

# **Lean Implementation and Bottleneck Identification through Value Stream Mapping in the Garments Industry**

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## **Abstract**

WTO data for 2024 indicates that Bangladesh posted export earnings of \$38.48 billion, showing a slight increase of 0.21%. Conversely, Vietnam reported \$33.94 billion in exports, supported by a substantial growth rate of 9.34%. Vietnam's success is driven by higher productivity achieved through skill development, worker education, and lean manufacturing. To remain competitive, Bangladesh must adopt similar efficiency-focused practices. This study addresses the urgent need to enhance operational productivity in the Bangladeshi RMG sector by systematically applying lean manufacturing principles. This study investigates the application of Lean Manufacturing principles, particularly Value Stream Mapping (VSM), to identify and eliminate bottlenecks and non-value-added (NVA) activities in sewing production lines. To eliminate the identified waste, this study implemented a comprehensive lean strategy, including Root Cause Analysis for problem identification and the deployment of targeted tools such as Kaizen and 5S for workplace organization and material flow improvement. The application of these interventions and the future state VSM led to a measurable reduction in NVA time and a distinct improvement in overall production efficiency. Upon determining the different types of waste, various lean tools were used to eliminate the wastes. Subsequently implementing these lean initiatives, a future state VSM was developed, showing a dramatic reduction in NVA time from 4.38 minutes to 0.33 minutes and an approximate 30% improvement in productivity. The results demonstrate that structured lean implementation can substantially enhance process efficiency, reduce waste, and improve the competitiveness of Bangladeshi garment industry.

## **Keywords**

Lean Manufacturing, Value Stream Mapping (VSM), Bottleneck Identification.

## **1. Introduction**

Lean manufacturing is a set of tools and methodologies that focuses on the continuous elimination of all waste in the production process which is a framework for improving efficiency and product quality (Haque *et. al.*, 2012). Japanese were the first to introduce lean manufacturing. Japanese quality leaders such as the Toyota Motor Company's Eiji Toyoda, Shigeo Shingo and Taiichi Ohno developed a disciplined, process-focused production method which is known as "Toyota Production System (TPS)" or "Lean manufacturing" (Haque *et. al.*, 2012). The Toyota Production System is a strategic arm for Toyota. A company culture that makes sure every single hand views their own processes

through the eyes of the customers. Toyota Production System (TPS) offers different types of tools for waste reduction, such as Value Stream Mapping (VSM), 5S, and Kanban system. Textiles industries are one of the prime drivers for the rapid growth of the global economy. Due to the expanding work and wage in developed countries, clothing production has been moving from high pay created nations to low wage agricultural nations. Prior to 1990, clients endured long lead time, which empowered the makers to limit the creation cost essentially by keeping everything under control size. However, late occasions clients are requesting more limited lead time. That is why garments industry need to save their time and use a technique to get maximum output in less time; they have no alternative to lean manufacturing for mass production in less time.

In the garments industry when sewing a garment, it requires many operations, using sewing machines to assemble fabric pieces and attached different types of accessories like elastics, buttons, labels, lathers etc. (Hasan, M. M., 2021). Swing is considered a labor-intensive section, and it relies heavily on worker skills and machine rigor to function a multitude of operations (Hasan, M. M., 2021). Since swing line is a labor-intensive section that's why needed to apply value stream mapping for visualize labor efficiency. The scope of value stream mapping (VSM) is recording approaches, but it is different than other conventional recording approaches, it enables to better understanding of what steps are taken, where the value is added, where the value is not added, and more importantly, how to improve the entire collective process in the factory. Also, it helps the visualization of material flow, cycle times, information flow and utilization of resources (Hasan, M. M., 2021). The lean production philosophy uses various concepts like Kaizen, 5S, Kanban, Just-in-Time, and Value Stream Mapping (Nunesca & Amorado, 2015). Lean production has been applied in various types of industries like automotive, electronics, pharmaceuticals, garments and consumer products manufacturing. So, the garments industry can adopt a lean manufacturing system by using above lean tools. Also using various lean tools as a co-operator with the supply chain and planning, maintenance, quality and management system which are respectively PDCA (plan-do-check-act), TQM (total quality management), SMED (Single Minute Exchange of Die), TPM (total productive maintenance), and visual system (Hasan, M. M., 2021).

The biggest problem in the garments industry is their waste, in such a situation, the formal way to manage with all these problems is the implementing lean manufacturing. Various types of research and manufactured units started lean production with value stream map implementation (Ben Fredj-Ben Alaya, 2016). Value-stream-mapping can be used for both visual and mapping and communications in addition to it also being a strategic planning tool, diagnostic tool and change of management tool (Ben Fredj-Ben Alaya, 2016). The garments industry is a labor-intensive industry, that's why there is a lot of waste generated like as high rejection rate, and long lead time. Lean manufacturing tools can improve productivity via reduction in the lead time of the process by eliminating non-value-added activities.

Hence, this study focuses on eliminating bottlenecks from a process line and eliminating waste time through value stream mapping. This study was conduct in a ready-made garments industry in Bangladesh. The objective of the proposed project is to methodically demonstrate how to eliminate non-value-added time. When lean tools are used appropriately, these can help the industry to eliminate waste, have better product quality, better line balancing, and better overall financial and operational procedures. Lean tools VSM principles is to generate the best possible method from the existing concept consumer currently using (Kumari et al., 2015). It builds a map of the current state in the production line and identify different types of waste in the sewing process (Hasan, M. M., 2021) to minimize waste and achieve improvement.

