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Original Article

A Proposed Model for Productivity Improvement by Implementation of Lean Manufacturing Techniques in a Textile Industry

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Abstract - *The development of the textile sector in India has experienced significant growth in recent years, becoming one of the main economic activities of the textile-industrial sector in south India. Many organisations face new competition and macroeconomic conditions in the current textile manufacturing scenario. Lean manufacturing system adoption is increasing due to the industry's challenges in this swiftly changing world. Lean manufacturing makes an organisation more flexible and adaptable as change occurs. More than ten per cent of Non-Value-Added Activities (NVA) from the total production of an organisation direct to loss. The main task of lean manufacturing is to maximise resource utilisation by minimising unwanted waste. This research aims to reduce waste by executing different lean techniques after adequately studying the current process. The lean execution in the textile industry is minimal, and different existing studies identify the research gap in implementing a sequence of lean elements in a selected industry. Implementing the proposed layout reduces the cycle time from 472 seconds to 438 seconds, and operator movement for the industry is reduced from 153 feet to 117 feet. After the proper execution of various lean techniques, it was observed that the overall productivity increased by 4.84%.*

Keywords - *Textile industry, Waste reduction, Lean tools, Inventory control, Visual management.*

1. Introduction

The textile industry is one of the leading economic sectors in India. Customer demand at the right time is essential to reach the maximum goal. Hence, proper process application by detecting the various issues at the current manufacturing level and finding the path to eliminate the wastes by constantly upgrading the new techniques. Execution of appropriate lean techniques in the current state of manufacturing is essential to improve the production environment for maximum efficiency. In early research, articles suggested that lean practices and maximising product level do waste minimisation. Many researchers focused on one or two parameters to know about the existing production process and how to implement the lean tools.

Lean execution makes product value expected by the customer without waste by adopting continuous improvement. The scope of this research article is to implement lean techniques using different lean tools such as line balancing, Value Stream Mapping (VSM), layout optimisation and Kaizen in a textile manufacturing industry as a unique case study. The problem was identified with the current manufacturing process. New ideas are implemented to enhance the production level by eliminating the NVA activities and minimising the cycle time to reach the customer demand at the right time with quality.

2. Literature Survey

Textile manufacturing has increased in production when compared to the last decades. Since the trend has changed, the need for modern design has existed. The fundamental lean principles include first-time quality, waste minimisation by removing all NVA activities, continuous improvements and flexibility in production.

In the textile manufacturing industry, lead time is the total amount of time required for completing the product, beginning from the date of receiving raw material to the stage of shipping to the customer, and it typically includes two components of information lead time (the time it takes to process an order) and order lead time.

2.1. 5S

The 5S implementation reduces the significant square footage of space essential for the existing manufacturing system in the industries. The way to implement the 5S tool is by sorting a company's waste [1, 2]. Implementation of 5S makes the workspace clean and arranges the process systematically with its existing configuration [3, 4].

The red box concept was introduced [5, 6] to clean the shop floor by keeping a box and storing waste. 5S pillar shine is implemented with the help of a new concept by providing a checklist of all the operations to be done [7, 8]. SOP provides how to perform a particular activity with step-by-step instructions, such as manufacturing or record keeping. SOP can contain images to understand a particular operation better. Mahesh focused on giving the best operations practices to an employee with different SOP formats [9, 10].

2.2. Line Balancing

Assigning tasks to an ordered sequence of stations is done by line balancing. The poor work arrangement and less accurate standard time as the cause of low efficiency were identified. Line balancing is effective when all the line segment's production demands can be met within the given time using the available time briefly explained [11-13]. Line balancing is suitable to overcome such causes. Line balancing aims to identify the tasks that can be grouped to reduce the cycle time. Line efficiency is calculated and compared with before and after results [14-16].

2.3. Value Stream Mapping

The VSM definition was given as all the activities needed to convert the raw material into a final product by mapping the entire production process. The different research works clearly explained the concept of lean manufacturing and the route map to implement lean manufacturing in an organisation. The overall performance of the working process, besides the present state of consumer needs and fulfilment, achieved NVA reduction by 14% of a manufacturing company [17-20].

2.4. Layout Optimisation

Layout optimisation was focused on reducing material handling costs and improving throughput with minimal space requirements. Human resources and material flow are utilised to meet the daily demand by shop floor layout. As briefed in a study, machines and other equipment are replaced to optimise the layout with the new layout provision. The literature shows numerous cases of implementing lean tools successfully [21-24].

However, it has been shown that most studies focus on the manufacturing sector, such as textiles, construction, and metalworking, evidenced by the scarce information about the usefulness of lean tools in agribusiness focused on the wine sector [25, 26]. For this reason, the scientific base is reduced to take a precedent on the treatment of low performance in the production of wines in the production line [27, 28].

The selection and evaluation of raw material suppliers for the textile industries play the leading role in getting the maximum output at the right time [29, 30]. In this sense, this research aims to provide an improvement model through the lean manufacturing philosophy that increases the textile production yield and generates greater profitability for textile industries.

3. Methodology

The research methodology starts with a detailed process study of the firm, and after further analysis, the problem is selected. The data are collected for constructing the current state VSM to identify opportunities for change. After finding the gap, various lean layout optimisation techniques and line balancing are introduced. The lean tools were implemented in the firm to improve productivity. Finally, the future state mapping shows the improvement achieved in the process. The methodology of lean implementation methodology flow chart is given in Figure 1.

3.1. Process Study

The textile industry competes with other growing industries and requires lean implementation. The detailed processes in the textile industry are listed in Figure 2.

3.2. Selection of Problem

Productivity stays low because of different shop floor wastes, thus increasing cycle time. No procedure is followed as per standard, so the industry does not meet the lead time.

- No standard procedure is followed, and it allows materials to get damaged. So, the defect occurs and can be avoided using standard operating procedures.
- Each product must wait to move to another work area due to poor layout and improper line balancing. So, waiting time should be reduced by using layout optimisation and line balancing.
- Operators are not able to follow the boards and signs which are provided. Visual management and onboarding must be effective in order to have clarity among operators.

The scrap materials are left on the floor due to the nonexistence of 5S implementation, leading to a messy work area.

