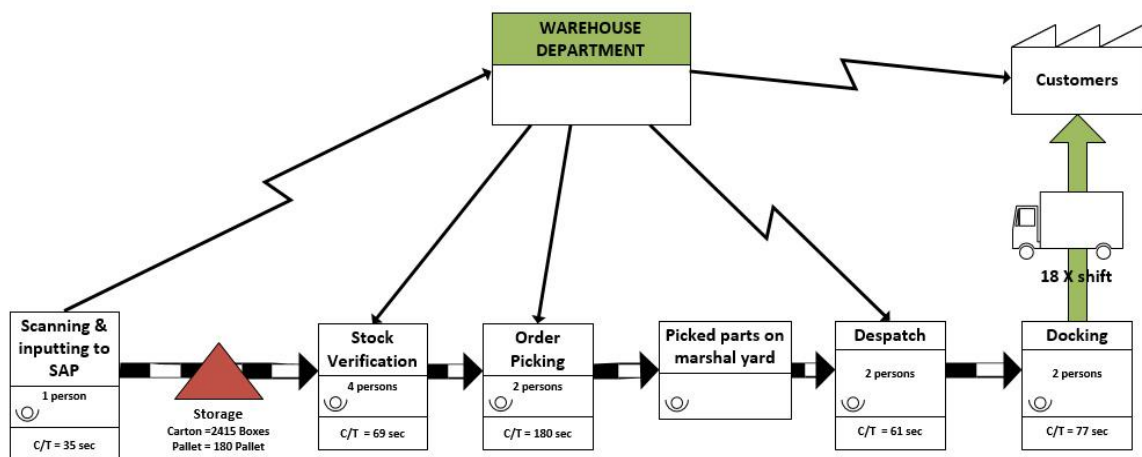


Figure 8 Future state value stream map

In Figure 7, customers are classified into three classes based on their contribution to the total sales value. The A class is the most important and is responsible for 80% of the total sales value, while the B class is responsible for 15% of the total sales value and the C class is responsible for

5% of the total sales value. The A class consists of 13% of customers, the B class consists of 11% of customers, and the C class consists of 76% of customers. Since the demand of the A class is higher, it is better to place those products nearer to the dock area than B and C class products.

Based on the solutions and their results, a future state VSM was drawn, as shown in Figure 8. This map shows the future state before implementation. Picked products are placed in the marshal yard instead of on the gangway, and the cycle time of each operation is reduced.

4. RESULTS AND DISCUSSION

Each warehouse operation is improved by value stream mapping and layout changes. Figure 9 shows the operation times of the previous layout and new layout.



Figure 9 Improvement in warehouse operations

The graph clearly shows that efficiency of operations is improved in the new layout. Scanning time is reduced from 59 to 35 s, and stock verification time is reduced from 102 to 69 s. Order picking time, which was previously 335 s, was reduced to 180 s by ABC inventory analysis. Dispatching was reduced from 77 to 61 s, and docking was reduced from 129 to 77 s by the marshal yard.

Table 3 Results

Sl. No.	Operation	% of time reduced
1	Scanning	40.67%
2	Stock verification	32.35%
3	Order picking	46.26%
4	Dispatch	20.77%
5	Docking	40.31%

Table 3 shows the results of the VSM and layout change solutions. Scanning time was reduced by 40.67%, stock verification was reduced by 32.35%, and order picking time was reduced by 46.26% due to the U-shaped layout. In addition, the marshal yard reduced vehicle loading, docking, and dispatching time.

Table 4 Improvement in vehicle loading

Sl. No	Factors	Previous layout	New layout
1	Vehicle loading time in minutes	63 min	16 min
2	% reduction in time	_____	74.60%

Table 4 shows that marshal yard implementation reduced vehicle loading time by 74.6%. In the previous layout, vehicle loading took 63 min, while after implementation it took only 16 min.

Table 5 Benefits of U-shaped flow layout

Sl. No.	Factor	Current layout	U-shaped flow layout	% of improvement or reduction
1	Cross docking distance (m)	67.5 m	30 m	55.5 % reduce
2	Storage area (m ²)	482.625 m ²	502.5 m ²	4.11 % improve
3	No. of storage locations	515	536	4.07 % improve

The benefits of a U-shaped flow layout are listed in Table 5. The cross-docking distance (distance from the receiving area to dock) is reduced from 67.5 m to 30 m in the new layout. Thus, for fast-moving products (products with the highest demand), the travelling distance is reduced by 55.5%. In addition, storage area is increased from 482.625 m² to 502.5 m² (a 4.11% improvement) and the number of storage locations is increased from 515 to 536 (a 4.07% improvement).

5. CONCLUSION

As part of a continuous improvement process, an attempt was made to improve the efficiency of the operations of a warehouse in the manufacturing industry using lean principles. Value stream mapping was used to track waste, and most types of operation waste, such as high order picking time, delayed vehicle loading, and improper storage, are eliminated by changing to a U-shaped flow layout and performing ABC inventory analysis. The majority of warehouse operations are improved by at least 40%. A future state map is drawn based upon the solutions showed the improvement in processes. This paper shows that lean principles can be successfully applied to warehouses as well as shop floors.

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