## **1.1 Objectives**

- To identify bottleneck and non-value-added activities through value stream mapping in a sewing production line.
- To analyze cause effect approach to identify the sources of non-value-added activities

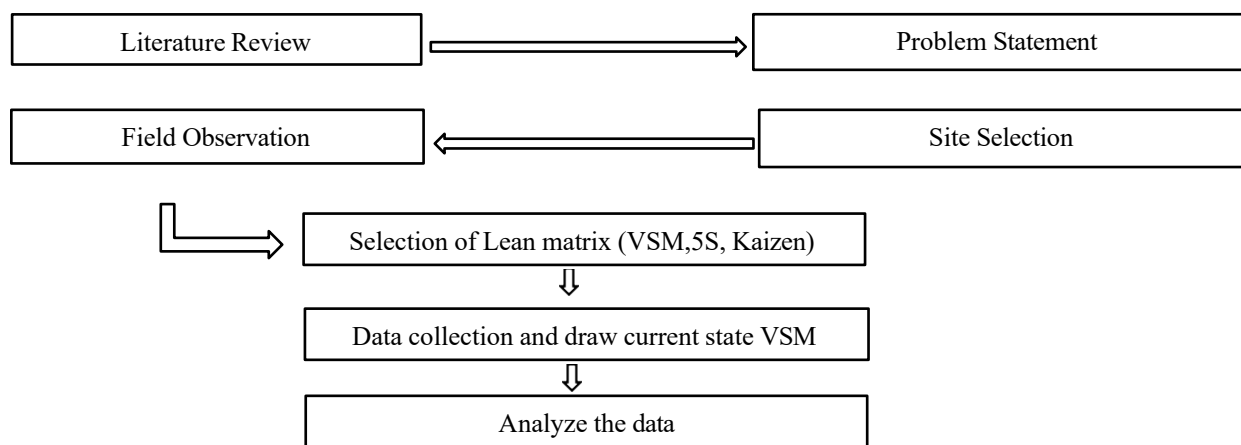
## **2. Literature Review**

Recent articles (from 2000-2021) were selected for the comprehensive literature review related to value stream mapping practices in garments industry and quality of a product in lean environment. Further, study is done to reduce non-value-added time from the production process and minimize production lead-time to improve productivity. There is a lot of opportunities to improve the process industries like ready-made garments industry if lean tools are utilized (Jasti et al., 2020). The main contribution of lean manufacturing (LM) is the identification and rejection of waste. Companies (Seyed Mojib Zahraee et al., 2014). In recent years, many literatures have broadly documented the implementation of lean philosophy into different manufacturing sectors, but several have addressed in the garments

environment. Lean manufacturing is a set of tools and methodologies that aims for the continuous elimination of all waste in the production process, i.e. a system for improving productivity and product quality, laconically more value with less work (Bristi, 2019). A lean manufacturing system's basic goal is to manufacture maximum quality products at the minimum cost and in the shortage time by eliminating waste. Productivity improvement is carried out by implementing the various lean tools in the industry, such as Just-In-Time (JIT), 5S, Value Stream Mapping (VSM) and many more (D. V. Kumar et al., 2019). Non-value-added activities considered waste, waste elimination is the basic principle of lean manufacturing. Each organization wastes a certain amount of its resources (Hasan, M. M.,2021). The efficiency of the garments industry is very low because the garments industry generates a lot of waste. Waste has been divided into different categories, mainly eight types of waste and in short, it can be called TIMWOODS. Value Stream Mapping (VSM) is a simple and visual tool based on the manufacturing process that allows the documentation, visualization, and understanding of materials and information flows throughout the process to identify and eliminate wastes (Zhu et al., 2020). Garments industries are important contributors to our country's economy despite lean not being a mass application in the garments context. VSM is one of the most commonly used techniques in lean manufacturing to recognize waste which is eliminated through continuous improvement/kaizen (Faulkner & Badurdeen, 2014). VSM is one of the most powerful lean manufacturing tools for an organization who want to plan, implement and enhance on its lean journey. VSM is a key performance indicator that measure the performance of a production process (D. V. Kumar et al., 2019). VSM is a graphical representation of tool which identify the material flow system. When drawing the value stream mapping it helps the organization to differentiate value adding activities and non- value adding activities and define kaizen (continuous improvement) opportunities (Silva, 2012). Value stream mapping is not the same as ordinary recording approaches as it helps in the representation of material flow, information flow in the scientific way (B. S. Kumar, 2016). The advantages of value stream mapping don't come exclusively from the making of a map however from the collaboration of individuals making the maps, with the process and making the observations on the floor, which are important to accumulate the data for the value stream maps (Islam and Sultana, 2011).VSM has shown itself to be an effective tool for redesigning the production process systems ( Hasan, M. M., 2021), it captures the information at individual sections like station cycle time, up time or utilization of resources, set-up time or change over time, work in process inventory, man power requirement and the information flow from raw materials to finished goods (Singh et al., 2011). The propose of Future State VSM is drawn by showing various kinds of Lean idea of kaizen, job sharing, process merging, multi-machine operating, multitasking and operation change, minimize transportation on the improvement spaces of Current State VSM. The Production unit needs to work with the necessary pace of creation and to keep up with the quality and proficiency too (Bristi, 2019). For the further Improvement and practical future state planning by focusing on key performance indicators (KPI) in the garments industry. After implementing the future state mapping, it is significant to measure the key performance indicators (KPI) in the production process (Hasan, M. M., 2021).

### 3. Methodology

The methodology is presented in Figure 1 below.



