STUDY AND ANALYSIS OF THE SCOPE OF VALUE STREAM MAPPING (VSM) TECHNIQUE APPLICATION IN A SELECTED GARMENTS FACTORY OF BANGLADESH

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Abstract
In Bangladesh a significant amount of foreign currency comes from the RMG sector. Garment industries in developing countries are more focused on sourcing of raw material and minimizing delivery cost than labor productivity because of the availability of cheap labor. Due to this, labor productivity is lower in developing countries than in the developed ones. So productivity improvement is one of the major concern in garments factories. This paper addresses the scope of value stream mapping (VSM) application in a selected garments factory of Bangladesh. The core idea behind the thesis work was to examine the existing condition of production system where there is no application of VSM technique and to analyze the scope of VSM technique application in the studied production line. The main objective of the research paper is to identify various wastes occurs in the production system. Additionally it tries to find out some areas for improvement and propose some improvement strategies. In this concern this case study has been conducted focusing cutting, finishing and on a particular production line of sewing section in a selected garments factory. During the investigation, attention has been concentrated how non- value adding activity hampers daily production rate and how to improve the productivity. Value adding, non-value adding (necessary and unnecessary) processes and different types of wastes have been identified by drawing the current state map for cutting, sewing and finishing sections. The study focuses on removing the big losses namely, breakdown losses, quality loss, small stops, startup rejects to improve the effectiveness of the production line. Some strategies are proposed for reducing these losses and improving the overall productivity. It is found that the non-value adding time has contributed significantly in total production lead time. Finally, a future state map has been proposed to the management that will be benefited for productivity improvement of the existing production system as well as to reduce the non-value adding time.

Keywords
VSM, Lean manufacturing, RMG, Cause effect diagram, Pareto Chart, 5S, 5 Why analysis.

1. Introduction

In Bangladesh, the Ready Made Garment (RMG) Industry has emerged as a major economic sector and has had its impact on the financial service sector, communication, transportation and on other related industries. 2 million workers in 4,000 factories, which is about one-fourth of the number of employees engaged in the manufacturing sector, constitute the real backbone of the country's economy [1].
Garment industries in developing countries are more focused on sourcing of raw material and minimizing delivery cost than labor productivity because of the availability of cheap labor. Due to this, labor productivity is lower in developing countries than in the developed ones. For example, labor is very cheap in Bangladesh but the productivity is low among other developing countries. Similarly, the cost of fabric is a major part of the garment so there seems to be great need for improvement in this sector. Even in developing countries the CAD and CAM system for fabric cutting has been implemented to save fabric. Now the worry is about labor productivity and making production flexible. The fashion industry is highly volatile and if the orders are not fulfilled on time, the fear for losing business is real. This means that time is very important driver for success. The Company that delivers goods with a shorter lead time is the market winner. This can be achieved greatly by adopting lean manufacturing system which is more than a cost reduction program. It aims at eliminating wastes which could be in the form of excess production and inventory, redundant movement of material, waiting and delays, over processing, excess worker motion, rework and corrections. Part of lean manufacturing is assessing operations and processes or products that add cost rather than value. Each step of the manufacturing process is examined to determine if it adds value to the product. If it does not add value, the process could be assigned to a subcontractor or outsourcing company in order to focus the workforce on value-added operations of its core business. This is known as value stream which is a set of processes required to transform raw materials into finished goods that customer's value. In this research work, the scope of one of the most important Lean Manufacturing tool called "Value Stream Mapping" will be evaluated in a selected garments factory of Bangladesh.

1.1 Objectives

The objective of this research is to investigate the scope and how Value Stream Mapping (VSM) technique can be adopted to the discrete manufacturing system and to evaluate their benefit on a specific application instance. In answering the research problem, the study sought to accomplish the following objectives.

1. To examine the existing scenario of production line where there is no application of VSM technique.
2. To Identify and eliminate waste and bottlenecks in the current manufacturing line.
3. To identify the potential avenues for improving present level of VSM.

