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Briceño G., Gustavo, A. ***Implementing lean principles to improve warehouse operations at XYZ Company.***

Abstract

The objective of this project was to develop a set of techniques to increase efficiency and improve the operations in the warehouse of the XYZ Company. To achieve this goal it was necessary to increase the mobility and the visualization within the warehouse. In addition, the intention was to improve space utilization and the picking time. This project evaluated the existing layout design and compared it to a new layout that was designed using lean theories and techniques. The project incorporated lean production theories that focused on waste elimination, creation of standardized work, and warehouse layout. At the conclusion of this project the organization received a proposal that demonstrated how lean manufacturing could impact their business, creating a standard for further continuous improvement throughout the company.

Acknowledgments

First and foremost, I would like to thank God for helping me to achieve this goal. I would also thank my teachers for their constant support, guidance, and understanding throughout the thesis writing process and studies at the University of Wisconsin-Stout. Last, but not least, I would like to thank my family, Mariam and my friends for their support.

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Chapter I: Introduction

In most of the northern United States the tendency is to build houses and buildings with basements. This means that these basements have to be built with windows for ventilation and emergency egress for that space. A frequent issue is that the windows are exposed to water and dust produced by the ground, in addition to the possibility of flooding under extreme conditions. A solution to these problems is to install a cover or shield for these windows. The company XYZ is in the business of manufacturing these basement shields for windows. These shields are built through a plastic vacuum forming process. As a result of this process, windows well covers of different sizes and shapes are made. These are in high demand during spring and summer. Due to this seasonal demand the company is pushed to produce enough well covers during the rest of the year to be able to meet the customers' requirements increment because of many construction projects by the high demand time.

This company stockpiles the finished goods in their warehouse to provide for seasonal demand. When new products are being stored, the old ones are pushed to the back of the row. When the time comes to pull inventory from this row, it is almost impossible to access the older product. This results in a problem in time and inventory management; it is either too time consuming to access old inventory or it never goes out to the customers by the time the season ends.

In addition, this method of stockpiling has presented troubles for employees and managers to maintain accurate and organized warehouse operations; in terms of location, space, and frequency, of the products to be stocked. These issues are appearing because of diverse causes such as different packages being received from suppliers, poor layout, inability to identify the space available, and lack of good product identification among others.

The presence of all these issues represents delays to almost every step in the company operational performance. In the receiving process, time is wasted trying to find a location for the pallet of goods or sometimes a temporary spot. If a temporary spot is used, time is wasted to place the product when it is moved to the final position. All of this represents how time is wasted in the unloading process, and shows that improvements were needed. Then when a raw material is needed by production, the employee must start an extensive search through piles of unsorted goods to locate and satisfy the need. This also represents unproductive time. Once a product is issued to warehouse from manufacturing, another time delay appears when operators have to make a space to stock it. At the end of this search more time is spent moving products within the warehouse in order to pick-up the right ones to fill order to be delivered.

Statement of the Problem

Finished goods were built and stocked at a rate that exceeded customers' orders activity. This practice created stockpiles of product which increased inventory carrying costs for the company and increased risk of inventory shrinkage. The company needed to develop a system to allow for efficient storage and retrieval of finished goods within their warehouse.

Purpose of the Study

The purpose of this project is to improve the finished goods inventory storage of window well coverings for The Company XYZ. Defining inventory levels and implementing visual aids that trigger product ordering would simplify the decisions for staff as to when to order additional finished goods. Establishing fixed storage locations for every item would increase staff efficiency when retrieving finished products and lead to improved flow of finished goods.

Assumptions of the Study

The results of this study were linked to the data collected during a specific period of time which represents the actual demands and inventory state for company XYZ. The following was considered:

- The company's business level at the time of this study represented the average sales volume.
- The proposed changes would not involve building additional space or purchasing additional equipment

Definition of Terms

Lean. A philosophy of production that emphasizes the minimization of the amount of all resources including time, used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and dealing with the customers (American Production and Inventory Control Society [APICS], n.d. "Lean" para 1).

Window Well Covers / Product. Plastic protectors for windows and ground holes connecting with basements, in ABC company with the following characteristics:

- Clear plastic allows as much light through as a normal window
- Molded with raised ribs for extra strength
- Include a steel back-bar for increased stability
- Easy to install, under 10 minutes
- Flat egress covers meet all egress standards
- Thick polycarbonate plastic means the covers are unbreakable and weight supporting
- Provide a UV formulated plastic to protect against sun and weather damage

- Attachment hardware meets government standards for long-term rust resistance

The following pictures are examples of the ABC company products:

Figure 1.Basement Egress Covers

Figure 2. Window Well Bubble Covers

Figure 3. Traditional Window Well Covers

Figure 4. Custom Flat Window Well Covers

Inventory Shrinkage. Losses of inventory resulting from scrap, deterioration, pilferage, etc. (APICS, n.d. “Inventory Shrinkage” para 1).

Organizational Culture. An organization's culture is reflected by what is valued, the dominant leadership styles, the language and symbols, the procedures and routines, and the definitions of success that make an organization unique (Cameron & Quinn, 2011, p. 22).

TPS. The Toyota Production System is Toyota's unique approach to manufacturing. It is the basis for much of the lean production movement that has dominated manufacturing trends (along with Six Sigma) for the last 10 years or so (Liker, 2004, p. 7).

Kaizen. A Japanese term for continuous improvement and the process of making incremental improvements, no matter how small, and achieving results (Liker, 2004, p. 24).

Demand. A need for a particular product or component. The demand could come from any number of sources. At the finished goods level, demand data are usually different from sales data because demand does not necessarily result in sales. There are generally up to four components of demand: cyclical component, random component, seasonal component, and trend component (APICS, n.d. "Demand" para 1).

Seasonal Demand. Consumer interest in purchasing particular products only during a specific period within the calendar year (Arnold, Chapman, & Clive, 2008).

Limitations of the Study

Company XYZ's warehouse used a specific frame in terms of scope and time, therefore this study only applies for this company at this time and with these products.

The project was limited to the current conditions and sales volume of the XYZ Company during the period of this research (May, 2012). The project was also limited to the existing building and number of employees, the number of parts the company purchased and produces, current designs, and purchase quantities.

Methodology

Across this research the collection of data such as facility area, equipment space requirements, and personnel operation activities, was taken directly from daily operations at Company XYZ. This data played an important role in identifying the issues that constantly interrupted employees. After the evaluation of these problems the next step was to rank them by level of impact. This impact was determined by the improvement that would be realized in the overall operations after applying one of the proposed changes. The improvement was measured in terms of time saving, movement and goods allocation reduction, and the cost attached to the job in the warehouse. This cost reduction was achieved by looking at factors such as number of employees on payroll, equipment needed to perform the job, and the total time that a product will spend in the facility, which would increase the handling cost.

With the issues identified in order, the research showed how the solutions would benefit the company. In the last step, logistical problems were analyzed to find which of the lean concepts, or what combination of them, would provide improvement to the order, movement, space utilization, and the overall operations of the company. This was based on the recognized effectiveness of lean practices through different companies with many different cultures. Lean practices would make changes to Company XYZ, and make it more productive and more competitive in the market due to less waste attached to products and procedures.

