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RESEARCH ARTICLE

IMPACT OF LEAN MANUFACTURING ON PRODUCTIVITY AND LAYOUT DESIGN IN SEWING SECTION OF A GARMENT INDUSTRY

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ABSTRACT - The adoption of lean manufacturing as a method for enhancing productivity that led to the reduction of waste and uniformity of cycle time is the subject of this research. In the fast-paced, dynamic, and ever-changing global economy, many businesses are employing the lean manufacturing approach to remove waste, improve processes, save costs, enhance innovation, and decrease time to market. Lean manufacturing is especially appropriate in Bangladesh because many Bangladeshi private garments manufacturing companies are operating below their actual capacity, or undergo late deliveries, due to problems with their traditional production systems and a lack of skilled personnel. A basic full-sleeve t-shirt sewing line was the focus in the study. Non-value-added activities such as a large number of work-in-process (WIP), unnecessary transportation, and product defects due to poor 5S (Sort, Shine, Set in Order, Sustain, Standardize) and lack of traffic light system (TLS) were observed. Researchers also noticed the indifference of the workers. They used time study, line target, process flow mapping, theoretically machine requirement, and line efficiency to assess conventional line productivity. After implementing lean techniques (5S, line balancing, just-in-time), the standard time was obtained using process flow and cycle time analysis. Thus, non-value-added tasks are reduced, resulting in an improvement in production. They compared the previous production line with the lean-implemented production line and they noticed a lot of changes. Results showed that, after lean implementation, SMV is decreased by 0.9 minutes, production is increased by 1,664 pieces per month, the number of workers is decreased by 2 (two) persons, alter percentages is reduced to 4%, spot quantity is reduced to 1.80%, the rejection rate is reduced to 0.68%, WIP is decreased by 7 (seven) pieces, 69.08% efficiency is achieved. Lean manufacturing brought about great improvements in the sewing sector by establishing a standard minute value, a smooth process flow, and productive operations, which made a significant contribution to the achievement of production targets. In this way, lean manufacturing tools and practices can change the overall scenery of a traditional sewing section of the garment industry. This paper gives the whole feasibility assessment for implementing lean manufacturing in the garment manufacturing process.

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1.0 INTRODUCTION

It is challenging to maintain a presence in the global market due to the garment industry's high production costs and product mix diversity. So, it is indispensable to minimize the production cost besides increasing productivity. Every garment manufacturer requires higher productivity with the least manufacturing cost. Lean is an extensively discussed term in ready-made garments (RMG) industries where the vision is aimed to increase production. Lean manufacturing is a production method that aims to maximize productivity while decreasing waste in a manufacturing operation. According to the lean concept, waste is defined as everything that does not bring value and for which customers are unwilling to pay. Being a labor-intensive assembly plant, RMG has a great deal to gain from embracing lean manufacturing in terms of output, worker conditions, and productivity. Lean is a concept based on 'The Toyota Production System (TPS),' which has its roots in the Japanese industrial system (Liker, 2021; Ohno & Bodek, 2019; Spear et al., 1999). Reducing or optimizing customer, internal variability and supplier to eliminate waste is the main objective of lean (Shah & Ward, 2007). It raises a higher degree of participation of the employees working in production and also helps in the continuous elimination of waste. The non-value-added process is also reduced during production (Hasle et al., 2012). The theoretical definition was analyzed by a few authors with a survey of the manufacturing industry in which lean practices were applied by sorting out ten key methods: just-in-time (JIT) delivery, supplier feedback, developing suppliers, pull, involved customers, set-up time, flow, total product maintenance (TPM), controlled processes, and involved employees. In the automotive industry when it had its first application, lean also has some controversial consequences in manufacturing

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processes. Lean directly deals with the changes in the working place, the working condition of employees is the main concern. By minimizing waste, lean would enhance workflow, strengthen management, and boost profits (Hasle, 2014).