2. Literature review

Value Stream Mapping (VSM) is a tool of lean manufacturing that helps to understand the flow of material and information as products make their way through the value stream. The value stream includes the value adding and non-value adding activities that are required to bring a product from raw material through delivery to the customer. In other words, Value Stream Mapping is an outline of a product's manufacturing life cycle that identifies each step throughout the production process. It represent a visual information of material flow for a particular product family [2].

2.1 Focus on waste

Waste is anything that does not contribute to transforming a part to the customer's needs. The aim of Lean Manufacturing is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible [3 & 4]. Typically the types of waste considered in a lean manufacturing system includes,

1. Inventory: An excess of inventory ties up money that could be used for other things. It also slows down the speed of production, which matters most when custom products or perishables are involved. It is important to remember that inventory includes not only supplies of raw materials but also finished products awaiting sale [3 & 4].
2. Overproduction: Producing more material than is required by the next process, making earlier than is required by the next process, or making faster than is required by the next process. The corresponding Lean principle is to manufacture based upon a pull system, or producing products just as customers order them [3 & 4].
3. Producing defective products: Defective products impede flow and lead to wasteful handling, time, and effort. Production defects and service errors waste resources in four ways. First, materials are consumed. Second, the labor used to produce the part (or provide the service) the first time cannot be recovered. Third, labor is required to rework the product (or redo the service). Fourth, labor is required to address any forthcoming customer complaints [3 & 4].
4. Motion: Any motion that does not add value to the product is waste. Motion of the workers, machines, and transport (e.g. due to the inappropriate location of tools and parts) is waste. Unnecessary motion is caused by poor workflow, poor layout, housekeeping, and inconsistent or undocumented work methods [3 & 4].
5. Processing waste: Extra processing not essential to value-added from the customer point of view is waste. Some of the more common examples of this are reworking (the product or service should have been done correctly the first time), debarring (parts should have been produced without burrs, with properly designed and maintained tooling), and inspecting (parts should have been produced using statistical process control techniques to eliminate or minimize the amount of inspection required) [3 & 4].
6. Transportation: Moving material does not enhance the value of the product to the customer. Material should be delivered to its point of use. Instead of raw materials being shipped from the vendor to a receiving location, processed, moved into a warehouse, and then transported to the assembly line, Lean demands that the material be shipped directly from the vendor to the location in the assembly line where it will be used. The Lean term for this technique is called point-of-use-storage (POUS) [3].
7. Waiting: Material waiting is not material flowing through value-added operations. This includes waiting for material, information, equipment, tools, etc. Lean demands that all resources are provided on a just-in-time (JIT) basis – not too soon, not too late [3].

2.2 Lean tools

In this research work different types of Lean Tools, such as: Pareto analysis, Cause-effect analyses, Five S (5S) and 5 Why analysis; are used to find existing situation and to identify various types of wastes exists in the selected industry which does not add any value to the overall production process. These tools are described below,