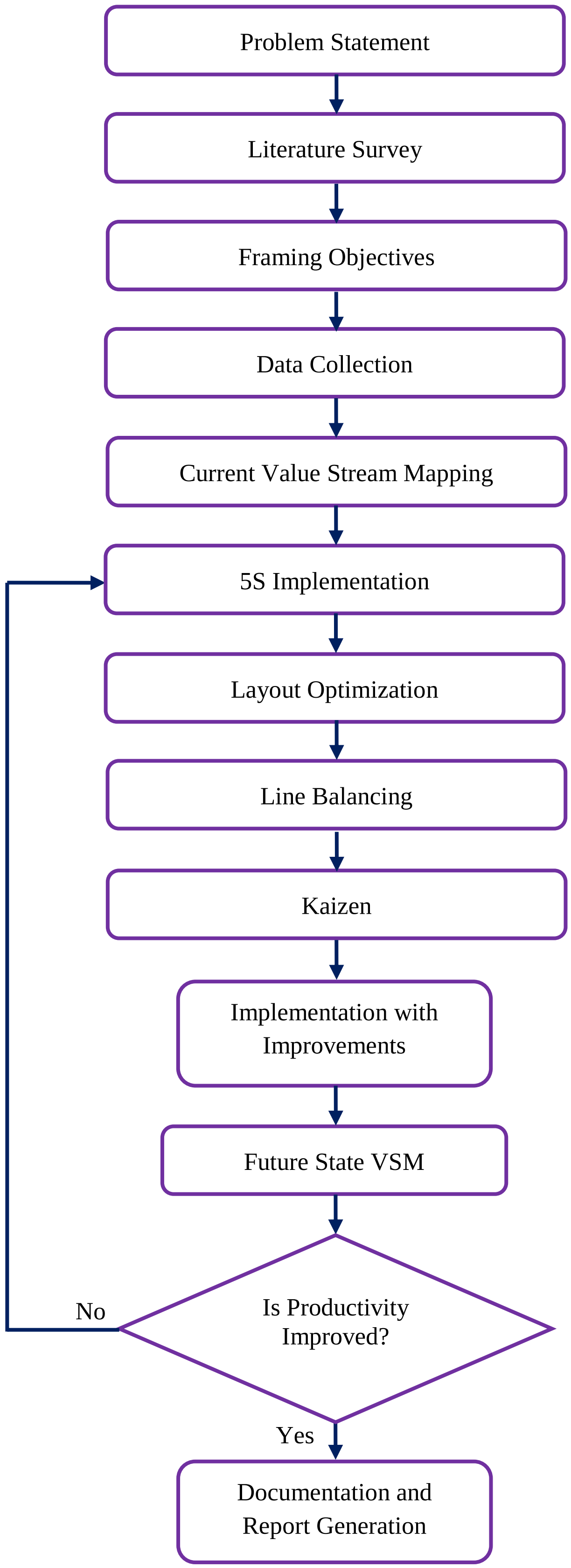

Fig. 1 Methodology flow chart

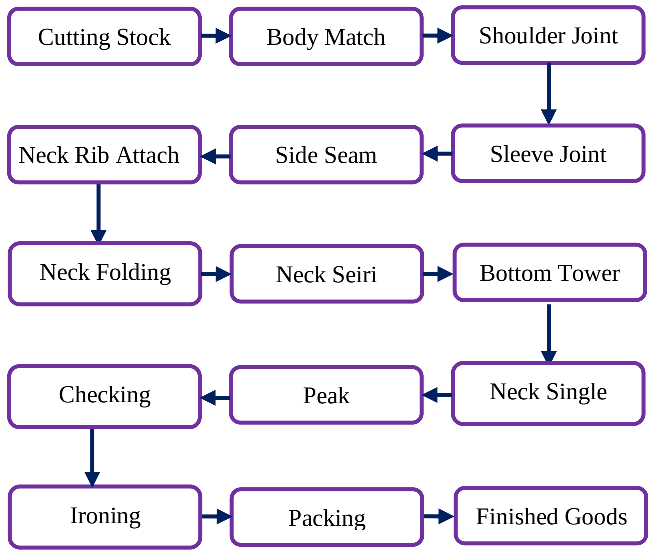

Fig. 2 Process map

4. Proposed Model

If a diagnosis was made of the production processes of a company in the textile sector located in the southern city, it was shown that the central problem presented by the organisation is low production performance and that the product that presented the lowest performance index is the production of the cloths. It was also possible to discover that two main causes or leading causes caused the problem: the poor condition of the raw material, which represented 54.7%, and the excess of the decrease in production, with 74% of the main problem.

Starting from the initial diagnosis, this research has developed an improvement model under the Kaizen methodology embodied in Figure 3 to increase production performance. The purpose of this research is to disseminate and validate the use of the Kaizen methodology in a scenario where research is scarce or null, so the literature does not present more into this area to set out and can be taken as scientific evidence that can optimise the production processes of companies belonging to the textile sector and thus increase the rates of profitability and satisfaction by the art of end customers.

Due to those mentioned above, it is essential to highlight the novelty of this research, where it was possible to combine 5S plus an S for safety and health at work, integrating layout optimisation, VSM, and applying training, all under a perspective of continuous improvement that is the Kaizen philosophy in a new field such as the textile sector, seeking the same goal: Increase the productive performance of textile companies. Figure 4 shows the flow of the implementation of 5S, where the materials are identified as necessary, and those that are not are eliminated. Also, they are classified, located according to the order of use, and placed in one place for easy access.

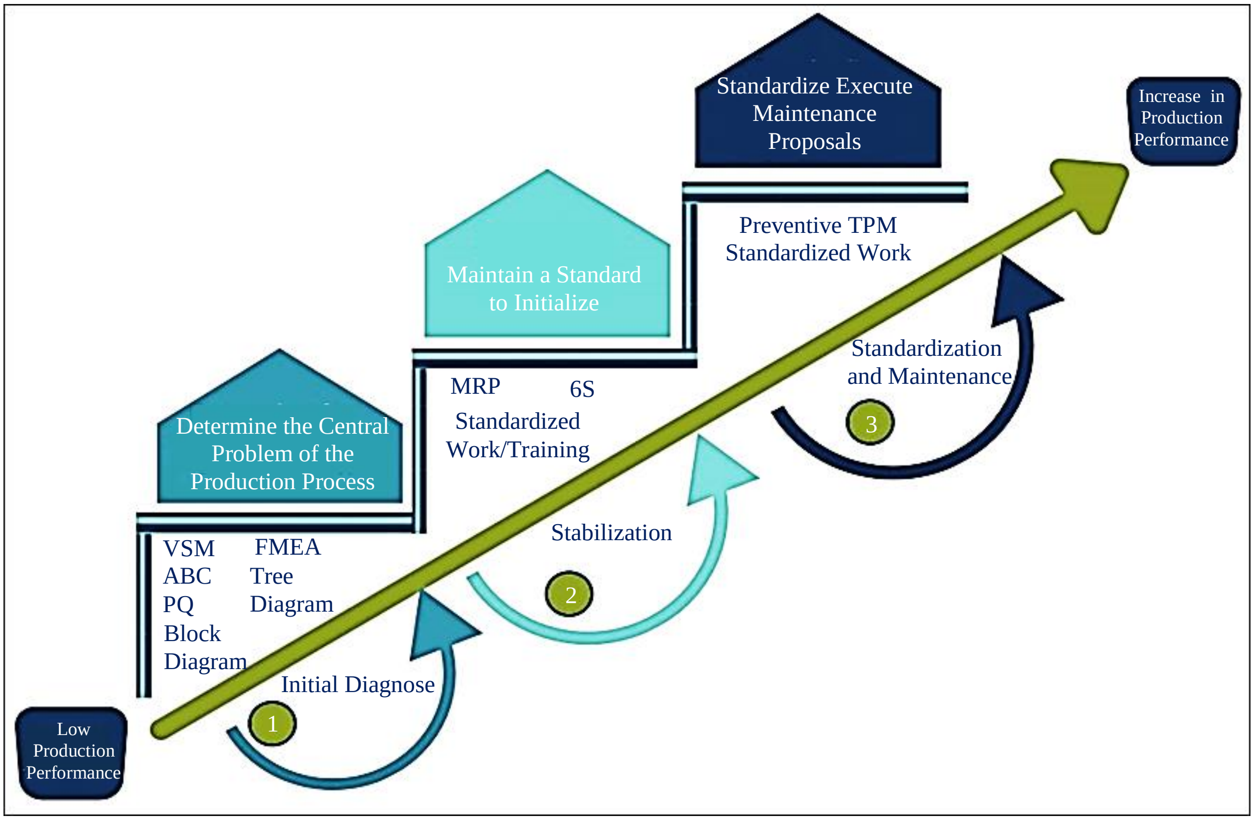

Fig. 3 Proposed model [31]