2.0 LITERATURE REVIEW

Many journal articles in various databases discuss the use of lean tools in multiple industries, including the healthcare industry, manufacturing industry, financial industry, education industry, textile industry, and so on (Singh & Rathi, 2019). The integration of several lean technologies, such as 5S, line balancing, standard work, and value stream mapping (VSM), leads in an increase in labour intensity and equipment flexibility, hence increasing productivity. It was discovered that the use of process mapping might result in considerable gains for businesses of any size (Grewal, 2008). Techniques such as time and motion studies, process mapping, line balancing, and lean manufacturing are gaining more and more popularity to increase productivity in the textile and apparel sectors (Iftikhar et al., 2022). To enhance productivity, a study of the seven lean manufacturing wastes which includes overproduction, waiting, transportation, incorrect processing, needless inventory, and wasteful motion, was carried out. In order to boost efficiency and cut down on waste, lean principles were suggested for use in the textile industry (Khan et al., 2020). Chan & Tay (2018) conducted a study that analyzed the advantages and applicability of lean manufacturing strategies from the perspectives of eight (8) distinct assembly and production lines across a variety of sectors. Nunesca and Amorado (2015) explored the usage and use of lean tools as methods for optimizing production processes that lead to waste reduction and cycle time standardization. Lean tools brought about substantial improvements in providing a smooth process flow and productive operations, which in turn make a tremendous contribution to accomplishing the company's objectives, focusing on the customer, and delivering quality goods at the correct time and place (Nunesca & Amorado, 2015).

Shakib et al. (2014) discovered that facility layout was the arrangement of machines, storage places, and work areas within the limitations of a physical building in order to maximize the production rate. It has been predicted that 20% to 40% of production costs may be reduced by arranging machines, storage rooms, and work areas well. By establishing a suitable layout, it is possible to avoid bottlenecks in moving people or materials, minimize material handling costs, limit risks to workers, maximize labor efficiency, reduce idle time, use available space effectively and efficiently, and give flexibility (Shakib et al., 2014).

The garment industry is a traditional industry that faces worldwide competition. Designing/creating clothing patterns, cutting, sewing, and packaging are the four major elements of the garment production process. The sewing step is the most challenging phase since it requires the completion of a large number of activities. The sewing line is equipped with a series of workstations, each of which processes a distinct operation in accordance with a predetermined order. It is observed that the condition of the sewing floor is in haphazard situation. There are so many WIP inventories between the operators and the output is quite less than the input. Precise work distribution is not maintained by the operators. Materials used travel long distances. The quality is not controlled by the line supervisors as they are not strict enough. Non-value-added time is increased because of total completion time is delayed by the workers' reworks. So, a smooth streamlined, and continuous process flow is required to avoid all such unwanted occurrences. Therefore, the prime objectives of this study are to identify various types of waste that exist in the sewing section and remove them, to increase production, to increase the line efficiency, to reduce the SMV, to maintain the workflow in the sewing section, to reduce excess motion of labors, to reduce the defects in sewing line, and to minimize the WIP inventory.

3.0 METHODOLOGY

This study's primary objective is to determine how lean manufacturing strategies affect production and layout design. In order to investigate the effect, the researcher classified the concerned sewing line of the industry as a conventional and lean line. Then, lean tools were applied in the lean line and the necessary data for both lines were recorded. For this process time study, SMV calculation, line target, theoretically machine requirement and line efficiency were used. The study consists of a detailed process flow mapping and time study of the existing production system of full sleeve t-shirt manufacturing line and an analysis of the main cause which increases non-value added time in the present system. Afterward, some of the suitable lean tools and techniques to adopt were checked and the new layout was proposed.

Time study: Time study is a way of assessing labor that involves using a stopwatch to record the times of doing a certain activity or its components under specified conditions. The operator does the same duty throughout the day. Time studies aid in determining the amount of time required for an operator to complete a task at a certain rate of performance.

<u>Calculation of Standard Time or SMV:</u> SMV is defined as the time allowed to accomplish a task successfully. Typically, the value is stated in minutes. Standard Minute Value is the comprehensive explanation of SMV. SMV is a common phrase in the apparel manufacturing sector. Standard Allocated Minute is another name for the acronym SMV. For an export order to be shipped efficiently and on schedule, a merchandiser must ensure that the SMV setup on the garment factory floor is adequate.