1. Pareto analysis: In nineteenth-century Italy, the Italian economist Vilfredo Pareto observed that about 80 percent of the country's wealth was controlled by about 20 percent of the population. This observation lead to what is now known as the Pareto Principle; it is also known as the "80-20" rule. In general, the Pareto principle, applied to quality, suggests that the majority of the quality losses are mal-distributed in such a way that a "vital few" quality defects or problems always constitute a high percent of the overall quality losses [5]. The intent of a Pareto analysis is to separate the vital few from the trivial many. Thus, the Pareto analysis can assist to identify the most important effects and causes to stratify the valuable data which can be used to prioritize the product-process improvement efforts [6].
2. Cause & Effect Analysis: A cause is a fundamental condition or stimulus of some sort that ultimately creates a result or effect. Most analysis are worked in both directions, from cause to effect or effect to cause in order to discover and document causes, effects, and cause-effect linkage [6]. Cause-effect analyses are usually summarized in a Cause effect (CE) Diagram. The CE diagram was developed by Ishikawa for the purpose of representing the relationship between an effect and the potential or possible causes influencing it. The CE diagram, sometimes referred to as a "fish-bone" diagram, is an organized or structured picture with lines and twigs (resembling fish bones) used to stratify and group causes. The effect is typically contained in a box on the right side, while the causes appear on the left side.
3. Five S (5S) or Work place Organization: 5S is a method to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. This tool is a systematic method for organizing and standardizing the workplace. It's one of the simplest Lean tools to implement, provides immediate return on investment, crosses all industry boundaries, and is applicable to every function with an organization [5]. The 5S pillars are, (1) Sort (2) Set in Order (Straighten) (3) Shine (4) Standardize (Systemize) (5) Sustain.
4. Five Why (5 Why) Analysis: Invented in the 1930's by Toyota Founder Kiichiro Toyoda's father Sakichi and made popular in the 1970s by the Toyota Production System, the 5 Whys strategy involves looking at any problem and asking: "Why?" and "What caused this problem?" [7]. The idea is simple. By asking the question "Why" one can separate the symptoms from the causes of a problem. This is critical as symptoms often mask the causes of problems. As with effective incident classification, basing actions on symptoms is worst possible practice. Using the technique effectively will define the root cause of any nonconformance and subsequently lead to defining effective long term corrective actions.

3. Research methodology

The methodology of this research work is a case study research. This case study is conducted in selected a garments industry located in Dhaka. The study gives an idea about the existing scenario of the different section of the garments industry. This study deals about various types of wastes of the industry, more specifically the waste of time. Several Lean Tools are used to investigate the existing situation of the selected garments industry that is discussed later. This section represents the necessary steps required to perform the case study. The overall steps involved in the study are presented below in Fig. 1 with the help of a flow diagram.

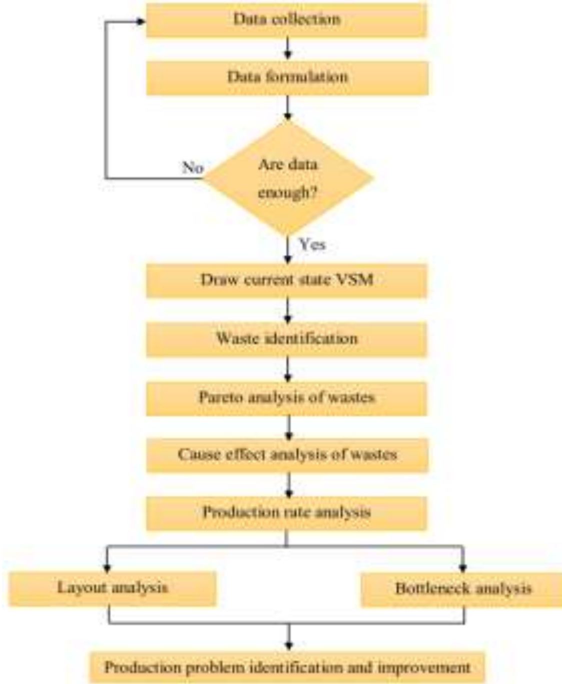

Figure 1: Steps involved in this case study

The information and data collected were sorted and arranged so that further study and analysis could be performed. Quantitative data were analyzed by using tables and graphs. Various types of information were given as a profile. Some analysis has been shown by Pareto Diagram and Cause Effect Diagram. After completion of the data processing, the analysis has been performed. The steps involved for the data collection and analysis are represented by the flow diagram, which is given in Fig.2