The utilization of computer aided design software represents a primary tool in modeling the area. The layout work was done in order to run different layouts where the application of lean tools helped workers to improve effectiveness in daily operations and optimizing the warehouse physical area. This was done in order to manage, efficiently, raw materials and finished goods.

Summary

Company XYZ needed to have lean strategies implemented throughout the entire culture of the operations. From the moment that raw materials enter the facilities, employees must have clear and defined plans and expectations on how the raw material is going to efficiently flow through the warehouse to the manufacturing floor. Then when the finished goods were ready to be stored, there needed to be a simple and concise format where all employees can see, read, and follow the overall plan of storage. When there was a need to ship the product to consumers there also needed to be a system implemented so that products were not damaged nor forgotten for a season. Some of the problems that impacted Company XYZ were physical problems that needed to be addressed with physical answers, while some of the problems were cultural and mental changes that needed to be taught to all levels. The concepts of lean should help this company see increases in profits, through increased employee productivity, fewer damaged finished goods, and faster response times both internally and externally. Increased employee morale and a safer working environment for all will also result in employees' involvement and commitment with the organization. This would help to sustain the lean concept changes and go beyond to future improvements not only in production but also in the organization culture.

Chapter II: Literature Review

The literature review included research on lean principles and concepts. The research also included research on lean tools and application of lean 5S visual management techniques, as well as warehousing management concepts and techniques.

Lean Manufacturing

Lean production is a new way of thinking to produce goods or services that was introduced by Japanese industry. Lean can be considered as the beginning of a new stage in the production process opposite to mass production. In the 1950's, Japanese industry realized that the mass production system caused too much expense for the Japanese economy. In the automobile industry, Eiji Toyoda and Taiichi Ohno concluded that mass production could never work in Japan (Womack, Jones, & Roos, 1990, p. 49), and Toyoda and Ohno came to the United States to study Ford mass production system.

As a result of that visit, Toyoda and Ohno concluded that this system could be applied and improved so that it would be successful in Japan. They started a new system called the Toyota Production System (TPS), which became fundamental to the current philosophy known as lean. Lean began to be known outside of Japan after 1979 and around 1990s started to be applied in all kind of industries.

The Lean Enterprise Institute (2009) stated that

> A popular misconception is that lean is suited only for manufacturing. Not true. Lean applies in every business and every process. It is not a tactic or a cost reduction program, but a way of thinking and acting for an entire organization (para 1).

According to Liker (2004) lean was first known as lean manufacturing as it was very much confined to large manufacturing companies when it first got its name. Since the early

2000s, the manufacturing part of the name has been dropped. This is because lean is now used in all kinds of industries whether it is large manufacturing, small manufacturing, logistics, customer service, hotels, financial institutions, and many others.

Principles of Lean

Lean consists of principles and tools, but also is a mindset. Liker (2004) explains lean must be implemented as a compound system, not only the tools are to be used but also the organizational culture in order to obtain the optimum results. James P. Womack, and Daniel T. Jones put their own spin on the basics of TPS and the philosophy of lean production was born. Womack and Jones (1990) explained that lean manufacturing is a five-step process where the product flows from customer demand until the product is available to the customer. Nevertheless, lean can be thought of as a manner of thinking in an organization and can be applied in any organization considering its purpose and processes.

Lean production places responsibility on people to understand the purpose and success of the business. Lean is a journey of continuous improvement rather than a destination. Once you have taken the first steps you'll almost certainly want to continue (Lean Enterprise Institute, 2009).

The lean process has bases in five principles that are interactive and co-dependent according to Feld (2000) and these principles should be deployed as the sequence.

Five Primary Elements of Lean

Feld (2000) states that there are five primary elements of lean which include; value, creating flow, value stream mapping, establishing a pull system, and seeking perfection. The target of the value principle is to identify costumers' needs in order to know the importance of these products for them. The goal of the value stream mapping is to draw out all steps in the

supply chain and identify all available opportunities to improve, eliminating waste. When this principle is applied, the mapping value stream tool is used. Building a new and consistent process, based on the information obtained from the new value stream map is creating flow. Once the map and the flow are being implemented it is necessary to allow customers control of the system by asking for new products or services, this is called the pull system. Seeking perfection in the last four steps systematically over time requires an evaluation and reinforcement of the process to assure excellence of the company.

In any process lean principles can be applied. One effect of the lean production is its changes in a person's professional career. Before, people thought about a career as a specialization to highest level of technical knowledge, but today a professional career requires application of creativity to the job in a team setting rather than in a rigid hierarchy (Womack, Jones, & Roos, 1990, p. 14). Another effect of lean is to produce what the customers want, when they want it, and offer it to them in a variety of options. Low cost production and fewer errors are essential in keeping end price competitive (Womack, Jones, & Ross, 1990). Womack, Jones and Ross (1990) stated the following:

> Lean production is a superior way for humans to make things. It provides better products in wider variety at lower cost. Equally important, it provides more challenging and fulfilling work for employees at every level, from the factory to headquarters. It follows that the whole world should adopt lean production and as quickly as possible (p. 225).

Kaizen

According to Hirano (1990) one objective in every business is to find the most convenient way to produce goods or give a service. As opposite of Hirano's statement traditionally, managers try to reach a point where quantities and prices are balanced. This

approach in production terms is called Economic Order Quantity (EOQ). This method seeks to optimize the number of pieces per order; sometimes low batches represent the most economical leverage. On the surface, larger batches give more revenues to the firm, but this also drives inventory cost, process inventory cost, and lead time for products. In the lean culture this approach is inconvenient and obsolete. The Kaizen approach brings an integral solution which pays attention to inventory costs, lead times, and availability of products. Hirano (1990) states that: The kinds of improvements JIT brings to changeovers can shorten changeover time and enables various product models to be made more quickly and efficiently (p. 594).

Work Cells

A basic practice to establish and perform a lean approach in a company is to adapt the production shop layout to a work cell. Reagan (2000) stated that a work cell is a group of all the machines or work stations necessary to make an entire product, or a large component of an entire product. They are placed as closely together as possible so that parts can be passed to the next operation as soon as the previous operation is completed (p. 35).

Based on the previous statement the objective is to establish, in this work cell environment, guaranteed production of goods in a smooth process, with backup from one cell to the others. This approach also gives the opportunity to control the flow of materials into the whole company.

Kanban

According to Hirano (1990) the Kanban approach has its basis in the reordering point method which establishes when a process needs to fulfill its inventory. This method evolved from statistical analysis of inventory management. This allows companies to know when a batch of a certain product or parts needs to be ordered to keep the production system running.

The reordering point referred by Hirano is a specific level of inventory which indicates when a new order is to be placed. This method has specific characteristics and is not suitable in environments with sharp demand fluctuations, but is conducive for use in automated reordering systems. Hirano's reordering method is useful when the products are relatively inexpensive, have a stable consumption level, easy purchasing, and storage.

In sharp demand situations the basic principle of a Pull system, helps the Kanban approach work through the issues of the reordering point method cited by Hirano. These demands are called for by the upstream process within the factory, which announces to its downstream process when it needs to produce more products, or parts to replenish the upstream process (Arnold, Chapman, & Clive, 2008).

