LEAN MANUFACTURING STRATEGY IN A SHOE FACTORY

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Abstract

ABC Company is a shoemaking firm that produces made-to-order products. It has several production problems as well as delays in production lead times. Three causes of the problems were identified. The first is unnecessary movements of work in process; the second is uncontrollable production lead times; and the third is bottlenecks in some production activities.

To solve the production problem, the lean manufacturing concept was chosen. Improvement of the production process, reduction of the production cost, and controllable production lead times are the expected result. Thus, the focus question was: "how could lean manufacturing strategy be applied to solve the manufacturing process problems of the ABC Company?".

Relevant data were collected via observations and interviews. Production processes and process mapping were identified. Detailed production activities were analyzed and categorized into three groups: value added, non-value added, and non-value added but necessary activities. The non-value added activities were removed from the production process through a proposed new plant layout, with consequent lower production cost and controllable production lead times. The results indicate that lean manufacturing concept could effectively and efficiently solve the production problems of the ABC Company.

INTRODUCTION

The shoemaking industry has a complicated production process and uses skilled workers. A common problem is inefficiency of the production process that leads to a long lead time to deliver the product to the customers (www.dtn.moc.go.th). Lead time is a very important aspect in managing the supply chain, especially in the downstream side since most customers do not want to wait long for the product. Reducing the lead time gains competitive advantage, through sales and market share.

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Lean manufacturing is an operational strategy which can help a firm to improve the production process, reduce production cost, and reduce production lead time. It is a management strategy that deals with the whole operational process of a firm. The mapping of all the production process from raw materials to finished products is first clarified. This is followed by analysis of the necessity for each activity so that wasteful activities can be identified and removed. This helps a manufacturer to produce more, with less time, fewer resources and lower cost (Yamashita, 2004).

The focus firm of this research, ABC Company (a pseudonym) is a shoemaking firm, founded more than forty years ago. It produces made-to-order products. The company does not have a finished product inventory. The production process starts when a customer orders the product, and after the materials have been received.

The company has almost 50 SKUs which can be divided into three types of footwear; formal shoes, closed shoes, and sandals. When the customers order the product, the administrative officer will check stock of the raw materials. If any items of raw materials are not sufficiently available, the administrative officer will order those materials from the suppliers. This needs at least 2-3 days for delivery. After production, the finished products are kept in the finished products area until shipped out to the customer.

STATEMENT OF THE PROBLEM

As identified by the business owner, the operational problems at ABC Company are:

1. The production process of the leather shoes is sequential, step by step: the next step can be started only when the previous step is completed.
2. Uncontrollably long lead time in manufacturing, causes delayed delivery, leading to customer dissatisfaction, complaints, and sometimes penalties. (Lead time is the time from the customer placing an order until the order is delivered to the customer).
3. Low operational efficiency and uncontrollable long lead time process leads to delays for the next orders.

Observation of the production process at ABC Company reveals that unnecessary activities are causing the problems, and therefore the lean manufacturing strategy is applied, as it focuses on reducing or removing all waste (Christopher & Towill, 2000), For manufacturing efficiency, a company must have an appropriate production planning and control system in order to meet their customer requirements (Vollmann, Berry, & Whybark, 1997).

LITERATURE REVIEW

Principles of Lean Manufacturing

'Lean' is a method of inventory management and production control (Coggin, 2003). The principle of lean manufacturing seeks to remove non-value added activities from the production process. Lean manufacturing technology focuses on production, quality, customer service, and profitability.

Lean methodology is used to increase speed and reduce the cost of any process, by eliminating waste. It can create a streamlined, high quality system, and produce the product, to the customer's requirements, with no waste (Shah & Ward, 2003). Lean can be used to eliminate waste, when demand is smoothly planned to maximize profit by reducing the physical cost (Womack & Jones, 1996). Lean principles can be used to improve productivity driven by workers, based on their knowledge of the work and equipment, with the goal of increasing value added work (Gaskins & Holly, 2004).