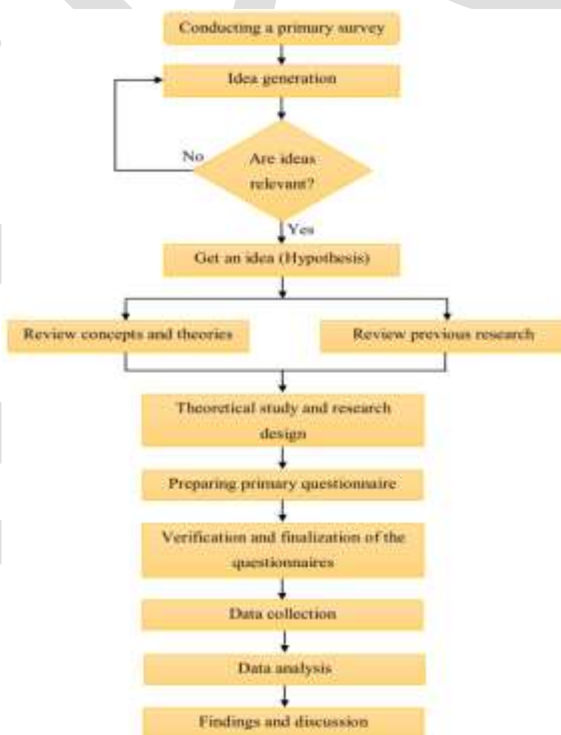

Figure 2: Steps involved in data analysis

Finally results from the overall analysis are given and necessary guidelines are provided for necessary improvement (productivity, quality, resource utilization, waste minimization) of the cutting, sewing, and finishing section.

4. Findings and analysis

This case study deals with various types of waste exists in sewing section more specifically time waste. The information as well as data has been gathered through the questionnaire, observation and interview. The data and information was collected through the observation of the production floor and some past record from the industrial engineering and planning department of the selected industry. Finally all data has been analyzed by using various types of tables, graphs and some tools such as cause effect diagram, Pareto analysis, 5 Why analysis and 5S.

4.1 Current state map

The current state VSM shows the process flow from the start to the end of the manufacturing line for cutting, sewing, and finishing sections. Figure 3 shows the current state map of the flow. The current state mapping shows that, this company is currently using a pure push production system; therefore, it requires mass effort to change from this traditional production system.