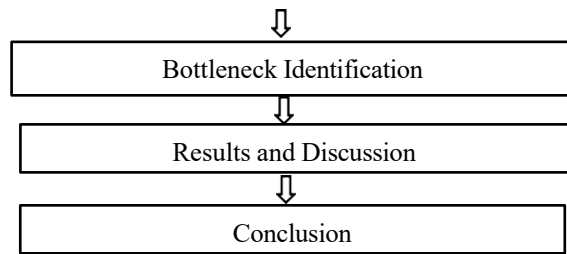


Figure 1. Conceptual Framework

#### 4. Data Collection

This section showed the procedure of data collection which was carried out based on the research questionnaire. Data was collected for this thesis through in-person observation. In the next section defines the primary data collection process (Table 1- Table 4).

Table 1. Data collection chart 1

	Process 1 (sec)	Process 2 (sec)	Process 3 (sec)	Process 4 (sec)	Process 5 (sec)	Process 6 (sec)	Process 7 (sec)
Cycle time (CT)	49.32	56.27	62.77	30.05	76.76	40.08	63.17
Standard time (SMV)	39.56	42.31	44.05	24.15	50.04	36.18	44.33
Operator Performance	80	75	70	80	65	90	70
Defects (%)	15	15	25	20	35	25	20
Work in Process	35	25	20	20	35	10	20
	Process 8	Process 9	Process 10	Process 11	Process 12	Process 13	
Cycle time (CT)	54.03	47.27	38.13	39.58	23.07	57.11	
Standard time (SMV)	37.92	35.56	32.52	27.81	16.25	42.94	
Operator Performance	70	75	85	70	70	75	
Defects (%)	30	25	20	15	2	25	
Work in Process	25	20	20	20	10	25	

#### 4.1 Observation of Individual Process Performance

All measurements are taken in second.

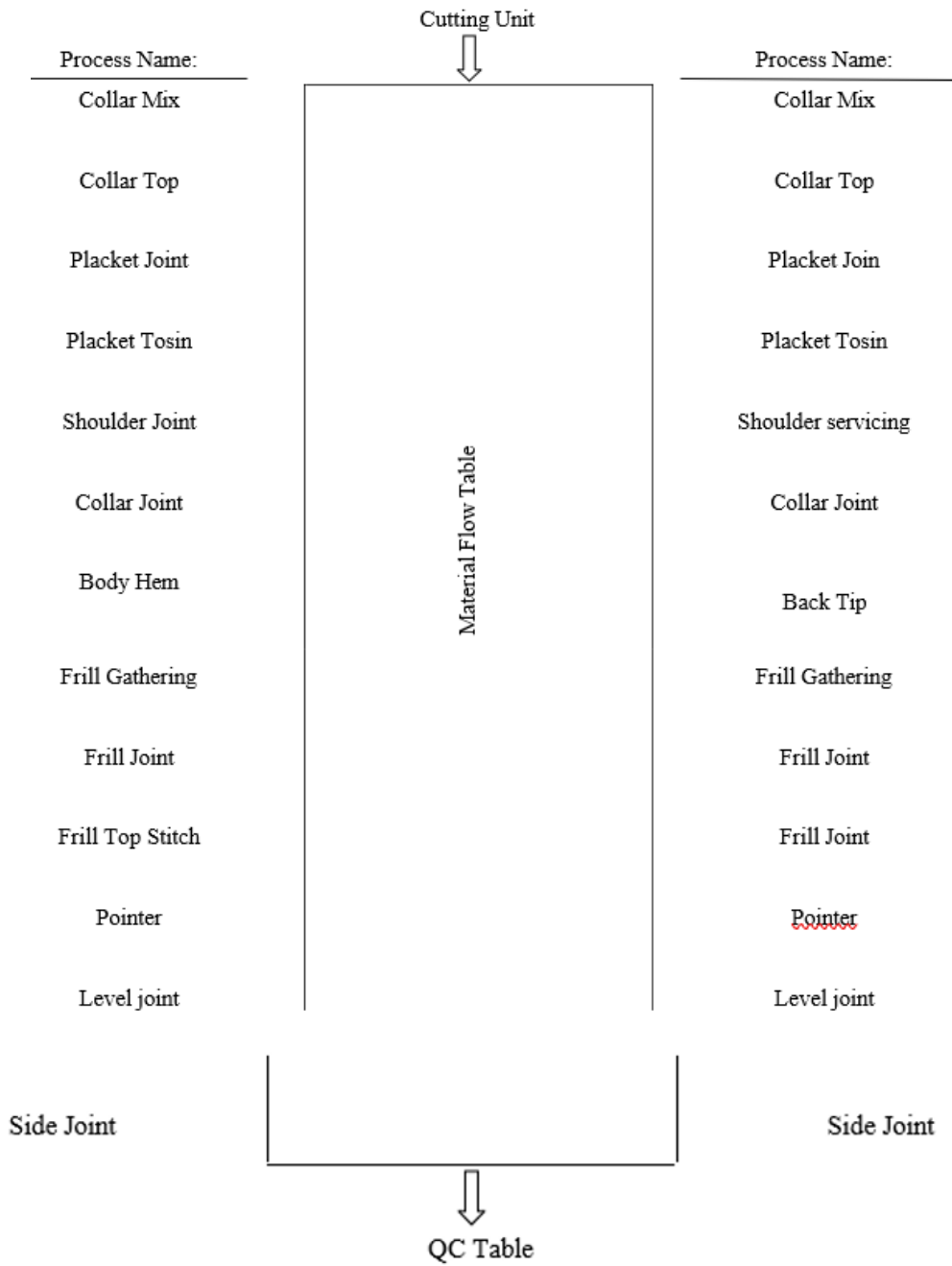
Table 2. Data collection chart 2

Process no:	Cycle time	Pick up and set	Stitch	Disposal	Value add	Non-value add
1	49.32	12.54	34.78	2	46.22	3.10
2	56.27	18.11	36.26	1.90	54.22	2.05
3	62.77	12.34	48.73	1.7	56.77	6
4	30.05	10.12	17.82	2.05	26.35	3.70