The Toyota Motor Company in Japan created the lean concept after World War II. 'Toyota Production System (TPS)' was the original moving assembly line that makes material continuously flow (Shingo, 1981; Monden, 1983; Ohno, 1988; Womack, Jones, & Roos, (1990). TPS identified seven forms of waste in manufacturing, called 'The Seven Deadly Wastes': overproduction, waiting, transportation, over process, inventory, unnecessary motions, and defect.

Characteristics of Lean Process

The characteristics of lean process can help the process run smoothly by using the cycle time (Cycle time is the time required for completing a task from start to finish, also known as the processing time.

Great accuracy is needed in the specification of working station activity cycle time, takt-time, the work sequence of specific tasks, and the minimum on-hand inventory needed (Stenzel, & Stenzel, 2003). (Takt Time is the maximum time per unit to produce a product in order to meet customer requirements). Characteristics of lean processes are:

- Make-to-order
- Single-piece production
- Just-In-Time materials/pull scheduling
- Short cycle times
- Quick changeover
- Continuous flow work cells
- Compressed space
- Multi-skilled employees
- High first-pass yields with major reductions in defects

Traditional vs. Lean Manufacturing

In the past, manufacturing created products by forecasting the market demand. The traditional operations were driven by these sales forecasts. A key difference is that lean manufacturing production is based on real customer demand. The key differences of traditional and lean manufacturing are shown in Table 1.

Table 1: Traditional and Lean Manufacturing

Production Methods	Traditional	Lean
Production schedules	Based on the demand forecast – product is pushed throughout the factory	Based on actual customer requirement – product is pulled throughout the facility
Manufactured products	To replenish the stock	To fulfill customer demand (instant delivery)
Production cycle times	Long production runs- weeks or months	Short production runs – hours or days
Manufacturing lot size quantities	Large, with large batches flowing between each process	Small, and based on one-piece moving between processes
Plant and equipment lay-out	Functional layout	Divided by product flow, using cells or lines for product families
Quality	Guaranteed through lot sampling	100% in the production process
Workers	Assigned one person per machine	Assigned one person per numerous machines
Worker empowerment	Low – little input into how operation is performed	High – has responsibility for identifying and implementing improvements
Stock levels	Massive inventories – large storeroom for finished goods, and central storage room for work-in-process inventories	Small inventories and low work-in-process inventories, frequent shipments
Inventory turns	Low – 6-9 turns per year or less	High – 20+ turns per year
Flexibility in changing manufacturing schedules	Low – difficult to change and implement	High – easy to change and apply
Manufacturing costs	Higher and hard to control	Stable or lower, and easy to control

Source: http://www.phitomas.com

Product Cycle Time Improvement

Lean eliminates waste by procuring the shortest cycle time. Reducing cycle time is the method to eliminate or reduce non-value added activities. This technique can decrease the lead time in delivering to the customer, and can also improve customer satisfaction (Cusumano, & Kentaro, 1998).

The manufacturing cycle time begins from product design until the end of the process which is product delivery to the customer (Campbell, 1995). To reduce cycle time; a manufacturer can restructure the operational technique, policies and methods.