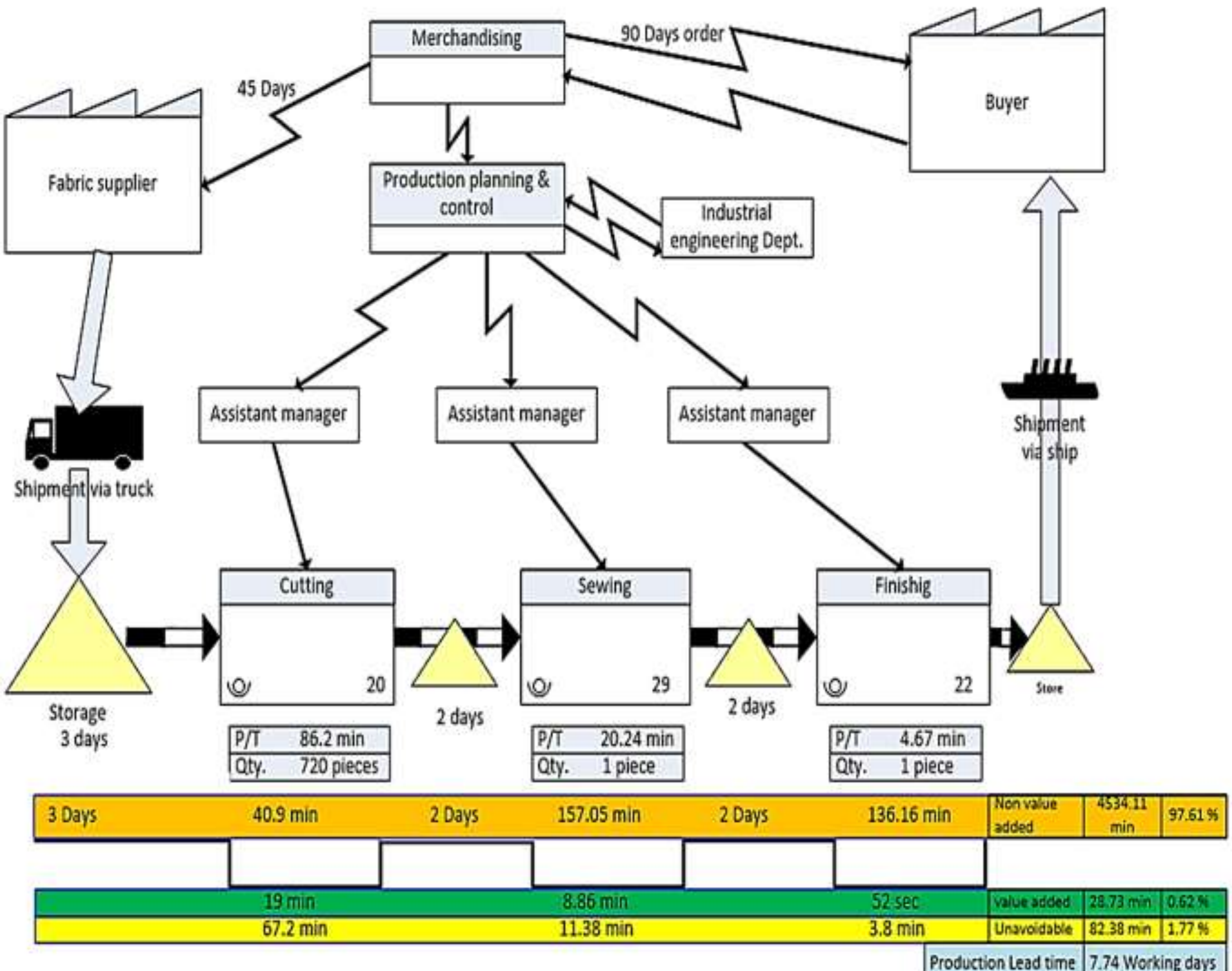

Figure 3: The current state map of the production

4.2 Findings of wastes in different section

The observed data and the current state map of the processes revealed some wastes in the flow. We assessed the company's current practice towards wastes analysed the percentage of the major wastes in sewing, cutting and finishing process.

Inventory: In cutting section, there are 3 days of inventory of fabrics and at the beginning of cutting process, there are almost 2 days of inventory before supplying the bundles to sewing section and there are about 2 days of inventory remain in the stock before supplying to the finishing section. Those three sections retain a large amount of inventory which is a waste of inventory which is about 90.44%

of total lead time.

1. Waiting Time: Most of the processes in cutting, sewing and finishing section have waiting time. The total waiting time is calculated as 283.58 minutes where 2.85 min (0.98%) waiting time in cutting section, 156.33 minutes (53.99%) waiting time in sewing section and 130.4 minutes (45.03%) waiting time in finishing section. The product waits at different processes, 6.10% of the total production lead time, which is a significant loss of valuable time.
2. Defects: There are considerable amount of defects in cutting, sewing and finishing section. Among those defects most of the defects occur in sewing section. Compared to sewing section there are a little amount of defects occurs in cutting and finishing.
3. Transportation: There is 11.03 minutes transportation in cutting section, 21.08 minutes transportation in sewing section and 2.8 minutes transportation in finishing section. Transportation takes 0.752% of the total lead time.
4. Excessive Motion: Excessive motion occurs in cutting section when the fabrics move from store to cutting table to quality check to store. There is little excessive motion in sewing and finishing section because of the positions of workstations. From the VSM data it's found that the total amount of excessive motion time is 15.62 minutes

4.3 Pareto analysis of wastes

The wastes that are found in current state mapping are ranked in terms of time to find out the leading waste.