Kanban is nothing more than controlled work-in-process (WIP) inventory stored between two work cells. When inventory gets low, the supplier cell makes more parts for the customer cell (Reagan, 2000, p. 37).

The rules to managing the Kanban in an organization are defined by Feld (2009) as follows;

- A Kanban demand signal is the authorization to begin work.
- No job is to be initiated without demand from the customer.
- The Kanban controls the amount of work in progress allowed in the flow.
- The number of Kanbans will control the manufacturing lead-time through queue management.
- Do not pass known defects on.
- Utilize first-in/first-out (FIFO) material flow (p. 54).

Robson (1991) stated to move from philosophical into practical application needs tools and techniques (p. 26). In practical application lean has two main tools, the mapping of the value stream and the 5S.

Value Stream Mapping

Liker (2004) explains that Taiichi Ohno, Toyota´s chief engineer, developed the basis of value stream mapping. His early blueprint allowed ongoing analysis and improvements by monitoring all facets of the company's operations.

Feld (2000) referred to his approach as a way to better view the flow of the materials and information within the plant. This approach also helps to identify the communication links inside, and outside the company. In addition the system shows communication with suppliers, customers and between them, as well as the frequency of this communications.

An important and extremely helpful resource in this system is that in just one page, all of this data is presented. The key to this page is the two dimensions that each map has; one is from side to side, for materials input and the other, from top to bottom for information input. The benefit that one obtains from drawing this map is that the whole process can be visualized. Intern this gives the opportunity to identify: waste that can be eliminated, the flow of the entire business such as transportation, material, information, the quality of components, all aspects of assembly, and bottleneck or inefficient processes (Arnold, Chapman, & Clive, 2008).

5S Methodology

To apply lean principles, in addition to mapping value stream, there is another tool called 5S. The 5S is a tool which should be applied when an organization decides to implement lean system. 5S provide visual cues in the workplace and it is also a system that seeks to continue improvement of processes. Hirano (1995) said Improvements must begin with eliminating

everything that is no longer necessary and making the remaining needed items easily accessible (p. 25).

This tool named 5S had its origin in five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke Hirano (1995). In English as in Japanese, these words start with the letter S and are as follows:

- Sort or Seiri

This means to clear the work area, separating the equipment and tools in accordance with their use.

- Set in Order or Seiton

Each item in the workplace should have a place. This place should have the most convenient location into the workplace. Orderliness means organizing the way needed thing are kept so that anyone can find and use them easily (Hirano, 1995, p. 36).

- Shine or Seiso

The workplace should be a clean place. Floor, walls, equipment, and tool had to be clean. The advantage is that it is easy to see a spot, some oil, or water drops. In other words, good cleanness contributes to prevention of damages. Cleanliness means sweeping floors and keeping thing in order (Hirano, 1995, p. 36).

- Standardize or Seiketsu

Everybody should do her or his job following the same instructions, which should be clear and easy to accomplish. Based upon these three elements, take timer, sequence, and standardized stock on hand, the standard work is set (Liker, 2004, p. 142).

- Sustain or Shitsuke

This refers to continually maintaining the four first steps. It requires constant supervision; the most important part is that every person who works there keeps in mind this system and makes it a habit, a routine. Discipline means always following specified and standardized procedures (Hirano, 1995, p. 38).

Warehousing

According with to Napolitano (1998) warehousing is performance of administrative and physical functions associated with storage of goods and materials. These functions include receipt, identification, inspection, verification, putting away, retrieval for issue, etc.

Napolitano (1998) refers to warehousing as the function and performance of storage space. Depending of the kind of goods to store, warehousing is classified in five types:

1. Whole Sale
2. Retail
3. Manufacturing
4. Service
5. Distribution

Inventory Turnover

The performance of a company is measured by the inventory turnover. The relationship between the annual or day sales of a company and the quantity of inventory that is on hand in the moment will reflect the assets or the failure to manage the inventory by the company (Arnold, Chapman, & Clive, 2008)

Inventory Levels

According to Arnold, Chapman & Clive (2008) there are three basic types of Inventory: Raw Material, Work in Progress, and Finished Goods:

- Raw Material: The total cost of all component parts currently in stock that have not yet been used in work-in-process or finished goods production (Arnold, Chapman, & Clive, 2008).
- Work in Progress: Work-in-process inventory is inventory that has been partially converted through the production process, but for which additional work must be completed before it can be transported out of the manufacturing area and recorded as finished goods inventory (Arnold, Chapman, & Clive, 2008).
- Finished goods: A reflection of the amount of manufactured product in stock that is available for customer-purchase. On an income statement, the finished goods inventory is considered an asset to the company (Arnold, Chapman, & Clive, 2008).

The levels of inventory depend on the following according with Arnold, Chapman & Clive (2008).

The production rate is the parameter that shows how many products are being produced by the company; normally this rate is impacted by the demand over a certain period of time.

Lead-time is the period of time that occurs between when an order is placed by the customer and the moment the item is received is the lead time. This could be categorized or confined to a specific stage such as production, inventory, or delivery.

Rework/ scrap rate, as refered by Parametric Technology Corporation (PTC) (2008) a scrap is the result of additional work leftover from a finished product or part. Depending on the operating stage the scrap could have attached to different levels of rework, and at the shop floor the scrap could be a defective part or product, even a part that will not be use anymore. A scrap piece could also be a finsished product that is returned by the consumer. The impact of these

will be felt directly on the operational expenses, more specifically on the major cost drivers of a manufacturing company, labor and raw materials.

Stock Rotation System

Once a product is stored into a warehouse the most important aspect is to identify it from the rest of the products (Arnold, Chapman, & Clive, 2008). This is a critical action from the management stand point because when the products or materials to be stocked are going to spend extended periods of time in storage, it becomes particularly difficult to find it after a month, especially when the products are perishables. To avoid this issue the establishment of an accurate system of identification, like barcodes, will reduce the waste of time, money, and products.

First In First Out (FIFO) Rotation inventory stock system.

Under the FIFO system, the products that come into inventory first are the first that are issued out of inventory. This prevents stock sitting out of rotation for an extended period of time (Arnold, Chapman, & Clive, 2008). With any stock/inventory management system there are risks that the production schedule may not coincide with customer requirements, over producing products, especially for slow moving or perishable products, or having excessive downtime which will affect inventory levels in the warehouse. Good communication is vital, between the production and warehouse/distribution departments in order to balance, customer demands, sales forecasts, and warehouse stock levels.

Summary

The use of the principles, techniques and procedures of lean demonstrate an improvement in the operations of the industries when they are applied. Also the improvements in terms of efficiency and space utilization are notable after implementation. The literature review showed the possibilities to combine these concepts in different ways in order to adapt them to a specific environment. The concepts are not exclusive to the manufacturing industry but also within warehouses, hospitals, and potentially to everything, depending on the willingness of the organization to change and to maintain the changes over the time.

Chapter III: Methodology

The purpose of this project was to improve the raw materials and finished goods inventory storage. The inability to meet customers' orders pushed Company XYZ to create stockpiles without a consistent order, increasing the cost of carrying inventory, and also the risk of an eventual shrinkage of product. Establishing fixed storage locations for every item increased staff efficiency, when retrieving finished products, and lead to improved flow of finished goods. In addition, the implementation of visual aids that trigger product ordering, simplified the decisions for staff.