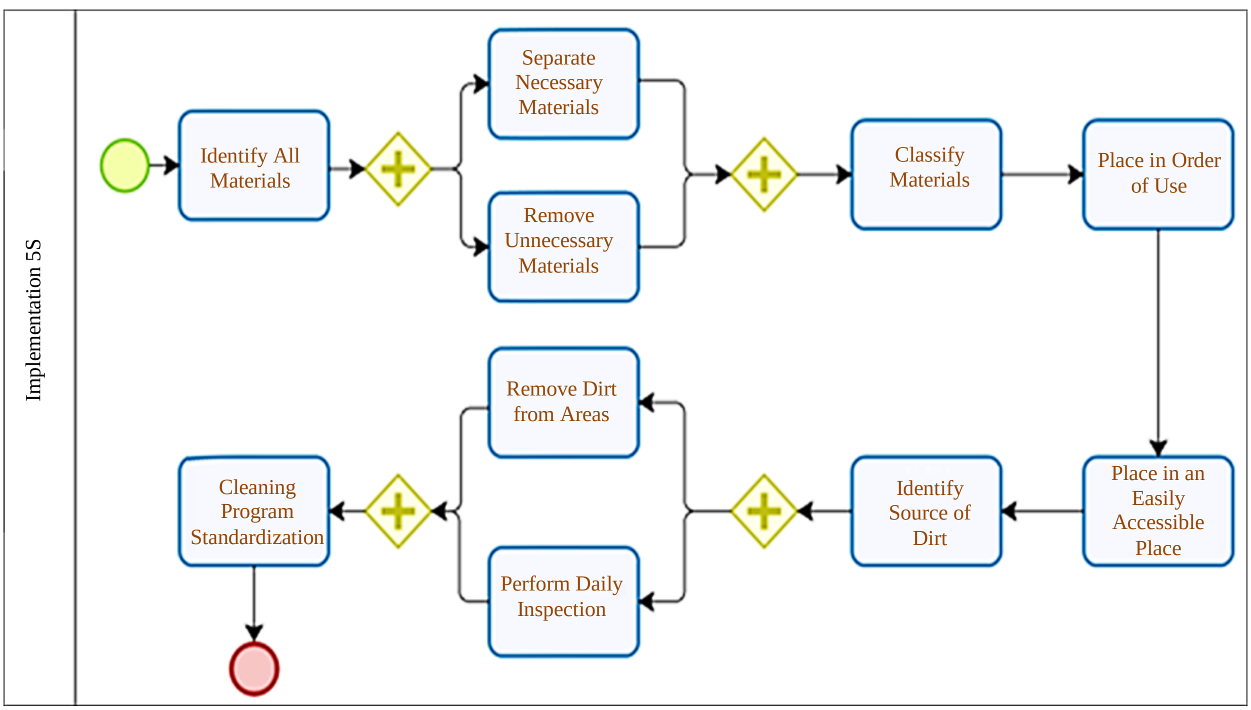

Fig. 4 5S implementation

5. VSM Implementation

5.1. Data Collection for VSM

The value-added time and NVA time of the overall textile industry processes are collected to create the current state VSM, and a time study for cycle time was conducted and shown in Table 1.

Cycle times for different processes with machine types are shown in Table 2. Value-added and NVA times for all the processes have been listed for current value stream mapping in Table 3.

5.2. TAKT Time

TAKT is the maximum time to produce the customer product at the right time. The industry rates 480 minutes per shift, including the 50-minute break, and there is only one shift per day; the customer demand is 7000 pieces of materials per 12 days. The available time and TAKT time are calculated.

Available time = 12 x [2 shift x {480 mins – 50 mins}]

Available time	= 24x 430 = 10320 mins
	= 6,19,200 secs
TAKT time	= Available time customer
Demand	= 6,19,200/7000
	= 88 secs per piece

5.3. Current State VSM

VSM is a lean technique used to analyse the current processes and to identify the NVA [32, 33]. The current VSM is developed using the input parameters such as total cycle time, customer demand, transporting time, forecast, inventory, and TAKT time are shown in Figure 5.

5.4. Finding Opportunities for Change

From the current state of VSM, unnecessary activities are identified. These NVA could be eradicated or minimised with the execution of lean techniques to enhance the overall production level of the industry. The suitable lean tools are layout optimisation, line balancing, 5S, Kaizen and visual management.

6. 5S Implementation

Creating and sustaining a well-organised, more efficient, productive, and efficient work can be done using five Japanese terms as in Figure 6.

6.1. Red

The tagging project is launched on the shop floor and carried out by developing places for clenching and planning for wasted disposal using the red tag form. The proper storage system is not allocated in fabric and cone hold, which leads to high search time and confusion in the production order; to avoid confusion in the production area, the red tag concept is implemented and shown in Figure 7.

Table 1. Existing time study

Process	T1 (sec)	T2 (sec)	T3 (sec)	T4 (sec)	T5 (sec)	Average Cycle Time (sec)
Cutting	0.3	0.5	0.5	0.4	0.3	0.4
Body Match	9	10	10	8	9	9.3
Shoulder Joint	62	63	64	63	68	64
Sleeve Joint	22	21	20	19	18	20
Side Seam	38	36	35	34	32	35
Neck Rib Attach	8	9	10	10	9	9.3
Neck Folding	6	5	6	5	5	5.3
Neck Seiri Closing	55	57	57	56	60	57
BTM	35	36	38	38	28	35
Neck Single Needle	65	60	63	61	56	61
Peak	27	28	29	28	27	28
Checking	65	77	72	64	77	71
Ironing	50	52	53	50	55	52
Label Attach	20	22	22	23	23	22
Box Closing	2.2	2.5	2.3	2.3	2.7	2.4

Table 2. Current cycle time

Station No.	Processes	Machine	Cycle Time (seconds)
1	Cutting	Manual	0.4
2	Body Match	Manual	9.3
3	Shoulder Joint	o/l	64
4	Sleeve Joint	o/l	20
5	Side Seam	o/l	35
6	Neck Rib Attach	f/l	9.3
7	Neck Folding	snls	5.3
8	Neck Seiri Closing	f/l	57
9	BTM	f/l	35
10	Neck Single Needle	snls	61
11	Peak	Manual	28
12	Checking	Manual	71
13	Ironing	Manual	52
14	Label Attach	Manual	22
15	Box Closing	Manual	2.4

Table 3. Data for VSM

Process	VAT (sec)	NVAT (sec)	Total Cycle Time (sec)
Cutting	0.2	0.2	0.4
Body Match	5.4	3.9	9.3
Shoulder Joint	42	22	64
Sleeve Joint	13	7	20
Side Seam	19	16	35
Neck Rib Attach	6.4	2.9	9.3
Neck Folding	3.5	1.8	5.3
Neck Seiri Closing	50	7	57
BTM	31	4	35
Neck Single Needle	39	22	61
Peak	17	11	28
Checking	66	5	71
Ironing	46	6	52
Label Attach	12.4	9.6	22
Box Closing	0.7	1.7	2.4

Large files are thrown at different places, and it occupies unnecessary space. These files are not used frequently, so a separate rack is provided away from the operator's place, as shown in Figure 8.