SMV or SAM or Standard minute,

= Normal or Basic time + Allowance%

={Cycle time(sec) x Performance rating %}/60+Allowance %

Line Target / Hour: Line target per hour can be calculated by dividing available minutes in hour by SMV. The formula of Line target per hour given below,

$$\text{Line target /hour} = \frac{\text{Manpower} \times 60}{SMV}$$

Theoretically Machine Requirement: Using the procedures below, we may estimate the number and types of machines required to produce a garment in an assembly line. The formula for calculating theoretical machine requirement,

$$\text{Theoretically machine requirement} = \frac{\text{Target quantity in pieces} \times \text{SMV}}{\text{Working hour} \times 60 \times \text{ desired efficiency}}$$

Line Efficiency: Like the efficiency of individual operators, the efficiency of a production line, batch, or division is essential to a plant. Daily line efficiency reveals the performance of the line. The formula for calculating line efficiency:

$$\text{Line efficiency} = \frac{\text{SMV} \times \text{Production} \times 100}{\text{Man power} \times \text{Working hour} \times 60}$$

3.1 Research instrument

A basic full-sleeve t-shirt was the targeted material for the experiment. Cycle time observation form, process flow chart, product inspection report, and 5S audit checklist were the primary instruments used to achieve the objectives. These data and information were used in the further development of the study. Stopwatch, calculator, and laptop were also used as equipment for data collection and analysis.

3.2 Application of lean tools

Few lean tools such as 5S, Line balancing, JIT, and TLS were used for the experiment and analysis.

4.0 DATA COLLECTION AND ANALYSIS

4.1 Conventional line's process flow

Figure 1 shows the conventional line's process flow, which has been designed with the support of necessary data collected from the sewing floor of the garment industry. Here, every sewing operation to make a full-sleeve t-shirt has been shown with respective operating times (in minutes). It is seen that a total of nineteen operations have been performed by the operator. The sequence of the operation is very important for making a complete full-sleeve t-shirt. These sequences can be modified to design a new sewing line.

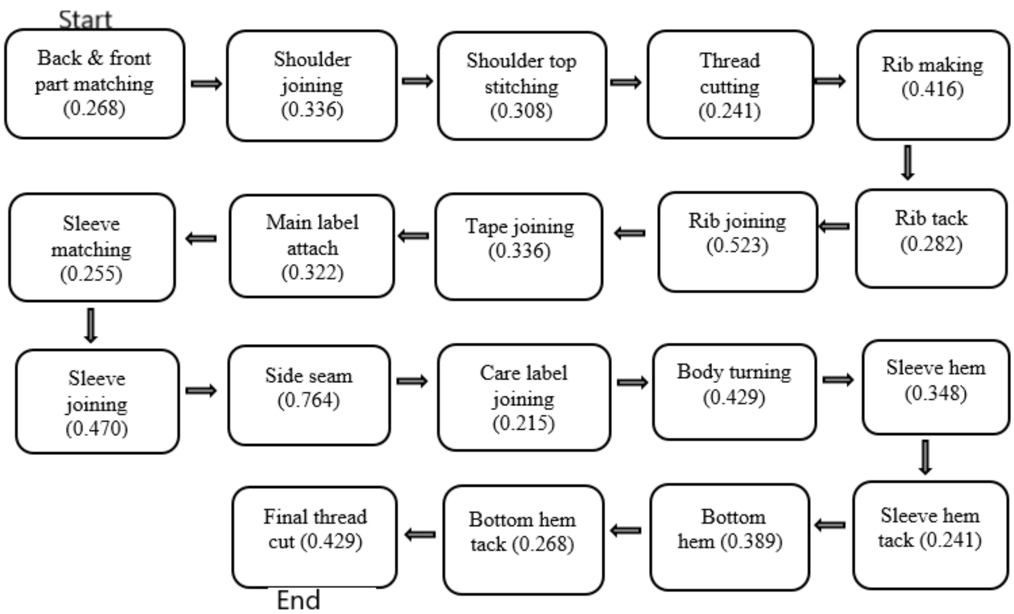

Figure 1. Process flow of conventional line with SMV

4.2 SMV for each operation

Table 1 shows the SMV for a total of 19 (nineteen) operations. Each operation in the conventional line and the lean line is collected by the time study given below.