From a customer's stand point, an efficient stocking process is a fundamental key to the success of a company. Every organization is evaluated by how efficiently the materials and products are managed; therefore a good warehouse layout and signal system is important.

The company XYZ was dealing with the issues of space utilization and warehouse layout. The root of the problems was due to the receiving of materials from suppliers with different packaging specifications. When various pallet sizes of raw materials were received it was difficult and time consuming to store them to a consistent and concise manner. The diverse pallet size caused a space problem. The pallets spilled over into the space allocated for finished products. This resulted in a twofold problem. First, when the production line asked for replenishment, the warehouse work was inefficient due to the confused storage system. Then when the finished products were to be stored and shipped, the spacing problem caused them to be stored in another place and out of order, stacking the pallets one in front of the other, pushing the old inventory to the end until the rows is full.

The objective of this study was to improve the Company XYZ current layout of the warehouse. This would reduce the time to store and obtain a product within the warehouse,

reduce the movement of materials and people into it, and develop a visual aid system to maintain organization. The study will guide the employees on how to move and store materials and where they should be located. To achieve this goal, lean 5S concepts were applied.

Project Scope

In order to develop the project scope the lean tool A3 Report was utilized. An A3 Report is a problem-solving tool developed by Toyota that keeps records of the issues and the scope of a project. The A3 Report also shows what should be performed to improve processes or shows a path to the final solution to an issue. With this tool, data displayed on an A3 report was easily reviewed and addressed. The A3 Report is a vital tool in seeing current up to date and organized information (Figure 5).

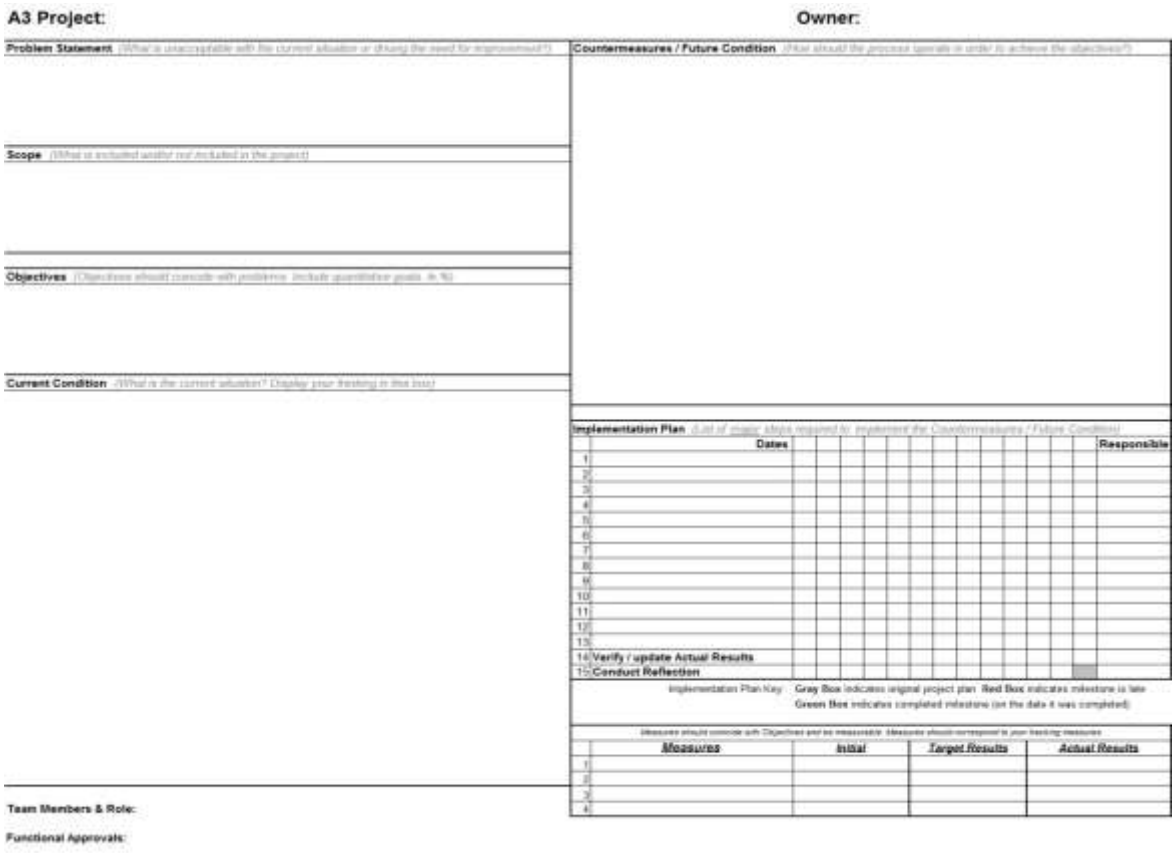


Figure 5. A3 Report.

A3 Reports collation process is the key to the success; it contains ten steps divided in two sections: the first one is problem identification which encompasses observation and analysis of the root causes, and the target or definition of the actions to take. Then using this information development of the second section contains the discussion with all parties affected by the actions in order to obtain their approval, with the implementation stage and finally the evaluation of the results. One advantage of these models is the existence of a primary working version and a final one that could be contrasted at the end of the study to evaluate the overall outcome.

At the beginning of this research, it was necessary to meet the production manager of the company with the objective of having a general overview of the warehouse area and the daily operations performed by the XYZ Company. During this visit, the focus was on obtaining data that allowed the researcher to identify issues and possible improvement opportunities. The manager answered questions such as what kind of packages they received from their vendors, what is the current path that equipment, materials, and employees cover each day, and what are the limitations that this operation presents in terms of space, weight, and time.

The second step performed, was to meet one of the operators to obtain data such as daily concerns, difficulties, and ideas, based on their experience in order to improve these areas. Also, with this help, measurements were taken in the warehouse area, pallets received, equipment used and their operation requirements. In addition organization of raw materials and final products allocation were identified.

After the visit, the researcher analyzed the data obtained and created the A3 Report to scope the project which showed the initial weaknesses of the company in terms of space utilization, that produced a chain effect in the overall operations. The A3 Report showed the necessity to perform an improvement project.

Data collection

To obtain the data for this study it was necessary go to The Company XYZ facilities and verify the size of the building and other elements to be considered in presenting the improvement recommendations.

The square footage of the warehouse was taken using a tape measure on site to account for the size of the space. This allowed for the visualization of all dimensions (height, width, and depth) of the facility with allowances for water pipes, sparkling systems, and heaters hanging from the ceiling, or other obstructions, number of pallets and warehouse capacity.

These factors helped to analyze the opportunities such as reordering materials, unifying sizes of pallets, grouping the products, and other improvements. Other factors included physical measurements of all of the pallets involved in the company's operations, a review of the forklift specifications, and the space available for both raw materials and finish product. These factors determined the impact of the redesigned warehouse layout in the overall operation of The Company XYZ. The data collected was organized and placed in a spread sheet that is shown in Figure 6.