Cotton threads and remaining materials are thrown on the floor, which makes the floor more dirty. Only four garbage are present in the existing state for 15 different garbage. 15 garbage are set at each operator's place, as shown in Figure 9.

Small-size garbage is placed so that the operator's work is not disturbed. The third S-Shine is now done, and thus higher visibility is attained. Operators must know their responsibilities, maintenance conditions and safe working conditions. Ironing, sewing and checking section workers are not following the standard procedure, resulting in inefficient work for the employee and company. The Plan-Do-Check-Act (PDCA) cycle was done inside the industry. Standard Operating Procedure (SOP), as in Figure 10 for three different sections, is made with the help of boards having images and in the local language for better understanding.

The PDCA cycle is implemented for the company authorities and operators to know whether the company follows all the 5S. This is the critical pillar of 5S to maintain the 5S system. A checklist is shown in Figure 11 with the list of the daily activities to attain the fifth S-Sustain.

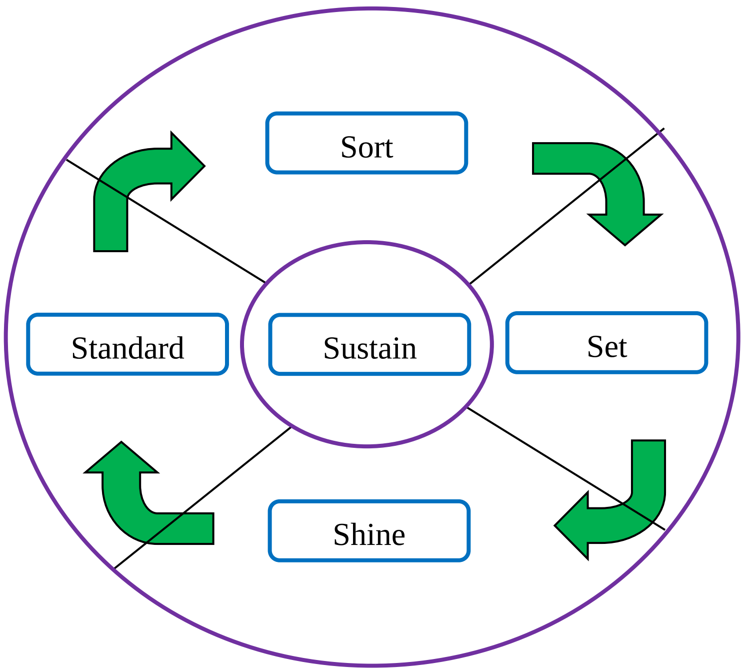

Fig. 6 5S terms

Fig. 7 Red tag implementation

Fig. 8 Set in order

Fig. 9 Shine

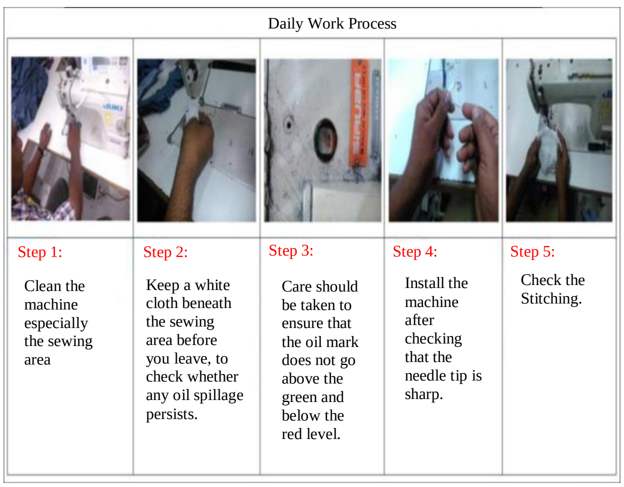

Fig. 10 Standard operating procedure

Fig. 11 Sustain

7. Layout Optimisation

7.1. Current Layout

The current layout has 15 stations, and it is shown with operator movement as a spaghetti diagram in Figure 12. The net cycle time and operator movement for the current layout are collected and shown in Table 4.

7.2. Proposed Layout

The proposed layout has 15 stations as same. Rearrangement of machines is done to reduce operator movement, and it is shown with operator movement in Figure 13 for better understanding. The total cycle time and operator movement for the optimised layout is tabulated in Table 5. By implementing the proposed layout, a firm can reduce cycle time from 472 seconds to 438 seconds, and operator movement for the industry is reduced from 153 feet to 117 feet.

8. Results and Discussion

8.1. Line Balancing

The line balancing tool balances the operator's assignment to reduce WIP between stations.

8.2. Before Line Balancing

The textile industry currently has 15 stations. Yamazumi chart is created to know the workload between operators, and it is shown in Figure 14.

8.3. Efficiency of Line

The line efficiency for the current stations is calculated from the layout.

Line Efficiency (%) = Net Operating Time (Total Work Stations X TAKT Time)
= 472 / (15 x 88)
= 0.3575 x 100 = 35.75%

8.4. Precedence Diagram

The precedence diagram shows the sequential task and relationships among stations in Figure 15. Based on the precedence diagram, stations A-B-C, D-E-F-G and M-N-O are clubbed into single stations respectively and balanced by dividing the job among every worker, and it is reduced to 8 stations.

8.5. After Line Balancing

The unbalanced line with 15 stations and the balanced line with eight stations having different operation times are shown in Table 6. After the line is balanced, the chart is created to determine the operators' workload, as shown in Figure 16.