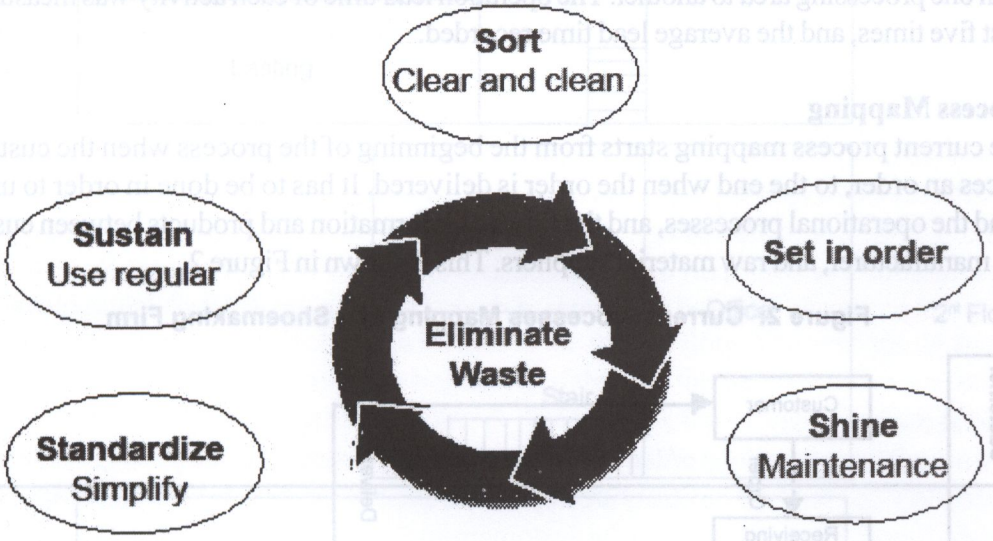
The Five S Method

The 5S method is the way to implement the workplace organization and standardization. The Five S's are:

- **Sort:** clearing and cleaning the organization.
- **Set in order:** redesign or redesignate the work area.
- **Shine:** regular cleaning and maintenance.
- **Standardize:** make all things to be the same, simplify or standardize.
- **Sustain:** maintaining what has been accomplished.

Set In Order, and Standardize are important in the later period of lean implementation.

Figure 1: 5S Process and Workplace Organization



Source: Liker & Meier (2006)

RESEARCH METHODOLOGY

First, required data are described, such as plant layout, material and information flow, the size of each area, and operational procedure. Then, the collection of information and the operational processes are obtained from observation and in-depth interview. Then comes problem analysis and process mapping. Finally, data generating and data analysis procedures, using Microsoft Excel, are explained.

Required Data

The required data for improving the production process i.e. reducing production time, increasing production effectiveness, and maximizing the resources utilization are:

- All production activities and plant layout to develop process mapping in graphical diagrams.

- The sizing of each work area is measured and recorded in metres.
- The operational and production process time, from the customer's order until the order is delivered to the customer.

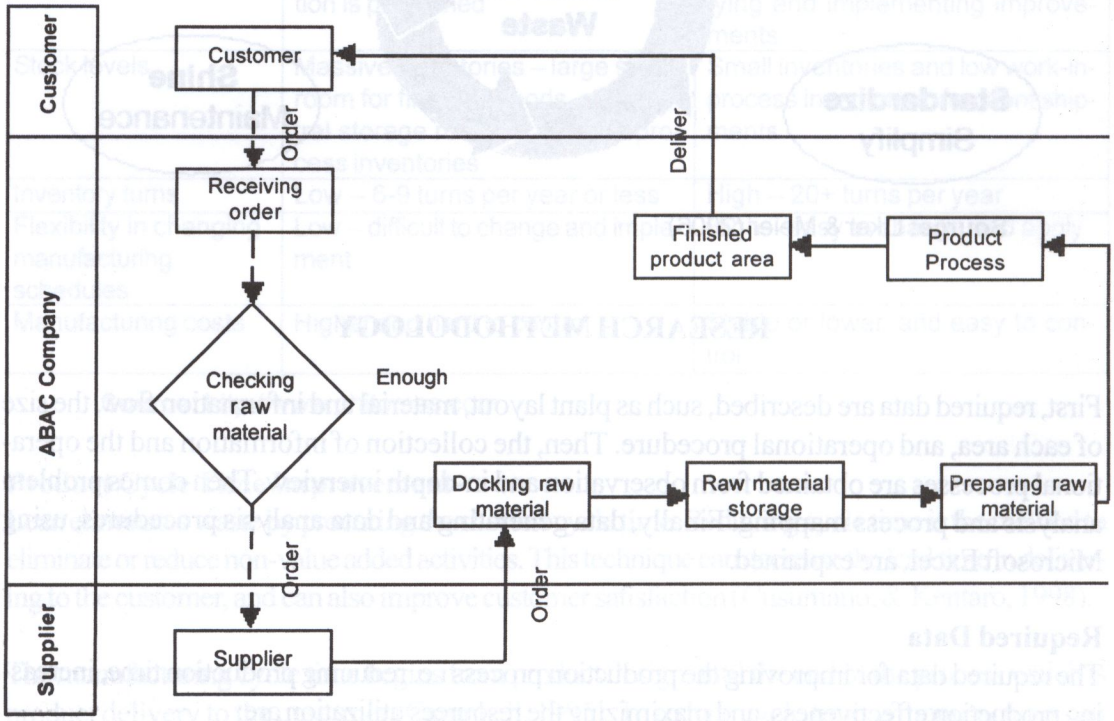
Data Collection on the Current Production Process