5	76.76	11.39	60.37	2	68.66	8.10
6	40.08	8.60	30.32	1.16	39.58	0.50

7	63.17	12.23	48.31	2.02	59.37	3.80
8	54.03	13.73	39.02	1.28	50.30	3.73
9	47.27	15.24	30.84	1.19	44.92	2.35
10	38.13	9.86	26.00	2.27	36.99	1.14
11	39.58	14.02	23.56	2	35.77	3.81
12	23.07	10.62	10.45	2	18.33	4.74
13	57.11	9.41	46.69	1.01	55.34	1.77

Table 3. Sewing line layout

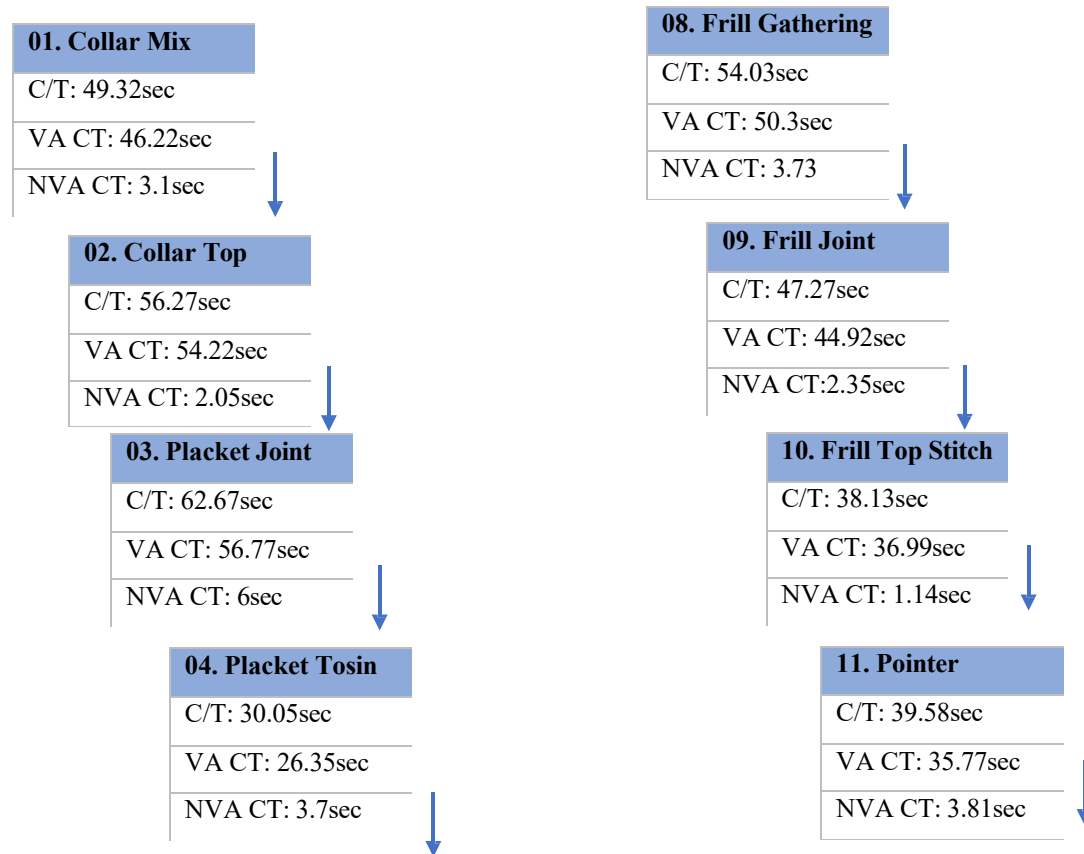


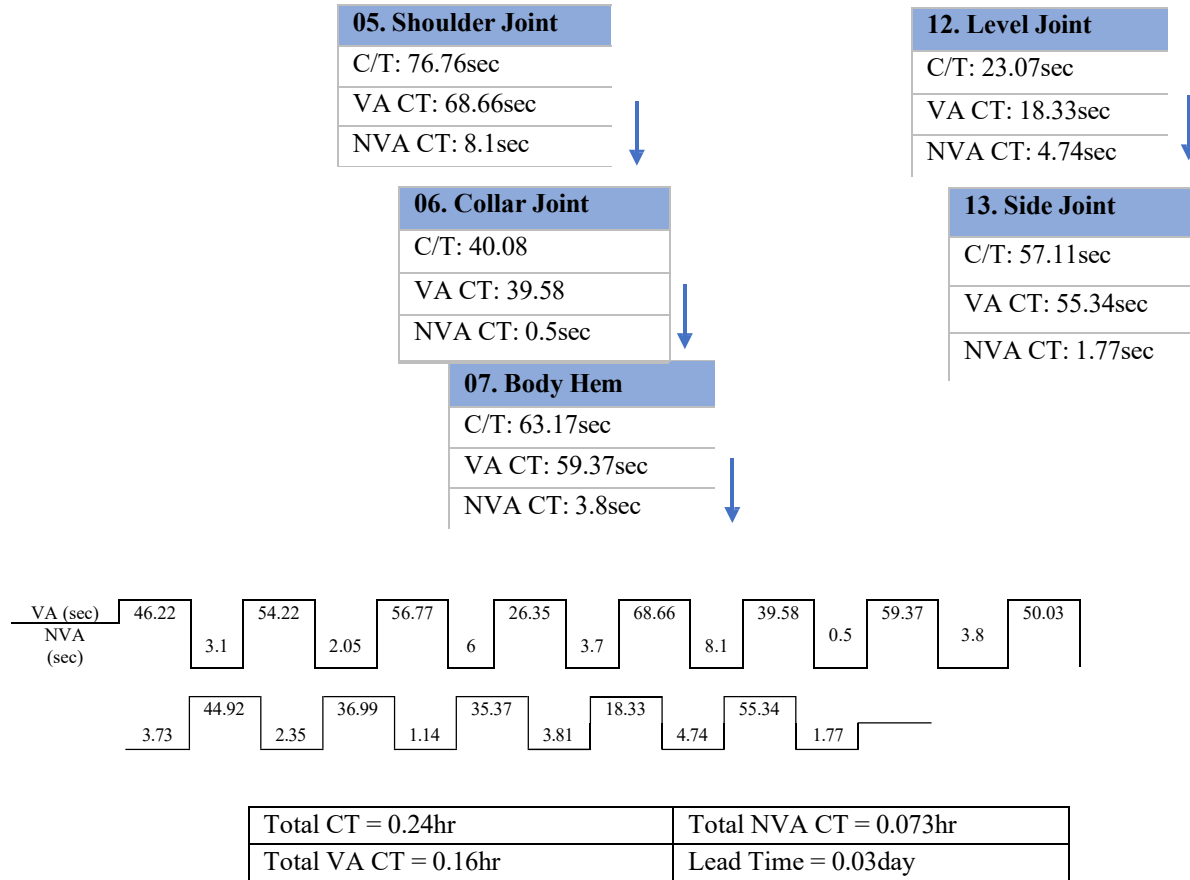
#### 4.2 Current State VSM

The current state VSM shows all the process stages with sufficient detail on how each stage is finished and what happens to the objects being processed (Verma & Sharma, 2017). Value stream mapping work done by the paper and pencil is also used in different software to show the material and information flow from the buyer order placing to the source of finished goods with the visualization of waste and the opportunity of improvement in the process. To conduct the current mapping process, the leaders must have all of the points that are important to the analysis of the present situation in mind (Henrique et al., 2016). A Current State Map shows work procedures as they are currently used. The evaluated performances of a value stream are analyzed additional to generate concepts for improvements in the current state map (kanda Boonsthonsatit & Siripong Jungthawan, 2015). The development ideas can be triggered by other lean tools such as elimination, combination, reorganization, relocation, and simplification, work adjustment, visual control etc. The potential improvement concepts are incorporated into the mapping of current state for developing the future state map.

Current State Map

Production Control: 01-13





## 5. Results and Discussion

While visiting the garments production floor, the study found some waste, such as rejection rate, over processing, huge number of In-process inventory, etc. which occurred Non-Value-Added Time. Main problem noticed that the rejection rate, and main target was to find out how to reduce the rejection rate as well as lean implementation. Initially, wanted to find out where the problems occurred by observing the collecting data, then the researcher wanted to reduce it by various types of lean implementation. First of all, a current state map would develop for improvements in lean tool implementation and towards the end a future state map would be shown through data analysis. After the data analysis through different types of lean tools such as fishbone diagram, pareto chart, 5S, line balancing and just in time than a future state map would be find which showed the improvement of the current process.