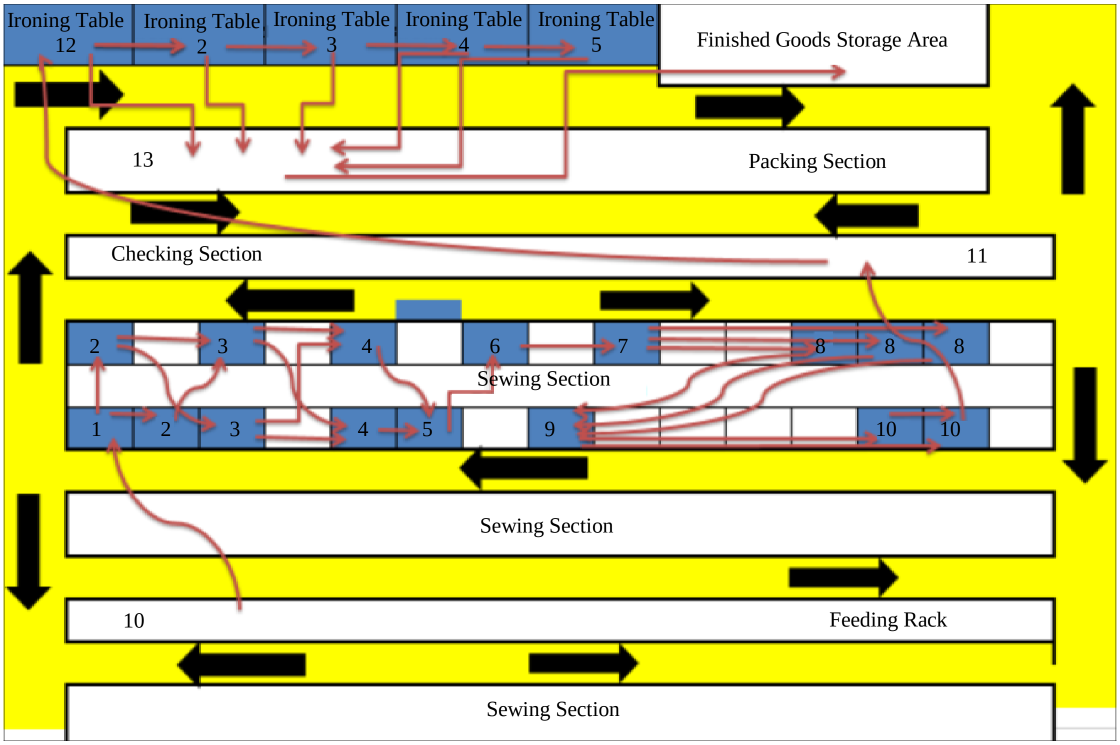

Fig. 12 Current layout

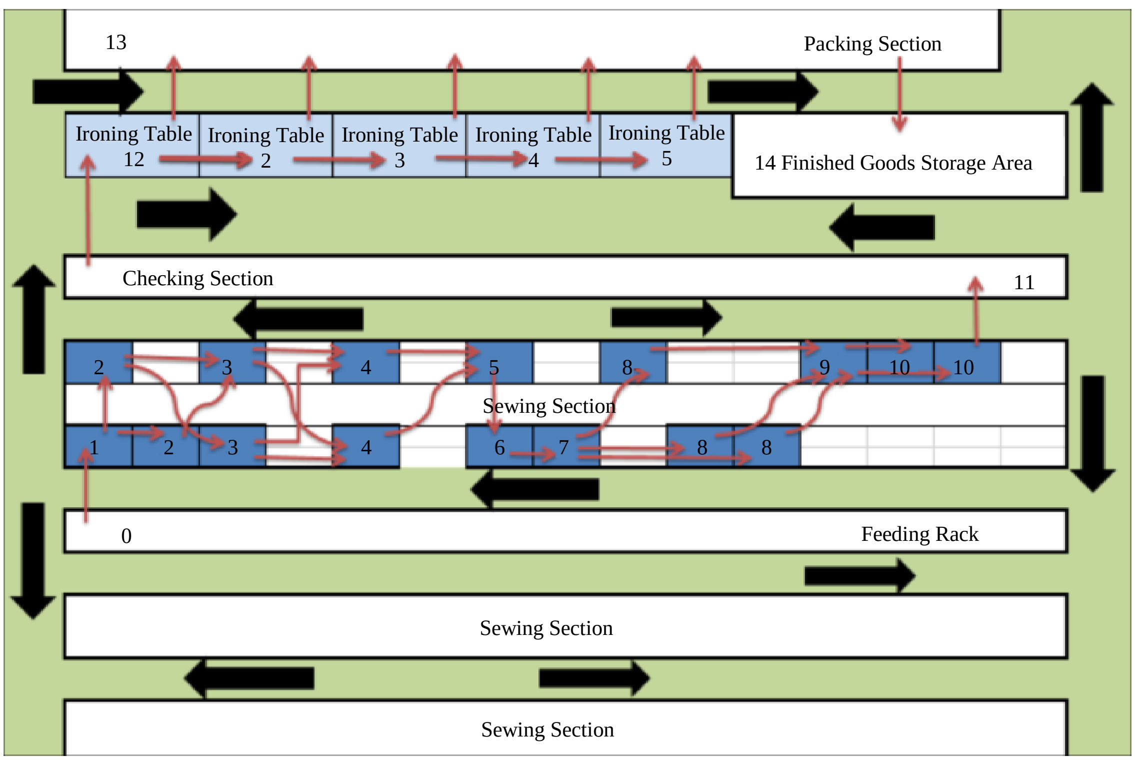

Fig. 13 Proposal layout

Table 4. Data collected for the current layout

Parameters	Value
Value Added time (sec)	352
Non-Value Added time (sec)	120
Total Cycle Time (sec)	472
Operator Movement (feet)	153

Table 5. Data collected for the proposed layout

Parameters	Value
Value Added time (sec)	352
Non-Value Added time (sec)	86
Total Cycle Time (sec)	438
Operator Movement (feet)	117