Data were collected, first through in-depth interviews to ascertain whether the flow of information, working problems, or other related information in shoemaking manufacturing are supported by all parts of the company (administrative officers, workers, and the company owner). Secondly, data were collected through observation, to gather information of the operation process, such as the working lead time for each production, and activities of the workers. Some physical information was collected, such as the layout, the flows of material, the distance from one processing area to another. The operation lead time of each activity was measured at least five times, and the average lead time recorded.

Process Mapping

The current process mapping starts from the beginning of the process when the customer places an order, to the end when the order is delivered. It has to be done in order to understand the operational processes, and the flows of information and products between customers, manufacturer, and raw material suppliers. This is shown in Figure 2.

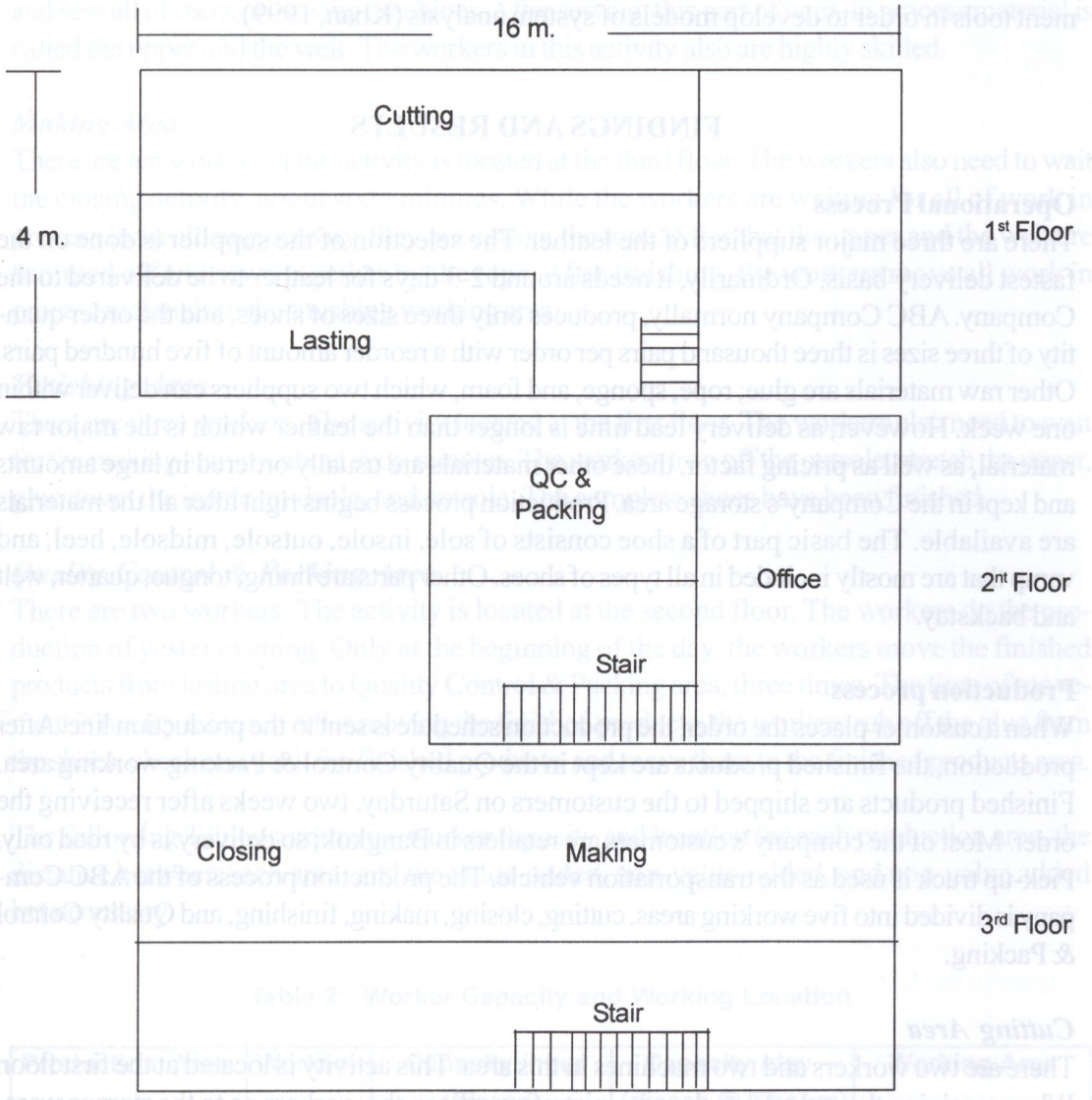
Figure 2: Current Processes Mapping of a Shoemaking Firm