Step	SqFt	# Picking Points	# Pallet Positions	# Pallets	Picking AverageTime
Original					
Final					

Figure 6. Data Recording Table

The information collected about the measurements of the building and of both raw and finished product was used to create a Computer Aid Design (CAD) layout in order to evaluate the options of the new layout proposal (Figure 7).

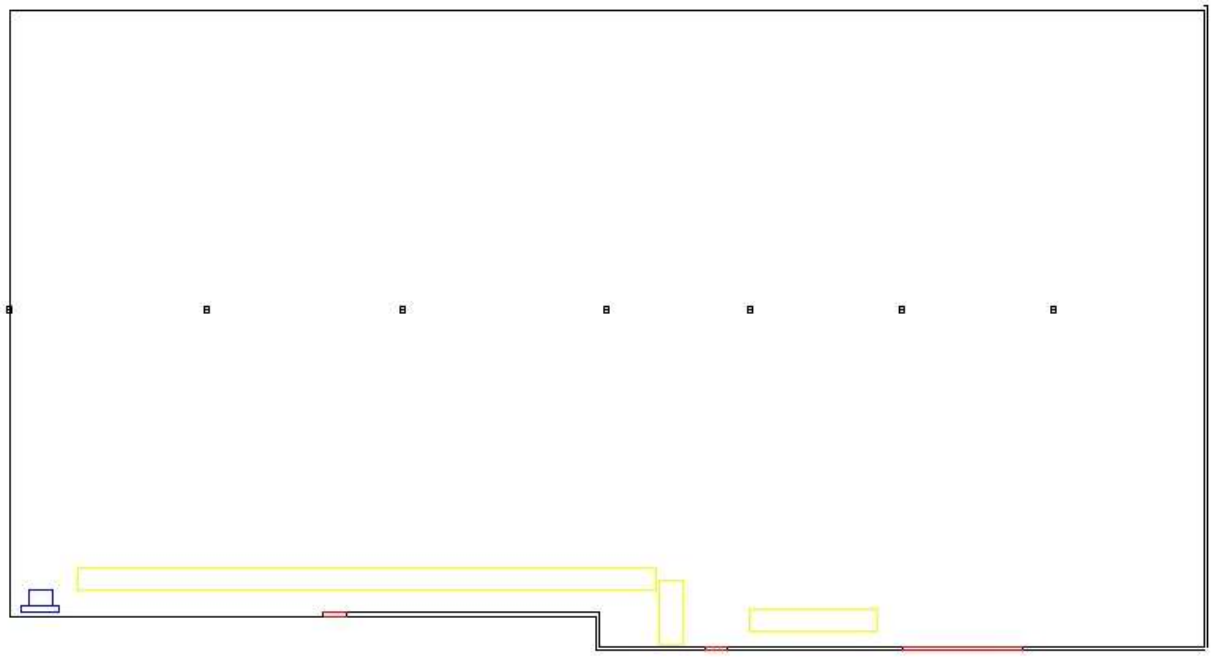


Figure 7. Original Warehouse Layout.

For warehouse layouts there are two fundamental techniques used for stock rotation, these are FIFO and LIFO.

FIFO is a method of inventory valuation for accounting purposes. The accounting assumption is that the oldest inventory (first in) is the first to be used (first out), but there is no necessary relationship with the actual physical movement of specific items. See: first-come-first-served rule, average cost system (APICS, n.d. “First In, First Out” para 1).

LIFO is a method of inventory valuation for accounting purposes. The accounting assumption is that the most recently received (last in) is the first to be used or sold (first out) for costing purposes, but there is no necessary relationship with the actual physical movement of specific items. See: average cost systems (APICS, n.d. “Last In, Last Out” para 1).

The research evaluated the present technique used by the XYZ Company and determined which would be most beneficial for them.

5S Implementation

The research evaluated opportunities to use 5S tools to improve the warehouse operations. The 5S method applied different tools such as Sort, Set in order, Shine, Standardize, and Sustain to improve the visualization and the organization in companies to facilitate processes.

The tools that this research used from 5S were Sort, Set in order, and Standardized. The Sort principle pursued elimination of all extra raw materials, final products and supplies. In the Company XYZ items like empty pallets, cardboard, uncompleted boxes of raw materials, and damaged or discarded products were options to be removed which would improve space utilization.

The principle of Set in order insures items within the warehouse are identified as well as the area where they are to be stored. This research used a new layout design to allow personnel to sort items in less time.

Appling the Standardize principle, consistency in processes is the goal, making all of them routine, uniform, and consistent in the movement of: raw materials, finished products and supplies across the warehouse area. The Standardize principle makes the day to day tasks easier for veteran employees and reduces the training time for new employees.

The 5S implementation included aspects of sort, set in order, and standardization. With these 5S tools time was saved, the floor organization was improved, the processes of the warehouse was optimized.

Data Analysis

The data collection process provided information about the current state of the warehouse. In order to evaluate this data it was necessary to create a layout that showed the old

information such as number of rows, number of depth pallet position in each row, the height of each row, how many different pallets sizes, and how many alleys existed. This information allowed for visual identification of the issues and the possible solutions based on lean principles, stock rotation, time, and distance.

After the layout of the current situation was developed, evaluation of the capacity of the warehouse was determined to see if the space utilization was optimal, or if there was a possibility for improvement. After that, the main objective to consider was evaluation of the storage techniques of final products, based on the company's manufacturing requirements. The next step was to optimize the movements of raw materials, finished products, and supplies within the warehouse, seeking to minimize the time of picking and also the storage time once the raw materials and supplies came from suppliers.

Summary

This chapter discussed methods used to identify the current warehouse systems used in the XYZ Company and the tools that were used to determine the present situation. The application of lean principles such as 5S tools helped to eliminate the disorganization problem and to improve the performance of the process of storage raw material, finished products, and supplies within the company warehouse. In chapter IV the results of this will be explained along with recommendations for improvement.