### Bottleneck Identification

Data and current state map showed that the bottleneck occurring in the shoulder joint section because there was much time waste rather than other sections. Also, most of the in-process inventory stuck in the shoulder joint section. That is why this point indicated bottleneck section. Current state map showed there was a lot of improvement and most of the worker spent lots of non-value-added time, in this section needed to an improvement for increasing worker efficiency. Data showed this process layout was not appropriate, and needed to change some section for getting a better process layout. In every section in-process inventory occurred, and it needed to eliminate using different types of process improvement technique. It was necessary to implement Kaizen, at first brainstorming needed for identify why this type of problem occurred. It was hard to change established working process and adapt the worker in a very short time. So, this study found out some problem and suggested a few solutions which may leading to the benefit for the industry, but to implement these types of methods need a systemize working procedure and a great arrangement of the high-level management participation with a team-based learning procedure.

## Causes of Waste

Waste was generated because of no one maintain 5S technique properly, unskilled worker and improper management system. When a problem occurred in the machine maintenance team were taking lengthy time to solve the problem. There was no preventive and corrective maintenance plan. The supervision was poor skilled and the motivation was not effective properly. On work training was not enough. The absence of multi talent operators was visible. The production schedule record scheme was not accurate. Material flow of the production line was very slow. Work in process inventory was very common and management were not taking it as a serious issue. sewing productivities were significantly low because of poor skilled workers, poor method and lack of proper motivational activities. Organization management designed an outdated process, unbalanced workload, unsystematic work plan without visual control, no efficient data recorded for each segment. For reducing rework rate and WIP from the process line that is why implement 5S, kaizen and arrange the training for workers.

## Cause and Effect Analysis

Cause and Effect Analysis also known as fishbone diagram, and Ishikawa Diagram. Fishbone diagram helps to finds out the cause and effect of a bottleneck. The issue is like a head of the fish, and the causes feed into the spine. This is an efficient tool that helps team to visualize the problem (Figure 2).