Total waste time = Total non-value adding time

= 4534.11 min

The factors and their percentages contributing this non value adding time are given below,

Queuing by inventory: 4200 min (92.63%)

Waiting time: 283.58 min (6.25%)

Transportation time: 34.91 min (0.77%)

Excessive motion: 15.62 min (0.35%)

From the above information a Pareto chart has been drawn to visualise the significance level of those wastes

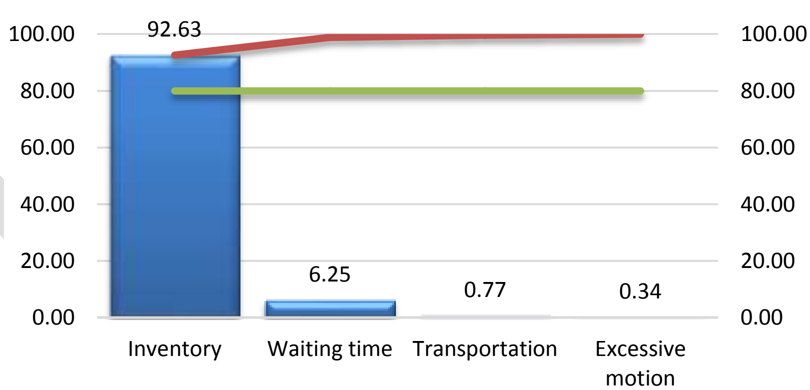

Figure 4: Pareto chart for Wastes

From the above analysis it's clear that the major cause of waste is product inventorying time.

4.4 Findings of Cause effect analysis of wastes

After performing Pareto analysis major wastes are identified then cause-effect analysis is done to find out the possible cause of those wastes. The following root causes have been found from the analysis.

Wastes	Reasons
Inventory	Raw materials, Safety stock, Finish goods, Delivery schedule, Min. Qty. requirement.
Waiting Time	Lack of skilled labor, Imbalanced layout, Transportation schedule.
Defects	Equipment problem, Lack of skilled worker, Material problem.
Transportation	Discontinuous process, Distance between work stations, Improper arrangement of machine.
Excessive Motion	Layout

4.5 Findings of 5 Why analysis

Waste	Root causes	Solution
Inventory	No formal set of procedures to handle inventory	Kanban
Waiting	No formal set of procedures to handle inventory, Lack of training & motivation	Kanban
Defects and rework	Lack of motivation & training	Training & motivation for workers
Excessive transportation	Poor layout	Training, motivation & instruction for workers properly
Excessive motion	Improper work sequence & layout	Proper layout

A solution to those wastes and root causes has been identified using 5 why analysis.

4.6 Bottleneck analysis

As the production rate data of the garments factory showed the production rate is only 56.79% so, it's clear that, the line's capacity exceed the demand. That's why the bottleneck analysis is done to find out the bottleneck point and eventually improve the condition. To find out if there is any bottleneck in the line Takt time is calculated and then compared with the cycle time. If the Takt time is less than the cycle time then it'll be clear that, the production line suffers with bottleneck problem [8].

4.6.1 Takt time calculation

After calculating operator availability, machine uptime & quality data Takt analysis is done. The Takt time calculation of the sewing process is shown below [8],

$$\text{Takt time} = \frac{\text{Effective working time}}{\text{Total demand for the products}}$$

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$$= \frac{\text{no. of shift} \times \text{avail. hrs. per shift} \times \text{op. avail.} \times \text{m/c uptime}}{\text{daily demand} \div \text{quality}}$$

$$= \frac{1 \times 10 \times 94.25\% \times 87.42\%}{1000 \div 92.01\%}$$

$$= 0.4549 \text{ min/piece}$$

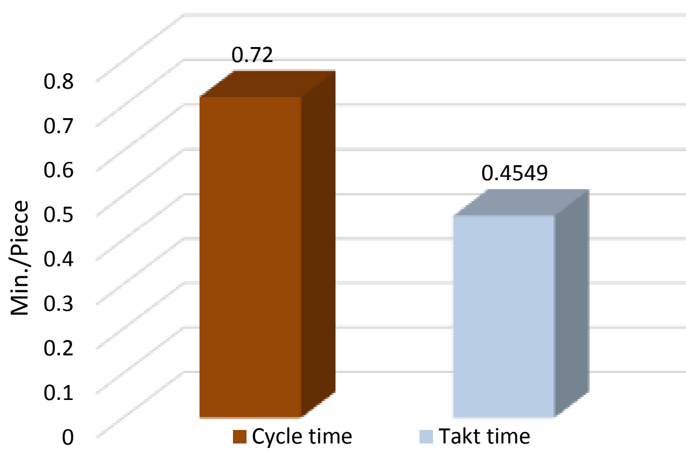
From the above calculation the Takt Time is found 0.4549 minute/piece.