Source: The Author

Figure 3 illustrates the manufacturing layouts in order to understand details of the activities involved.

Figure 3: Manufacturing Layouts



Source: The Author

Data Generating and Analysis

The production process activities were identified. Then, the necessity of each activity was analyzed. The waste or unnecessary activities were identified, and problems in the production process were analyzed.

The support of lean manufacturing strategy in a virtual environment may enhance decision capability in terms of time saving, risk minimization and higher system transparency (Aslanertik, 2005). Using as a model the Microsoft Excel-spreadsheet provides an interactive modeling environment in which a simulation technique can be utilized by applying quantitative management tools in order to develop models of system analysis (Khan, 1999).

FINDINGS AND RESULTS

Operational Process

There are three major suppliers of the leather. The selection of the supplier is done on the fastest delivery basis. Ordinarily, it needs around 2-3 days for leather to be delivered to the Company. ABC Company normally, produces only three sizes of shoes, and the order quantity of three sizes is three thousand pairs per order with a reorder amount of five hundred pairs. Other raw materials are glue; rope, sponge, and foam, which two suppliers can deliver within one week. However, as delivery lead time is longer than the leather which is the major raw material, as well as pricing factor, these other materials are usually ordered in large amounts and kept in the Company's storage area. Production process begins right after all the materials are available. The basic part of a shoe consists of sole, insole, outsole, midsole, heel, and vamp that are mostly included in all types of shoes. Other parts are lining, tongue, quarter, welt and backstay.

Production process

When a customer places the order, the production schedule is sent to the production line. After production, the finished products are kept in the Quality Control & Packing working area. Finished products are shipped to the customers on Saturday, two weeks after receiving the order. Most of the company's customers are retailers in Bangkok; so delivery is by road only. Pick-up truck is used as the transportation vehicle. The production process of the ABC Company is divided into five working areas, cutting, closing, making, finishing, and Quality Control & Packing.