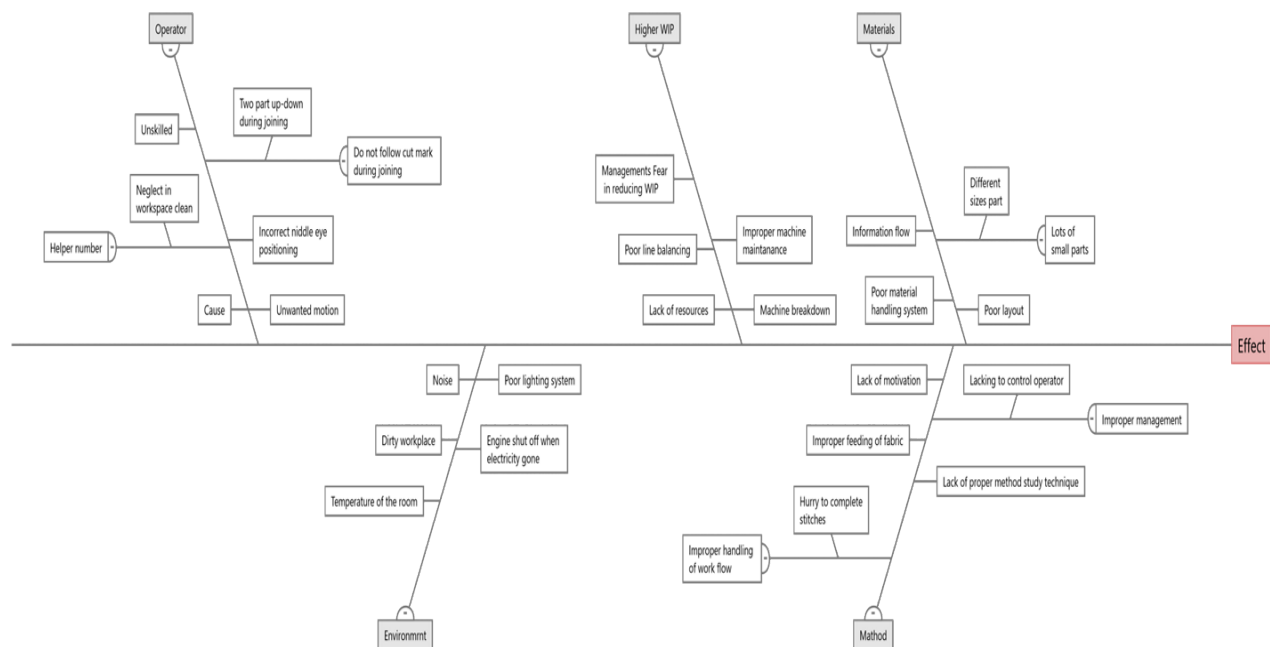


Figure 2. Cause and Effect diagram for high rejection rate

## 5.1 Proposed Improvements and Recommendation

### 5.1.1 Lean Improvement

#### Arrange Proper Training

The main goal of this thesis paper was to develop a Value Stream Mapping (VSM) approach, which is becoming a suitable tool for implementing lean manufacturing in actual production settings (Rohani and Zahraee, 2015). During the working in any job arena, everybody does several types of job. Some job is the value-adding job, some job is help positions to add value to the job. Except for these two categories, there is some other work that the worker does but can't avoid which is called non-value-adding jobs like thread breakage, product arrangement, record, etc. for these reasons needed to train whole organization employee to properly utilize their working time. Cause and Effect Analysis showed the main problem of the swing line. And these areas needed to upgrade for better outcome. Main problem that the author identified was unskilled worker, and WIP, when these two problems were solved, probably 80% problem

were solved that is why it was very necessary to arranging proper training for top management to worker level. It was not possible to bring sudden change in everyone; everyone has to come up with practice to bring a trend of improvement through small changes. These improvements will not happen in one day, gradually these changes will come to everyone. First of all, all the workers have to be introduced with kaizen. It is possible to improve an organization goal through kaizen practice.

### Kaizen implementation

All innovations and improvements start with everyone in the organization becoming aware of the need for change and the role each will play in the realization of that change (Biswas, 2013). The most important step is to begin by catching people's attention and raising their awareness (Biswas, 2013). Kaizen is a Japanese word kaizen means continuous improvement. Kaizen procedure is used to make continual improvements all over a plant or the process. The Kaizen system is used to decrease the waste and non-value-added stages in order to minimize the time. The study author identified Some problem in the production floor. These problems are: Low lighting facility, Movement of worker, Indiscipline in work place, Low work efficiency, Stress and fatigue of worker. When study author was looked at the workplaces, some was operating smoothly and some was not smoothly and sometimes needed assistance to get things together. However, in this situation the important factor is to understand the requirement for improvement and discover ways to do it. Once come to the realization, factory that improvements are required, first stage to do is to work on an action plan. Typically, action plan consists of the following steps,

- Identify the areas that needed to improvements.
- Analysis the current condition.
- Brainstorming with the team for many possible recommendations for improvement.
- Established KPI's and observe the progress to determine in which technics work and which are not work.
- Once reach primarily probable results, try to follow the same stages again to set the new targets.

Solution for keep continuous improvement:

- Get involve all employee and trained them for check his/her own work properly.
- Create a list for employee to find out basic problem and Inspired employees to offer creative solutions.
- Introduce of risk analysis and pre-production meeting before start the production.
- Implementing quality management system such as traffic light, poka yoke etc. and maintain continuous improvement process.
- Continuous improvement system would be to introduce with quality targets and repeat the necessary steps to gain expected result, and either remain their or further improvement.

### 5S Implementation

The 5S framework focus on generating visual order, organize work system, cleanliness and standardization work to increase profitability, efficiency, improve services and safety. In the period of data collecting time author noticed that no one maintain 5S properly, maybe worker didn't know about the 5s system. The production system was very poor and dirty, firstly everyone has to be motivated to maintain 5S framework.