Chapter IV: Results

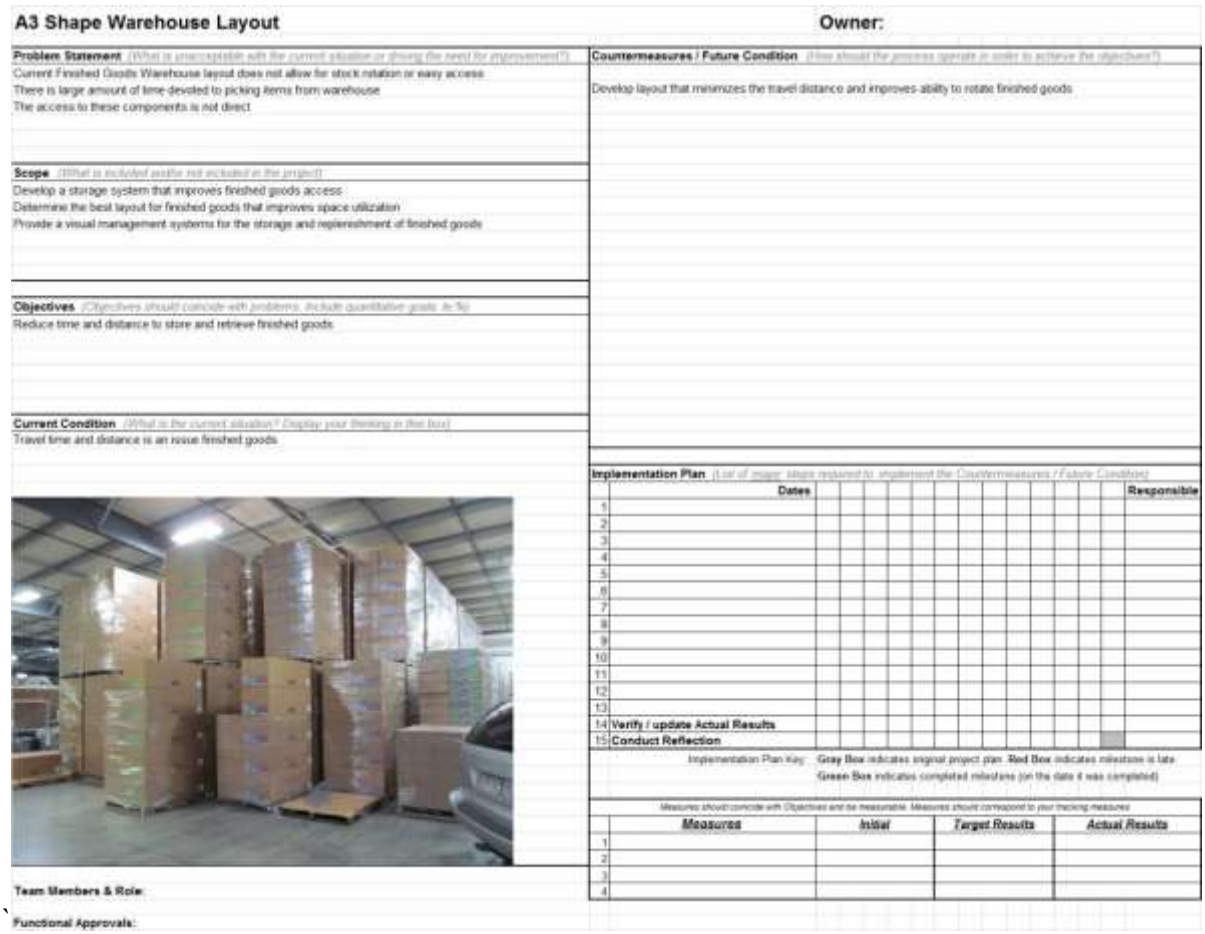
The main objective of this research was to improve the operations at the XYZ Company warehouse. The issue in this area was inefficient space utilization causing poor product access which is delaying pick up tasks during daily operations. This research proposed a new layout and the implementation of visual signs which would help operators to become more efficient and to maintain organized work and storage spaces.

The analysis, and later application of lean principles to the data obtained, proposed the reduction of wastes in terms of motion and old inventory in this warehouse operations. Also, with the use of Computer Aided Design (CAD) software the new layout proposal helped to visualize the space and gave an accurate rate of movement, based on distance covered by operators, to move materials and goods. Contrasting the current, or actual situation data, and the calculations obtained from the proposed CAD visualization, made the waste clear to understand and identified the need for improvement. The application of lean 5S represented the long term support for sustaining the overall project in order to maintain and to identify possible failures in the operator's compliance.

This chapter will cover the analysis and evaluation of the data obtained and the implementation of the concepts and techniques used to helped the XYZ Company improve.

Project Definition

The A3 report was completed with the information obtained from the visits to the warehouse, the meetings with management and the work force. The next step was to evaluate the current situation, finding the possible areas or issues to improve such as, part access, part picking, and overall efficiency of the warehouse operations measured in terms of time and distance (Figure 8).



A3 Shape Warehouse Layout — **Owner:**

Problem Statement (What is unacceptable with the current situation or driving the need for improvement?)
Current Finished Goods Warehouse layout does not allow for stock rotation or easy access
There is large amount of time devoted to picking items from warehouse
The access to these components is not direct

Countermeasures / Future Condition (How should the process operate in order to achieve the objectives?)
Develop layout that minimizes the travel distance and improves ability to rotate finished goods

Scope (What is included and/or not included in the project)
Develop a storage system that improves finished goods access
Determine the best layout for finished goods that improves space utilization
Provide a visual management systems for the storage and replenishment of finished goods

Objectives (Objectives should coincide with problems, include quantitative goals, ie %)
Reduce time and distance to store and retrieve finished goods

Current Condition (What is the current situation? Display your thinking in this box)
Travel time and distance is an issue finished goods

Implementation Plan (List of major steps required to implement the Countermeasures / Future Condition)

	Dates	Responsible
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14	Verify / update Actual Results	
15	Conduct Reflection	

Implementation Plan Key: Gray Box indicates original project plan. Red Box indicates milestone is late. Green Box indicates completed milestone (on the date it was completed)

Measures should coincide with Objectives and be measurable. Measures should correspond to your tracking measures

	Measures	Initial	Target Results	Actual Results
1				
2				
3				
4				

Team Members & Role:

Functional Approvals:

Figure 8. Completed A3 Report

To complete the A3 Report it was necessary to go through a process that started by observing the day to day operations at XYZ Company's warehouse. Observations showed that operators had problems finding and picking the materials and products needed. These observations were addressed in the Problem Statement: Current finished goods in the warehouse layout did not allow for stock rotation or full access, there was large amount of time devoted to picking items from warehouse, and the access to these components was not direct. In addition, the inconsistency of the packaging received, produces confusion about where these new arrivals would be stored. The scope of the research was to develop a storage system that improves the access to finished goods, determine the best layout for finished goods that improves space

utilization, and provides a visual management system for the storage and replenishment of finished goods. The objective of the research was to reduce the time and distance to store and retrieve goods; finished, raw, or supplies. The next step to complete the A3 Report was quantifying the number of pallets Company XYZ was able to store, and the different sizes of pallets received. Next was determining the root causes of the storage issues, asking why they were occurring. After the root causes were found, possible solutions to each problem were matched side by side. All of the solutions were evaluated and the most effective one was selected and put into the A3 report.

Data Collection

The data collected showed that the current layout of materials limited the operations of the company. First the operators could not access all of the pallet positions, and in some cases they created alleys in the storage area to access pallets located behind other products. To access the products they had to move unrelated products to access the needed supplies. These movements added time to the picking process, driving down the efficiency of the warehouse.

The data collected from the XYZ Company warehouse was placed into a spreadsheet. The spreadsheet in Figure 9 shows the measurements in square footage of the area to be modified, and the capacity of the warehouse through the two stages of the research.

Step	SqFt	# Picking Points	# Pallet Positions	# Pallets	Picking Average Time
Original	10,023	35	280	560	5 min

Figure 9. Data Collection Spreadsheet

The area shown in Figure 10 is the original layout of the warehouse. In order to store both raw materials, supplies, and finished goods in this area the company decided to set 35 picking points where the pallets containing raw materials, supplies, and finished goods were to be placed.