4.6.2 Cycle time calculation

The cycle time for a line (time between completions of successive items on the line) is determined by the maximum time required at any work station. Highest cycle time is found as 0.72 minute. So it's the cycle time of the product for sewing section.

4.6.3 Takt time and cycle time comparison

After calculating product cycle time and the Takt time, a chart has been drawn to compare the cycle time and Takt time to find out if there is any bottleneck in the production line. Figure 5 illustrates the Takt time and cycle time comparison.



4.7 Future state value stream mapping

After improving various waste, removing bottleneck from the sewing process and improving current layout future state map is drawn. The future state VSM is shown in Figures 6. The improvement activities are shown in the VSM by the Kaizen burst icon. Kanban pull system are also proposed to replace the traditional push system.

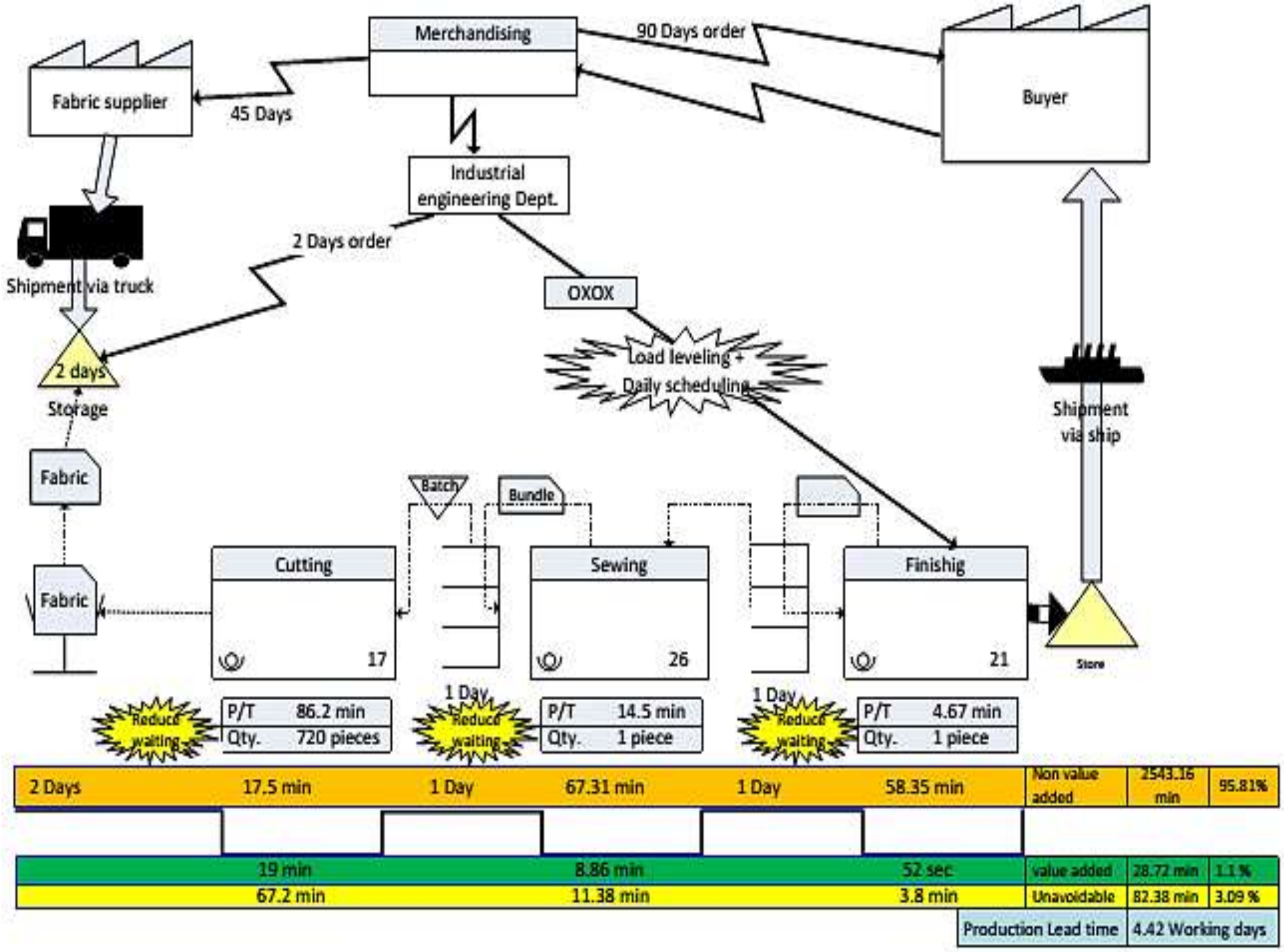


Figure 6: Future state VSM

4.8 Comparison of current state map and future state map

More detailed explanation about these improvement activities are provided in table below :

Factor	Current state map	Future state map
Inventory	7 Days	4 Days
Waiting time	283.58 Minutes	115.26 Minutes
Transportation	34.91 Minutes	17.64 Minutes
Non-value added time	7.56 Days	4.24 Days
Total lead time	7.74 Days	4.42 Days
Super market	None	2
Production information	Production planning & control	Industrial engineering dept.
Manpower	71	64

5. Conclusion and recommendations

The main goal of this thesis was to find out the scope of VSM technique application in garments factory. On a selected product of the studied garments factory VSM was implemented to find out the amount of wastes in cutting, sewing and finishing section; because the selected product had a long lead time and was unable to meet the expected production rate. Pareto analysis was done to identify the dominating waste. Cause effect and 5 why analysis was done to identify the reason of waste, after proposing different solution strategies to reduce the identified waste and problems, a future state map was drawn to meet the expected production rate with reduced lead time and wastes. The result has significantly been improved over the current state map. As value stream map can be drawn in relatively short time with almost no expenditure of money and as it can identify wastes with good accuracy, thus it's very helpful for managers who are having difficulties with their low production rate, higher lead time and high production costs. A careful future state value stream mapping can put an ease to their problems.