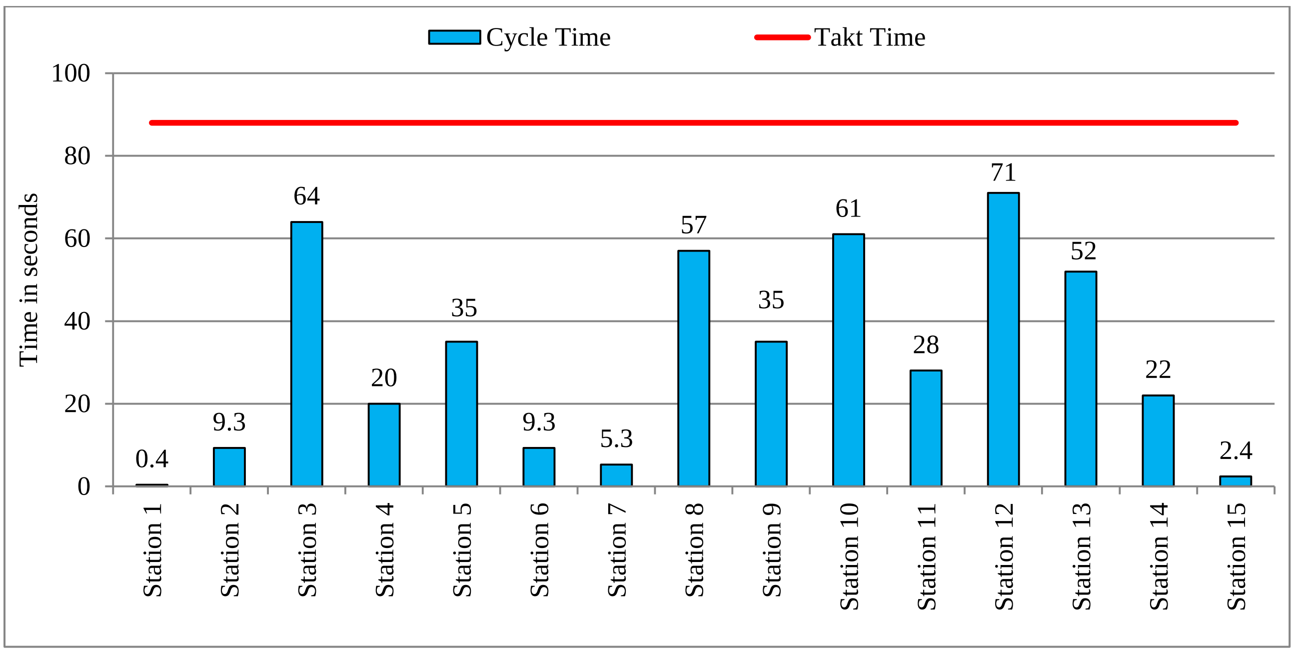

Fig. 14 Yamazumi chart before line balancing

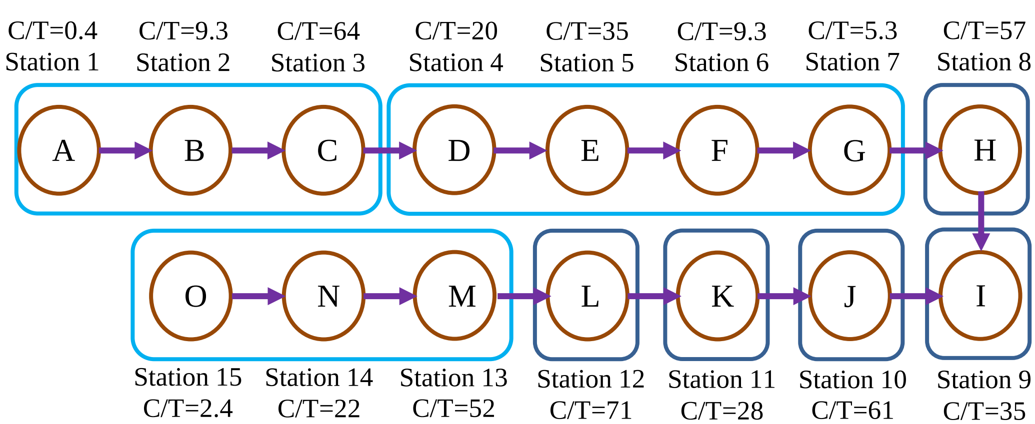

Fig. 15 Precedence diagram

Table 6. Operation time for each station after balancing

Station No.	Processes	Cycle Time (seconds)	Cycle Time after Balancing (seconds)
1	Cutting	0.4	52.6
2	Body Match	7.9	44.9
3	Shoulder Joint	57.0	62
4	Sleeve Joint	17.0	36
5	Side Seam	29.0	42
6	Neck Rib Attach	8.2	20
7	Neck Folding	4.5	71.1
8	Neck Seiri Closing	54.8	70.1
9	BTM	33.8	36
10	Neck Single Needle	58.0	42
11	Peak	24.0	20
12	Checking	70.0	71.1
13	Ironing	50.0	50
14	Label Attach	21.0	19
15	Box Closing	2.4	1.1

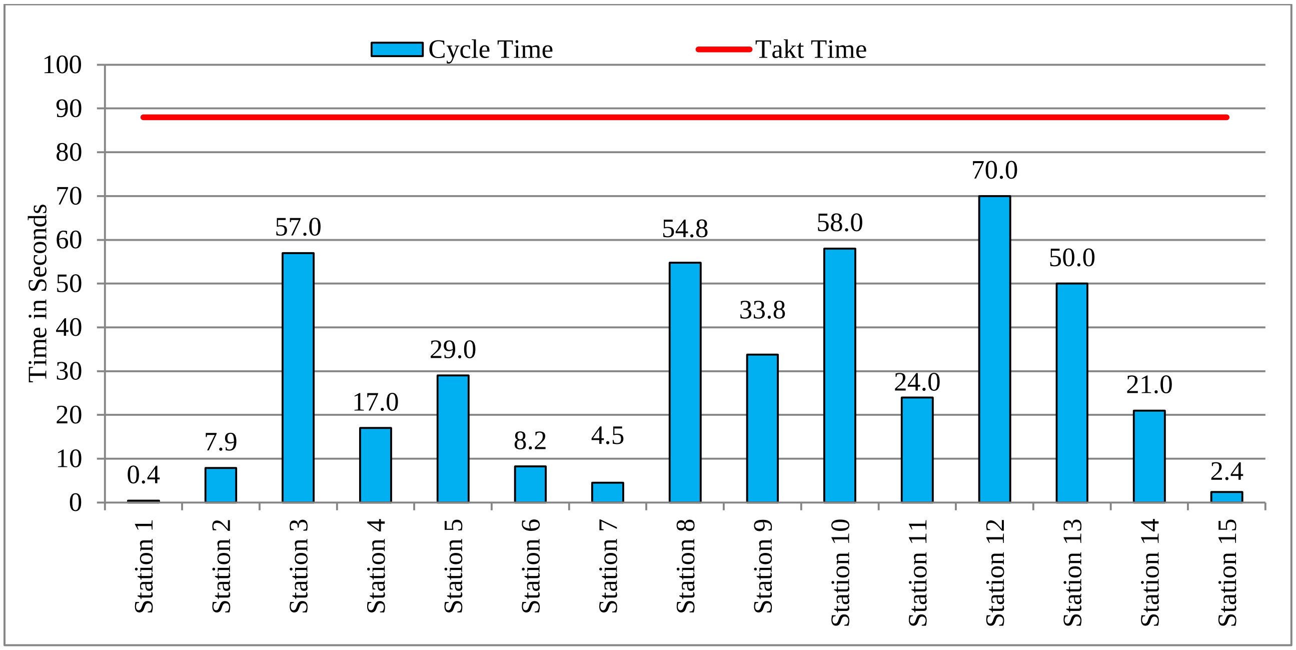

Fig. 16 Yamazumi chart after line balancing

8.6. Line Efficiency

The line efficiency is balanced after proper line balancing.

Efficiency of line (%) = Net operating time (Total work stations x TAKT time)

Efficiency of line (%) = 472 / (8 x 88)

= 0.6705 x 100 = 67.05 %

By balancing the line, a firm can reduce the workstation from 15 to 8 and increase the line's efficiency from 36% to 67%.

9. Kaizen

Kaizen means the removal of non-value-added activities by making minor continuous improvements. Kaizen tools are used to identify and increase performance. Many companies seek continuous improvement to increase their productivity and quality of products at the lowest cost [34, 35].

9.1. Production System

An organisation's production system produces parts based on customer demand. The production system transforms various inputs into valuable outputs. A batch production system is followed in the industry, leading to an increase in WIP inventory, waiting time and downtime.

The defective parts for rework have been identified at the end of each batch, increasing the lead time. The batch production system is converted into a line to the system in order to resolve the existing problems. The batch production of the textile industry is shown in Figure 17.

Line production is a set of sequential operations established in an organisation where materials move from one station to another to produce an end product. Line production, shown in Figure 18, reduces the rework of materials and increases productivity. There will be no size mix-ups, so the cycle time will also be reduced. Work in Progress also gets reduced by this implementation.

9.2. End Line Checking

Keeping the diverse requirements of clients in mind, the quality of the product should be checked and verified. Inspecting the materials at the checking section takes much time, and sending them to the required rework station. So, line checking is implemented to check the materials at the end of working stations, as shown in Figure 19, and it can be given to rework stations easily.

10. Visual Management

To visually communicate expectations, performance, standards or warnings that require no training is called visual management. Six categories of visual management are there to allow an increase in standards, quality and performance. It starts from simple communication of facts to visual controls to prevent errors from happening.

10.1. Hourly Production Board

Hourly production board helps find abnormalities that do not allow achieving the target. It helps to compare the production hour rate and each operation's target rate. From the difference between actual and target time, reasons for the low productivity can be found. The hourly production board is shown in Figure 20 and is implemented, allowing the workers to meet their target, resulting in more productivity.

10.2. Colour Coding System

Colour codes eliminate time spent searching for information and increase organisational productivity. 5S, process and safety are distinct types of colour code standards. Sizes of different materials are written on paper and stuck on the material, and it takes time to search for the information. So, the colour coding system Figure 21 is implemented, and different colour papers are stuck for different sizes of materials.

11. Future State VSM

The current layout is optimised, and the workload is balanced. After the implementation of line balancing, the future state VSM is constructed and is shown in Figure 22. It shows that the total cycle time is reduced from 472 seconds to 438 seconds. The following results were achieved.

The productivity of the textile industry has increased by 4.84%, as shown in Figure 23.