Cutting Area

There are two workers and two machines in this area. This activity is located at the first floor. When receiving the order from the administrative officer, the workers go to the storage warehouse in order to pick up the raw material every week. The distance between storage warehouse and cutting area is one hundred meter and fifteen minutes per time. After moving raw materials from storage to cutting area, the workers prepare the pattern of shoe, cut out cow leather into various shapes i.e., insole, midsole, and outsole in order to make the upper of the shoes. One leather can produce one pairs of shoes per time. Pig leather is cut in order to make the liner of the shoes. All are bunches in order to wait the next activity. In this operation the workers have high cutting skill because leather is an expensive material.

Closing Area

There are three workers and three sewing machines in this area. This activity is located at the third floor. The workers need to wait for the cutting activity to finish, about sixty minutes. After waiting, the workers pick up all work in process from the cutting area. The workers trim off, and sew all of them on sewing machines. After sewing, this part of work in process material is called the upper and the welt. The workers in this activity also are highly skilled.

Making Area

There are ten workers. This activity is located at the third floor. The workers also need to wait the closing activity, about sixty minutes. While the workers are waiting for all of work in process from closing activity, they are cutting the rope. After that the upper and the welt are trimmed off and sewn together by the rope. After finishing, the workers move all work in process materials to the finishing working area.

Finishing Area

There are three workers. The activity located at the first floor. The workers also need to wait for the making activity, about sixty minutes. The workers trim off the outsole, stretch the upper, glue down the insole, midsole, and outsole. The complete shoes have been finished.

Quality Control & Packing Area

There are two workers. The activity is located at the second floor. The workers do the production of yester evening. Only at the beginning of the day, the workers move the finished products from lasting area to Quality Control & Packing area, three times. The time of movement is twenty minutes. After moving the finished products, the workers rub off the glue from the shoes, check and pack the finished products, and move them to the finished products area.

The following Tables summarise worker capacity and location for each production area, the distance between each area, and the value-added, non-value-added, and non-value added but necessary.

Table 2: Worker Capacity and Working Location

Production Area	Workers	Capacity /hour (pieces)	Capacity /day (pieces @ 8 hours)	Working Area
Cutting	2	30	240	1 Floor
Closing	3	30	240	3 Floor
Making	10	25	200	3 Floor
Finishing	3	30	240	1 Floor
QC & Packing	2	30	240	2 Floor

Table 3: Cutting Activity: Distance, Time, and Activity Values

#	Activity	Area	Distance (m.)	Time/batch (min.)*	VA	NVA	NNVA
1	Prepare the block and pumping all part of shoes	Cutting		45	✓		
2	Bunching all part of shoes	Cutting	0	15			✓
		Total	**5**	**60**			

Remark: *Time/batch = maximum capacity per hour of this activity

Table 4: Closing Activity: Distance, Time, and Activity Values

#	Activity	Area	Distance (m.)	Time/batch (min.)*	VA	NVA	NNVA
1	Waiting for cutting activity	Cutting	0	60		✓	
2	Moving WIP from cutting to closing area	Cutting	15	10		✓	
3	Trimming off WIP in order to sewing	Closing	1	30	✓		
4	Sewing all of WIP by sewing machine	Closing	1	15	✓		
5	Bunching all part of shoe in this process	Closing	0	5			✓
		Total	**17**	**60****			

Remark: *Time/batch = maximum capacity per hour of this activity
**Total activity time = 60 minutes (exclude waiting time)

From the movement of raw materials in the plant layout, it can be seen that the cutting working area is located in the first floor, the closing working area is on the third floor, the making working area is on the third floor, the finishing working area is on the first floor, and the Quality Control & Packing working area is located on the second floor. Figure 4 indicates the flow of information from the administrative office to the five working activity areas, and the flow of physical goods from the cutting activity to the closing, making, finishing, and Quality Control & Packing processes.