Through this thesis work,

- Value added activity has been increased from 0.62% - 1.1%
- Waiting time has been reduced from 283.58 min. to 115.26 min.
- Productivity has been increased 31.94 %
- Lead time has been decreased 7.74 days to 4.42 days
- Bottleneck point has been reduced from 0.72 min. to 0.49 min.

Therefore organizations of similar type can use the research outcomes as a knowledge base to identify their wastes and come up with suitable remedies.

For improvement of production system of the selected garments industry, below some recommendations are proposed:

- ✰ Value stream mapping should be applied to determine the current scenario of production and to identify various types of wastes.
- ✰ Kanban supermarket pull system should be implemented to reduce unnecessary raw material inventory and waiting time.
- ✰ To reduce other waste various technique such as zero defects, setup time reduction, line balancing, SMED, 5S, and Poka-Yoke can be applied.
- ✰ Layout needs to be improved to reduce unnecessary transportation wastes.
- ✰ Bottleneck point should be identified and removed to get the maximum output from the production line.
- ✰ Proper and adequate training should be provided to employees and workers so that they can gather proper knowledge and consciousness about the operation of various machine to maintain desired quality.
- ✰ To reduce worker absenteeism and to build up moral and trust among the workers some measures should be taken such as job enrichment, implementation of proper incentive plan, relationship improvement between employee and management, total productive maintenance, worker motivation.
- ✰ Instead, minimize total cost in the long run (low bids do not always ensure quality). Reduce the number of suppliers for the same item by eliminating those that do not qualify with statistical evidence of quality. A single supplier for any one item should be chosen based on a long-term relationship of loyalty and trust.

It's necessary to involve Industrial and Production Engineers for optimum use of resource at best quality.

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