Table 4. 5S implementation

5S Element	Criteria	Comments
Short	Removal of unnecessary items from the workplace area so that no unwanted items are on top of the equipment's.	Unnecessary item: rework product and WIP present in the system. remove all types of unnecessary item from the workplace.
Set in order	Proper organization of tools and materials for easy accessibility.	Materials: for saving time it is necessary to keep spare tools near the machine and it is kept in a box, spare tools like needle.
Shine	Adequate cleanliness of machine and workplace area.	Cleaning: Unnecessary threads, fabrics and yarns was present but low in amount in the floor, keep machines and equipment's are clean and windows and work surface also

		kept clean. Floors kept cleaned minimum two times per day.
Standardize	Adherence SOPs and standardized procedures and guidelines.	Maintenance system: all machine and materials needed to maintain properly, paint all materials for preventing the rust, install safety guard sign etc.
Sustain	Proper maintenance of cleanliness and adherence to SOP's.	Sustain: in every day a team will be checked to 5s maintain properly.

**Poka yoke (mistake-proofing)**

As rework rate was high that is why all fabric parts needed to mark properly for accurate joining. For poka yoke worker can easily identified the fabric parts joint area. Needed to implement traffic light system, when a machine needed to maintenance a light will be remained for machine maintenance, also when material flow stuck then the light will be remained for an action needed for reduce WIP.

**Action taken for reduce rework rate**

- A mark sign use for joints the part.
- Parts should be joint very carefully
- An automated conveyor can be used for materials transportation, it also reduces WIP.
- Shoulder and zipper joints with fabric should be done correctly, a skilled helper assigned to keep ready the fabrics for sew.
- Sew carefully for remove alter.
- Extra spare parts kept near the machine for reduce breakdown time.
- More QC assigned for check the product after a while.

Also, authors noticed that the current layout is not suitable for better output. Then update. Update layout will be like this (Figure 3):

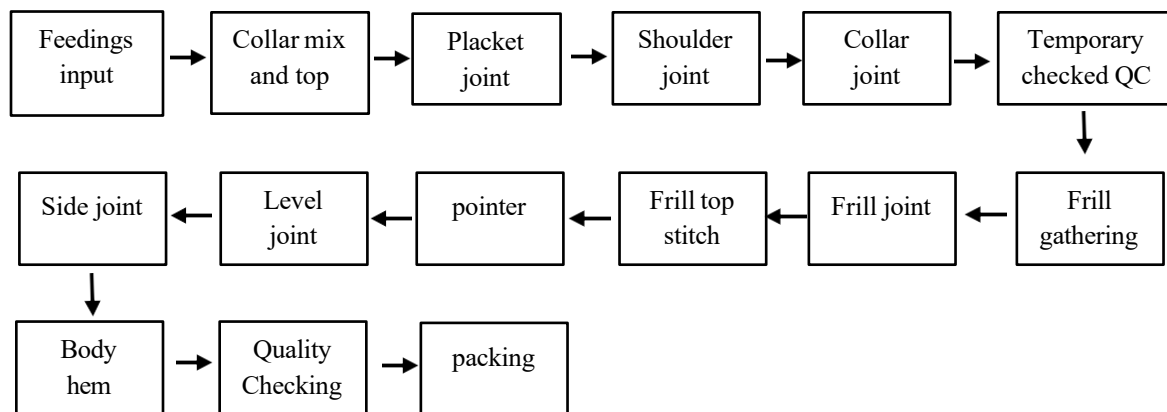


Figure 3. Update layout (Authors’ own contributions)

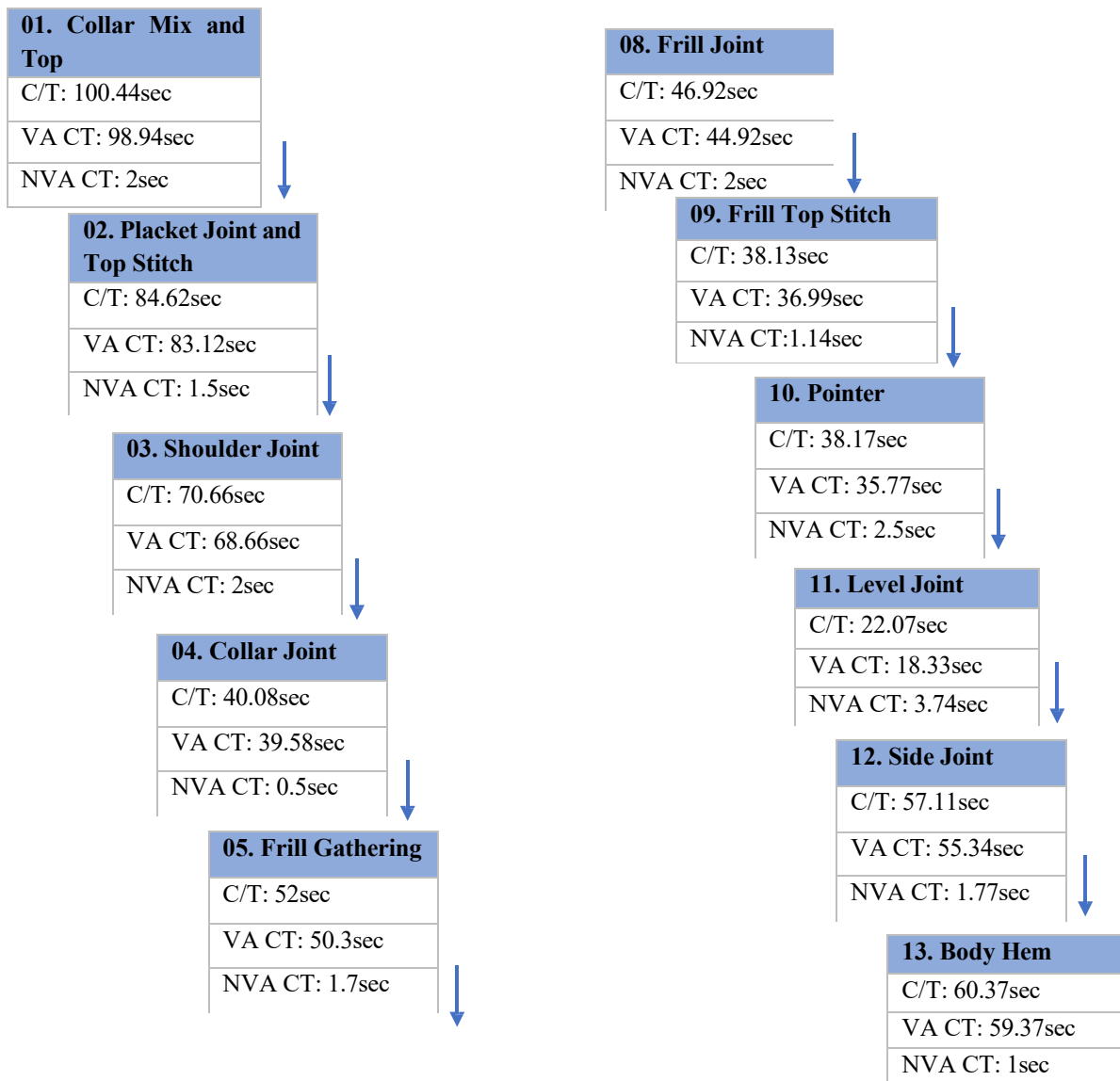
A temporary QC assigned in the section five because it was the ending part of all sew in top section in a dress. Sew body hem section brought in the last section because it is not necessary to able in the middle point, it is time consuming operation that is why it brought in the last section.