The diagram shown that the manufacturing layout and movement of work in process in the manufacturing as can be seen in Figure 5

Analysis of the Company Problem

The problem of the production process is the unnecessary movement of raw material caused by the inappropriate plant layout which is not suitable for the production of shoes. The prob-

Figure 4: Process Mapping for ABC Company

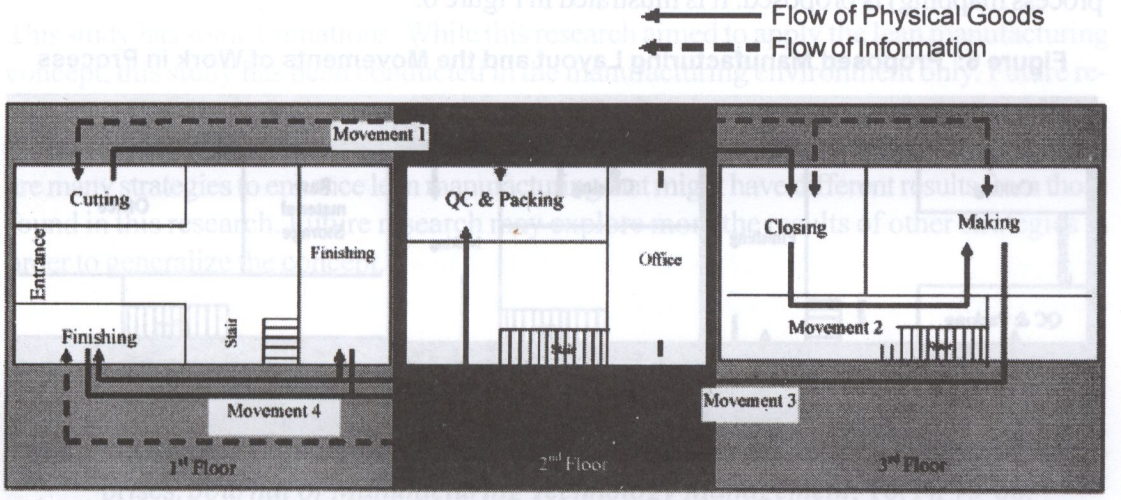
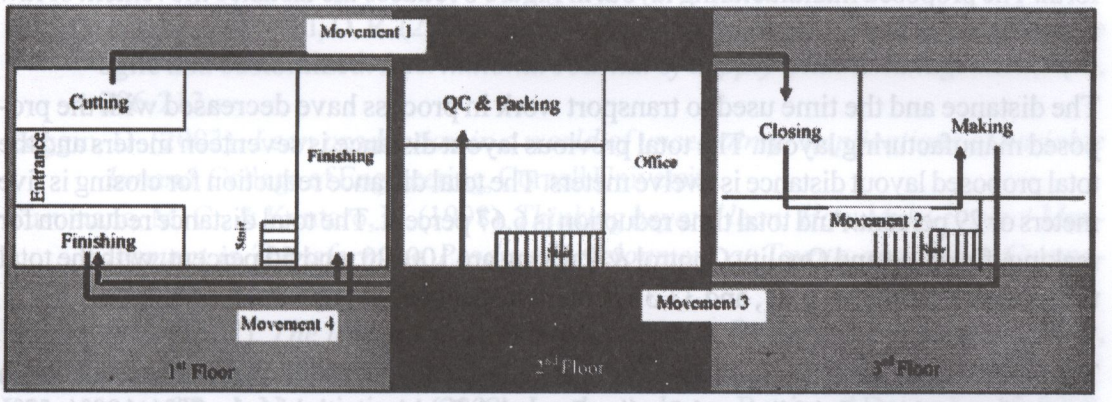