Productivity = Actual Output / Planned Output
= 5231/7000
= 74.27%
Productivity after Lean Implementation = 5538/7000
= 79.11%

Fig. 17 Batch production system

Fig. 18 Batch production system

Fig. 19 End-line checking

Fig. 20 Hourly production board

Fig. 21 Color coding system

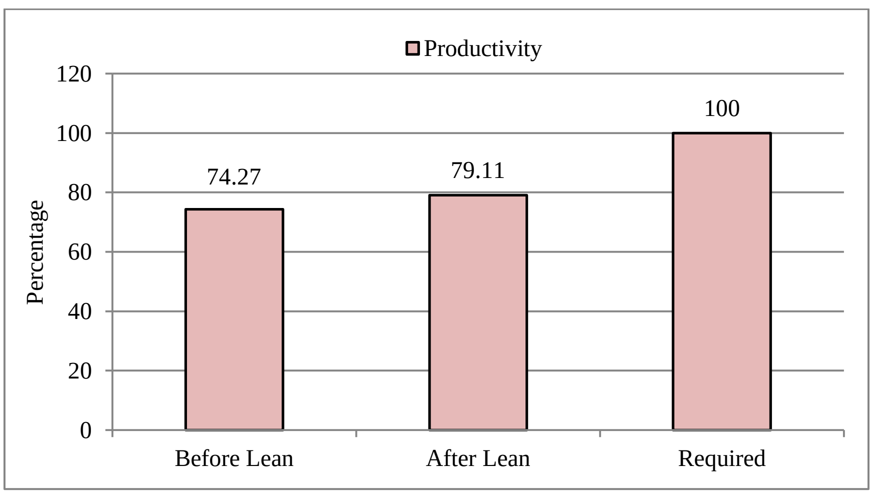

Fig. 23 Productivity chart

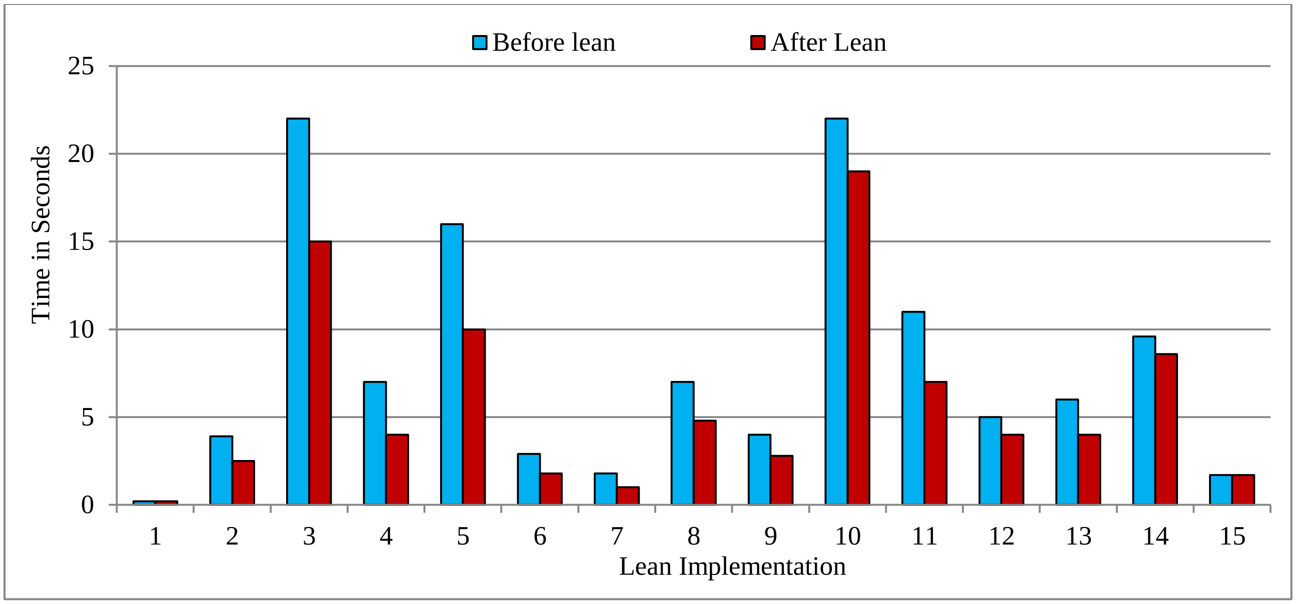

Fig. 24 NVA comparison chart

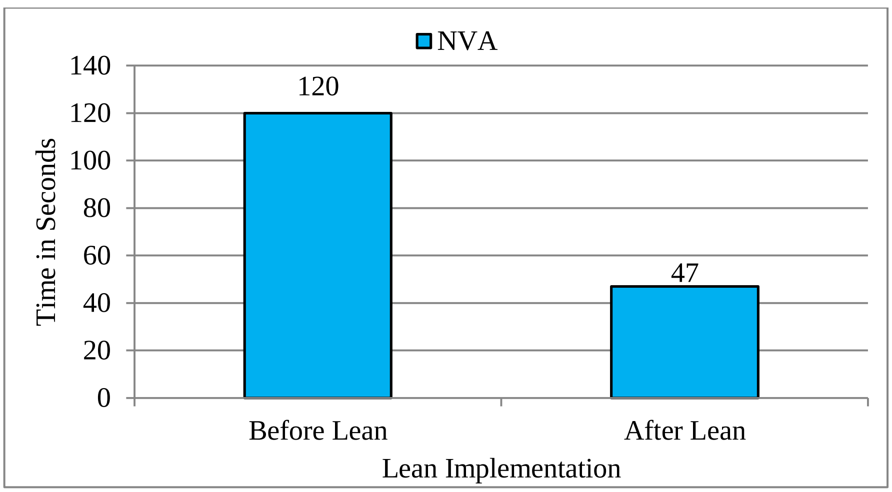

Fig. 25 NVA overall comparison

Figure 24 explains non-value-added activity time before and after each station's implementation. Figure 25 explains before and after implementation of non-value-added activity for overall stations.

Reduction of NVA = (120-47)/120
= 0.6083 x 100
= 60.83 %

12. Conclusion

Lean tool execution in the textile industry was carried out with a proposed model by identifying the research gap. The critical NVA activities were identified with the current state of VSM. Opportunities for improvement have been identified, and future state VSM was constructed. 5S implemented with a lot of space and time-saving.

A spaghetti diagram was created for the current layout and optimised. The workload was equally divided among the operators in the line. Continuous improvements have been attained in the industry. Visual management was implemented for better communication through displays. Solutions to enhance productivity have been identified and implemented.

- From the final observed results, we conclude that the total reduction of NVA is about 60.83%.
- By implementing the proposed layout, a firm can reduce cycle time from 472 seconds to 438 seconds.
- After proper layout, the operator movement for the industry was reduced from 153 feet to 117 feet.
- The overall productivity of the textile industry was increased by 4.84%.