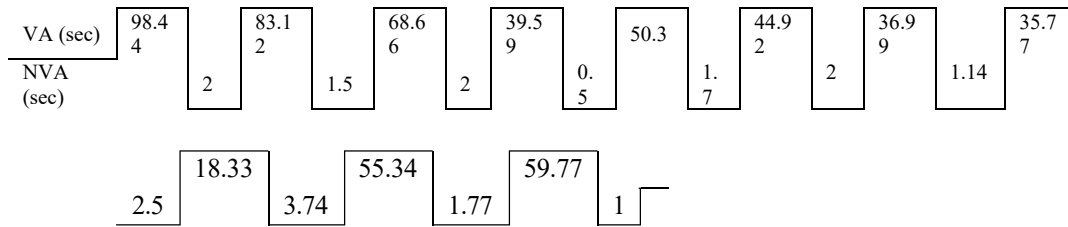
### Future State VSM

Here the future state VSM after implementing the lean. Sewing WIP should be removed in the future state mapping. If simply eliminate the Non-Value-Added time than the total cycle time also reduced. The information flow needs to be smooth when information flow will be better and QC inspection occur in two or three steps consecutively than the rejection rate will be low and the defect will be very easy to find out. The future state map draw depends on the changed process line and reduced NVA time. Collar mix and collar top these two steps now produce in one employee for reduce small parts and WIP, but for reducing bottleneck there individually work two employees. Again, placket joint and placket tosin these two steps of work now done by one employee for reduce small parts and WIP, but two individual workers done by this job for reduce bottleneck. For drawing the future state map here considering the NVA time (Figure 4).

### Future State Map

#### Production Control: 01-13





Total CT = 0.17hr	Total NVA CT = 0.0055hr
Total VA CT = 0.16hr	Lead Time = 0.021day

Future state map showed the reduced cycle time and improved process line.

Before implementation	After lean implementation
Total CT = 0.24 hr	Total CT = 0.17 hr
Total VA CT = 0.16 hr	Total VA CT = 0.16 hr
Total NVA CT = 0.073 hr	Total NVA CT = 0.0055 hr
Lead Time = 0.03 day	Lead Time = 0.021 day

Figure 4. Reduce cycle time

## 6. Conclusion

This study successfully demonstrated the application of Lean Manufacturing principles, particularly Value Stream Mapping (VSM), to enhance operational productivity in the Bangladeshi Ready-Made Garment (RMG) sector. The investigation focused on identifying and eliminating non-value-added (NVA) activities and bottlenecks within a sewing production line. The current state VSM and data analysis pinpointed the Shoulder Joint section as the primary bottleneck due to high non-value-added time and a significant accumulation of work-in-process (WIP) inventory. Root Cause Analysis further revealed that high rejection rates stemmed from factors such as unskilled workers, poor 5S maintenance, and improper management systems. A comprehensive lean strategy, incorporating targeted tools like Kaizen, 5S, and process improvements, was subsequently proposed and implemented through a future state VSM. The results demonstrate a substantial improvement in process efficiency. These structured interventions led to an approximate 30% improvement in productivity. This study provides strong evidence that structured lean implementation is a vital strategy for the Bangladeshi garment industry to reduce waste, improve process efficiency, and significantly enhance its global competitiveness.

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## **Biographies**

**Ferdous Ahmed Rana** is an Industrial Engineering graduate currently studying for a Master's degree in Advanced Industrial Engineering at TH Rosenheim, Germany. My academic focus lies in lean manufacturing and the use of machine learning to improve industrial processes.

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**Dr. Md Alamgir Hossain**, a distinguished academic leader and researcher, joined BUFT as a Professor of Industrial Engineering in January 2023 and quickly rose to become the Dean of the Faculty of Fashion Studies (FFS) in February 2023. Currently he is serving as Treasurer at the BUFT. Dr Hossain graduated from BUET, Dhaka, from Mechanical Engineering Department in 1999 and received PhD from Swinburne University of Technology, Australia in 2005. Dr. Hossain is an accomplished researcher with over 50 publications in renowned journals and conferences.

**Dr. Nazia Muhsin** graduated from the MIST on 2008 in Mechanical Engineering. Her academic journey continued in

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