Figure 5: Manufacturing Layout and Movement of Work in Process



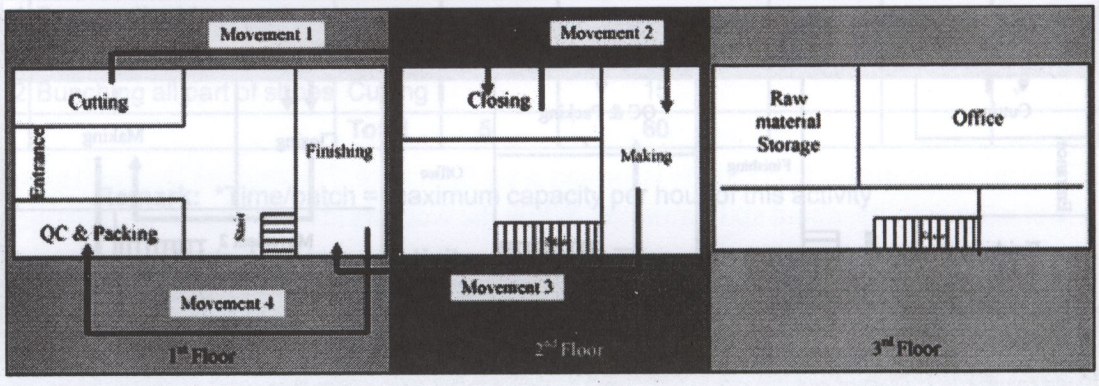
lem of long lead time is caused by the working hours, which were currently 8 am. to 5 pm, Monday to Saturday. The production of leather shoes is sequentially step by step. This inflexible production system creates a long lead time, and therefore it needs to be revised.

Applying Lean to the Company

This research found the need to adjust the schedule time of cutting activity by shifting it from 8am-5pm. to 7am-4pm. in order to eliminate the waiting time in the closing, making, and finishing activities. Another problem is the bottleneck in the making activity; therefore, two workers from Quality Control & Packing activity are assigned to work for two hours for Quality Control & Packing, and six hours in the making activity. The last problem is the unnecessary movement of work in process. Based on the problem analysis, a new manufacturing

layout was proposed, and the movement of raw material and work in process (based on process mapping) is proposed. It is illustrated in Figure 6.

Figure 6: Proposed Manufacturing Layout and the Movements of Work in Process



It can be seen that the total distance of moving the raw material and work in process has been reduced. Raw material and work in process flow in the same direction without going back and forth. The proposed manufacturing layout in Figure 6 reduces the distance movement of raw materials, work in processes and finished products.

The distance and the time used to transport work in process have decreased with the proposed manufacturing layout. The total previous layout distance is seventeen meters and the total proposed layout distance is twelve meters. The total distance reduction for closing is five meters or 29 percent. And total time reduction is 6.67 percent. The total distance reduction for making, finishing and Quality Control & Packing are 100, 20, and 50 percent, with the total time reduction of 3.34, 6.67, and 33.33 percent respectively.

The total distance reduction is 48.2%. The changed plant layout results in distance reduction in the closing, making, finishing, and Quality Control & Packing activities, by 29%, 100%, 52% and 70% respectively.

The lean manufacturing concept is employed in order not only to reduce the travel distance, and the production lead time of each activity, but also to solve the bottleneck in the production process. The decreased times in the production process are: 6.7% in the closing activity, 3.34% in the making activity, 6.7% in the finishing activity, and 58% in the Quality Control & Packing activity. Also, the adjusted schedule time of the cutting activity eliminates waiting time in the closing, making, and finishing activities. The bottleneck problem in the making activity is solved by transferring two workers from QC & Packing activity to the making activity.

The reduction of delay in production lead time enables products to be delivered on time, which finally satisfies customer requirements. Moreover the company can reduce the labor cost per

order by 6%.

This study has some limitations. While this research aimed to apply the lean manufacturing concept, this study has been conducted in the manufacturing environment only. Future research can also apply the concept in logistics and also supply chain environments. In addition, the limitation of this research is the use of only the lean manufacturing concept. In reality, there are many strategies to enhance lean manufacturing that might have different results from those found in this research. Future research may explore more the results of other strategies in order to generalize the concept.

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