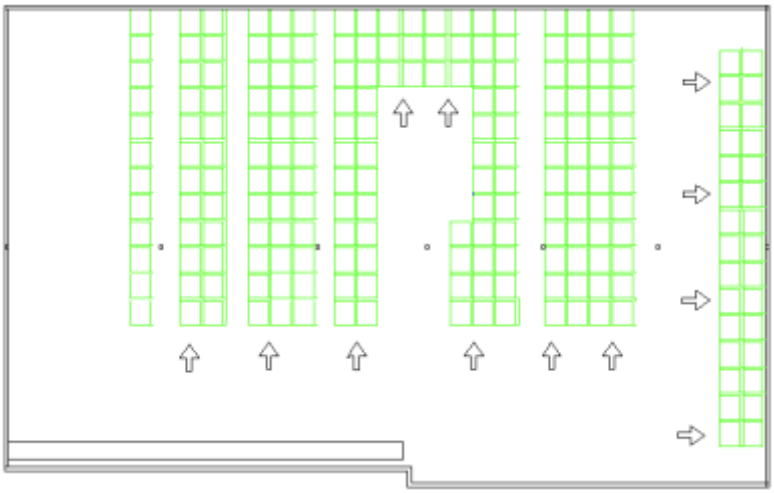


Figure 10. Original Area Layout

An important aspect that Figure 10 shows is the actual pallet access/retrieving direction denoted by the arrows. This technique of access and retrieving from the end causes the majority of the company warehouse operational issues of picking process, stock rotation, and time to perform. The problem was that this storage technique presents in the picking process is that when the operators need to find a pallet, they do not know where to start looking for it and sometimes have to move many pallets to access the needed pallet. The stock rotation was also affected by this type of storage because of the first product that came into storage. That pallet was stored in the back and new products were stored in front of the older products. Access to the older products was lost and only the newest product could be shipped. The final issue was the increase of the time necessary to perform these operations due to the inconsistency of the processes explained. This stock rotation technique currently used by the XYZ Company is known as First In, Last Out (FILO).

The storage system in Company XYZ resulted in wasting time moving other products that were stored, restricting access to the desired product, and also looking for their exact location due to lack of a signage system.

Figure 11. Current Storage Condition

The lack of shelving or racking systems added to the storage problem of the warehouse resulting in unstable and unsafe stacking (Figure 11). This specifically affected the stacking of finished products. Due to the weight, the packages could not be stacked three high, because if the third pallet is added the products on the bottom pallet will be damaged.

The major factors in the storage problem using this layout and operational techniques, allowed the company the ability to manage 280 pallets positions without stacking. Stacking the pallets is not always an option because of the physical size and weight of the pallets, and because of the possibility of damaging goods due to stresses from this storage method. The pallets of goods that are produced or received to and from Company XYZ were not designed to support the weight caused by a storage system that involves pallet stacking. The incapability to stack raw materials was due to the organizational and physical restraints mentioned before. The additional issue of suppliers lack in consistency of the package sizes pushed the XYZ Company operators to make changes in the receiving operations spots where the materials had to be placed. All of these factors contributed to the disorder, confusion, and overall inefficiency.

Data Analysis

The key point in the improvement process was the arrangement of the floor plans in the warehouse that allowed the company to improve the efficiency. To accomplish this task it was necessary to use digital blueprints of the area and CAD software. This provided the opportunity to use measurements and easily move the design of the racks, alleys, and pallets. The floor plan designs also took into consideration the boundaries of the warehouse, the presence of pipes, columns, and exit areas, in order to avoid any interruption of the new layout with other areas, safety, or infrastructure.

After design, the drafts were analyzed for opportunities and constraints. One important constraint to consider was supplier inconsistency of packaging. To address the issue of supplier packing inconsistency, calculations were recorded and recommendation s to use over calculated pallet space to become able to receive any range of pallet sizes were provided. The end result was that the storage space was increased to be larger than the full pallet dimensions. In Figure 12 the pallet industry standard is depicted.

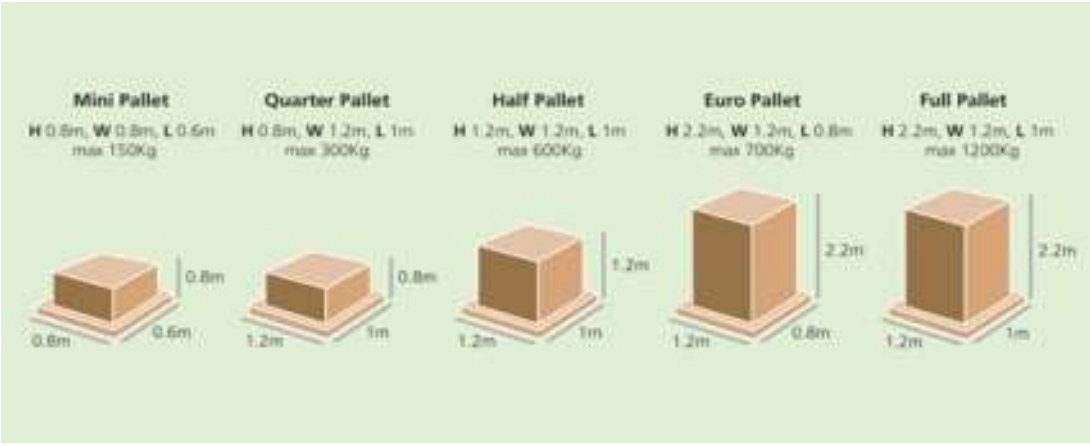


Figure 12. Pallet Dimensions.

From the space utilization stand point the old stocking process presents a great disadvantage. The pallets weight of both raw materials and finished goods resulted in not being

able to stack more than a few pallets high .This also meant that the full volume of the warehouse area was not fully utilized. This lack of utilization was another point considered and solved by the implementation of a rack system making it able to resist loads of a superior weight that the sum of two of the current pallets would be at the Company XYZ.

The original situation of the poor cubic space utilization that resulted from the physical constrains explained above is shown in Figure 13.

Figure 13. Cubic Space Utilization.

A racking system would allow the company to store multiple pallets in multiple levels which increase the capacity and minimize the floor space utilized. The benefits of these systems are extensive and include improvement on safety due to the steel construction. Additionally there is flexibility in terms of expansion or modification, almost free of maintenance, and easy replacement of individual components in case of damage among others. Figure 14 shows the lateral view of the racking system that is proposed.

Figure 14. Warehouse Racking System.

After considering all of the factors and variations, it was determined that the stock rotation technique that would work better for the company was the First In- First Out (FIFO). In addition, the new layout recommendation allowed for a new possibility of forklift access between the 52 picking points created. To facilitate the movement of the forklift within the warehouse meant, an improvement in the order picking process that eliminated the extra distance was necessary. This also eliminated the extra trips taken by the forklift more than one time, to pick a pallet, reducing the average picking time from five to two minutes. In addition, this new layout allows operators to access the racks from multiple directions, facilitating the storage and retrieving process.