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Appendix

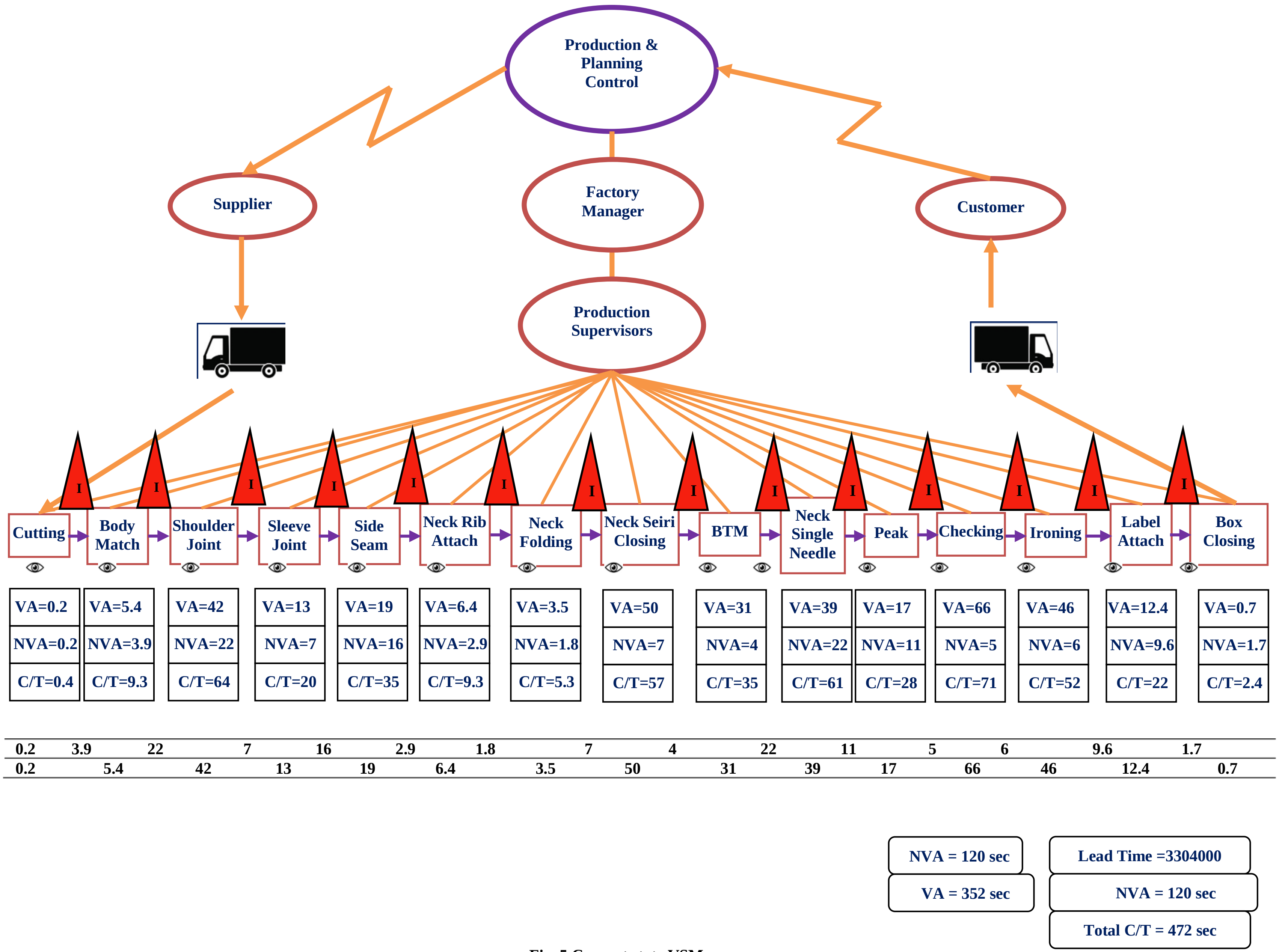

Fig. 5 Current state VSM

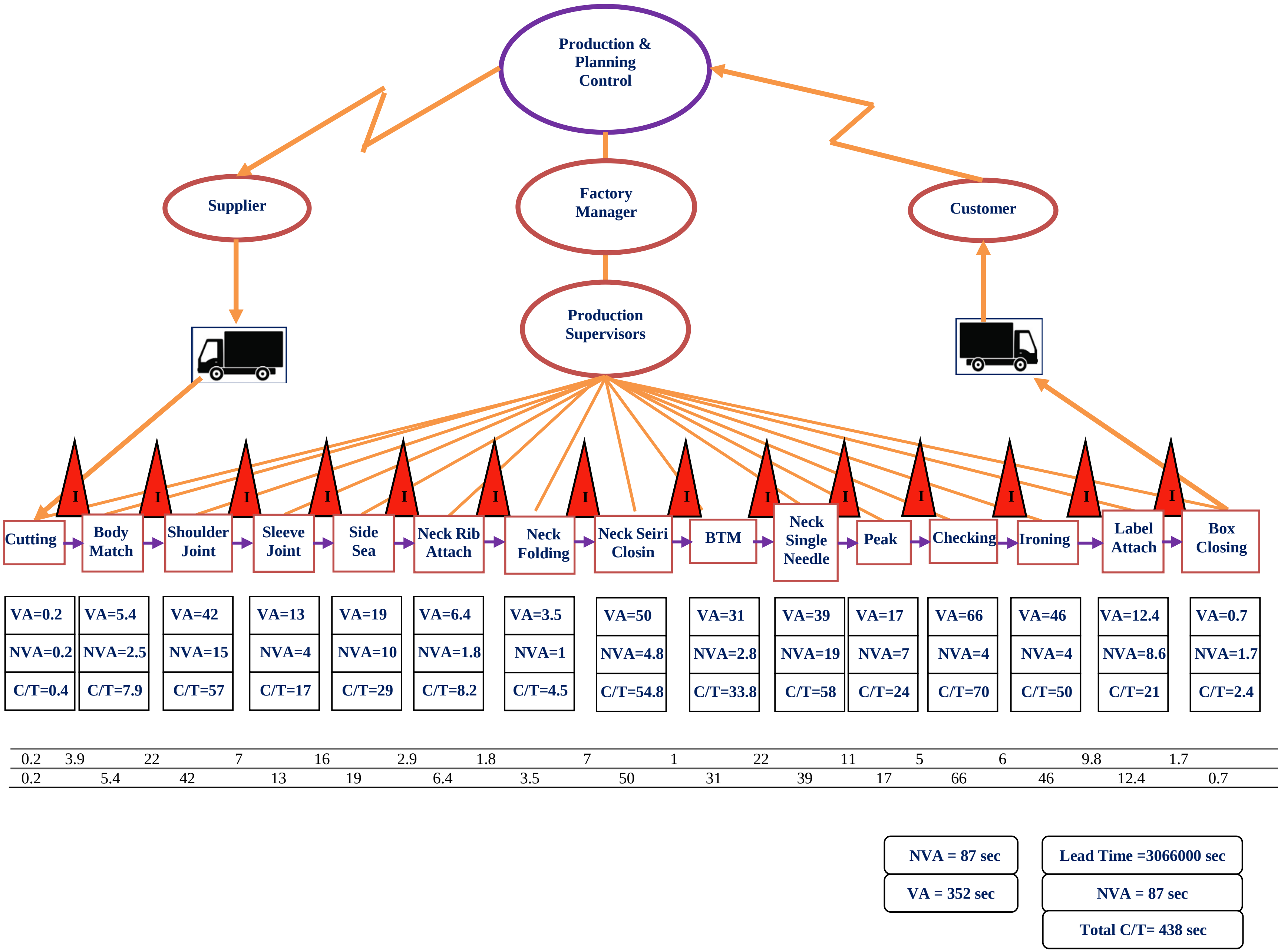

Fig. 22 Future state VSM