Step	SqFt	# Picking Points	# Pallet Positions	# Pallets	Picking Average Time
Proposed	10,023	52	132	528	2 min

Figure 15. Proposal Data Collection Spreadsheet

The new layout when contrasted with the old layout, improves the space utilization, obtaining 132 pallet positions, and now utilizing the rack system where it is possible to optimized the cubic space utilization to store four high at each of them obtaining finally a full warehouse capacity of 528 (Figure 15). Also, the new design allows for separation of raw materials, supplies, and finished products into specific picking points within the warehouse, making a location of these a consistent process instead of using a general area showed in the original layout where operators needed to find empty spaces to store the new coming pallets. All of these proposals allow the XYZ Company to be fast, effective, and efficient in their warehouse operations. The Figure 16 shows this new proposed layout.

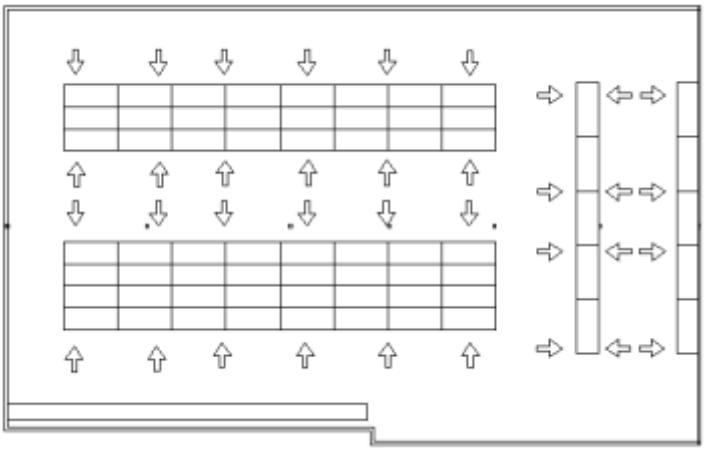


Figure 16. Final Layout Proposed

5S Implementation

The data collected showed that the current layout of materials limited the operations of the company. First the operators could not access all of the pallet positions easily, in some cases they created hallways in the storage area to access pallets located behind other products. To access the products they had to move unrelated products to access the needed supplies. These movements added time to the picking process, driving down the efficiency of the warehouse.

The 5S tool of sort would be implemented by using a new labeling system that enabled employees to sort products in less time, and also maintain the products identification during and after warehouse operations. In addition, the set in order tool, utilizing of stripes on the floor that would indicated which products are in a row or area, this would reduce the operators picking time. The use of large visual signs would help the supervisors and operators recognize and allocate each area from the distance. This maintains the order, to increase the effectiveness of overall operations.

In addition, shelf labels were proposed for every item and were linked to each physical storage location to indicate what supplies were stored at each location. The information contained on each shelf label would consist of the inventory control number, a brief item

description, the quantity of the item to be stored in the location, the manufacturer or supplier, and the manufacturer's reference number.

The Standardize tool proposed by the new layout and racking system would assist by having a consistent and repetitive routine to store and pick products from the warehouse to production or final customers.

The proposed layout and 5S of the area would provide the XYZ Company with improved stock rotation, assuring that oldest product is shipped first, improved picking of products, in distance traveled and reduction in time by an estimated two minutes, and improved product and area identification, increasing operators' accuracy.

Summary

The implementation of Lean principles to the XYZ Company warehouse area would help to improve the area efficiency and contribute to improving the overall company performance. The creation of an A3 Report pointed to the company's problems and drove the research to the root causes of these issues in order to improve or solve them, with the objective of becoming a better operation. The new layout proposal would provide the improvement of the physical organization and the operation itself, giving the company the opportunity to design a picking process in a concise manner. With the 5S tools implemented, the sustainability of these efforts would assure the consistency of their processes and the ability to perform the job fast and effectively. Chapter V will discuss the limitations, and recommendations of this research as well as the conclusion of it.

Chapter V: Discussion

This project examined the existing conditions that cause inefficiency in the XYZ Company operations. The company needed to develop a system to allow for efficient storage and retrieval of finished goods within their warehouse. Due to the seasonal fluctuations in demand finished goods were built and stored in an unorganized warehouse. This practice created stockpiles of product which increased inventory carrying costs for the company and increased risk of inventory shrinkage. Establishing fixed storage locations for every item would increase staff efficiency when retrieving finished products and lead to improved flow of finished goods. The purpose of this project was to improve the finished goods inventory storage of window well coverings for The Company XYZ. Defining inventory levels and implementing visual aids that trigger product ordering would simplify the decisions for staff as to when to order additional finished goods. An A3 Report and 5S tools were implemented and conducted to apply lean principles in the warehouse areas to reduce storage and picking time to increase operational efficiencies. The results of applying lean principles were a reduction of time and distance spent by materials, equipment and personnel.

Chapter I defined why the XYZ Company needed to reduce the movements needs to operate and the techniques utilized to store raw and finished good into the warehouse area. Chapter II reviewed the literature concerning of how lean principles become a huge advance in improving techniques for companies. Chapter III summarized how lean principles as 5S methodology were used to collect and analyze data to facilitate its application. Chapter IV outlined the results of applying lean principles to reduce motion and time wasted in the processes.

Limitations

The limitations of this project were based on concepts from lean that only applied for this particular research considering the current data and the current facilities and products. The scope of this project was centered in the warehouse operation and additional possible improvements were not considered by this research. The impossibility of testing or actual implementation of this proposal resulted in limitations. The results presented in this study were based on calculations obtained by using CAD software.

The project was limited to the current conditions and sales volume of the XYZ Company during the period of this research (May, 2012). The project was also limited to the existing building and number of employees, the number of parts the company purchased and produces, current designs, and purchase quantities.

Conclusions

The three main accomplishments of this research were the development of a new layout, identifying improvement opportunities within the warehouse operations, and the visualization within the warehouse. The development of a new layout for the warehouse contributed to the organization of the floor space reducing the number of picking points from 35 to 52. The improvement in the warehouse operations would result in facilitating and optimizing the order piking process by the reduction of the average picking time by two minutes. The improvement of the visual aids across the warehouse with the proposed labeling of materials and products and the identification and signage of areas and racks would help to allocate raw material, finished products, and supplies faster and efficiently.

Recommendations

This research demonstrated that with the application of the lean concepts in the XYZ Company, the possibility of improvement is tangible. The final implementation of these concepts is the recommendation. The actual change of the company warehouse layout plus the acquisition of a racking system will increase the company's productivity and efficiency from the warehouse stand point. The order in which this implementation should be done is presented as follows:

- 1st Reviewing and reorganizing the floor plans, based on this research layout
- 2nd Installing the rack system
- 3rd Fully implement lean 5S in the warehouse.

These recommendations would allow the Company XYZ to implement First in First Out stock rotation system. The benefits of this system would allow the company to maintain an up to date inventory, and ensure that products that are produced and shipped in the order that they come through the warehouse. The FIFO system would reduce the possibility of damaged products due to the minimized movement and storage time of the product.

The requirements of a standard pallet sizes received by suppliers would improve the capacity and the flexibility of the storage area, allowing for rearranging the position of pallets without consideration the pallet size diversity.

The racking system proposed would increase the speed at which products can be stored, picked, and an effective solution for the cubic space utilization of the Company XYZ warehouse.

Summary

This chapter presented an overview of the project with recommendations that encouraged company XYZ to implement the lean process improvement within their warehouse. By doing this the company would experience benefits in both space utilization and operation efficiencies.

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