Table 1. The SMV for each operation in conventional line and lean line.

Sl. no.	Operations	Conventional line SMV (in min)	Lean line SMV (in min)
1	Back and front part matching	0.268	0.241
2	Shoulder joining	0.336	0.281
3	Shoulder top stitching	0.308	0.295
4	Thread cutting	0.241	0.174
5	Rib making	0.416	0.389
6	Rib tack	0.282	0.241
7	Rib joining	0.523	0.493
8	Tape joining	0.336	0.308
9	Main label attach	0.322	0.281
10	Sleeve matching with body	0.255	0.228
11	Sleeve joining	0.470	0.429
12	Side seam	0.764	0.694
13	Care label joining	0.215	0.161
14	Body turning	0.429	0.279
15	Sleeve hem	0.348	0.281
16	Sleeve hem tack	0.241	0.214
17	Bottom hem	0.389	0.362
18	Bottom hem tack	0.268	0.241
19	Final thread cut	0.429	0.348
Total SMV		6.840	5.940

4.3 Traditional line layout

Figure 2 shows the layout that has been developed with the help of collected data from the swing floor and respective officials. It is found that total 19 operations have been done by 23 operators and helpers for making a full-sleeve t-shirt. In this layout, operation 7 and 11 performed by 2 operators and operation 12 is performed by 3 operators.

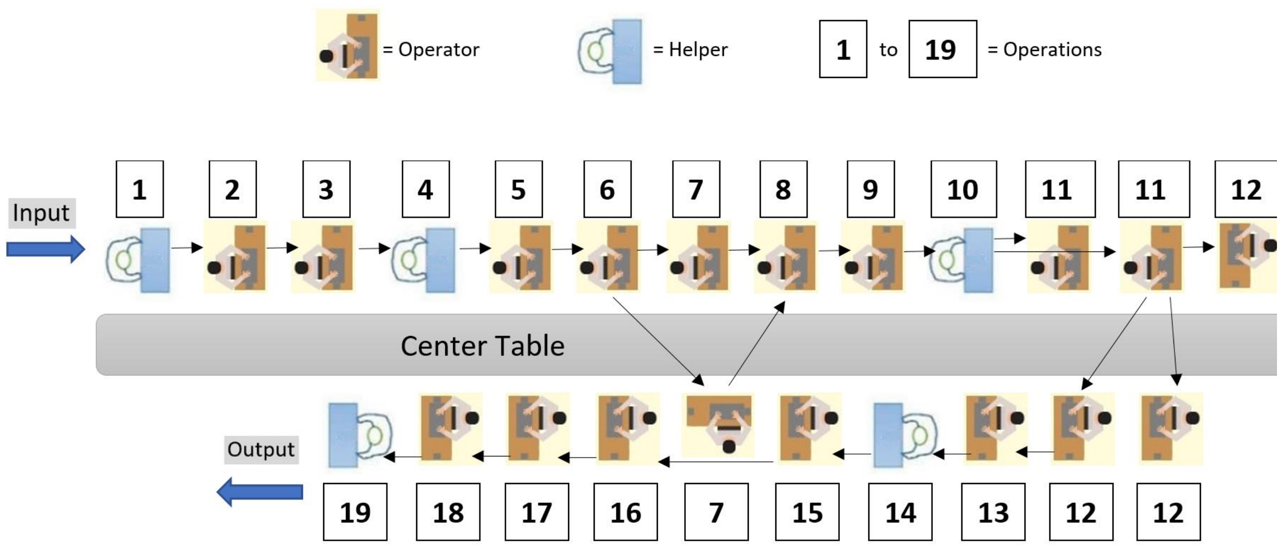

Figure 2. Layout of traditional line

5.0 RESULTS AND DISCUSSIONS

Collected data between the conventional line and lean line for the experimental item full sleeve t-shirt was observed. Firstly, capacity in both lines was calculated. Therefore, the following difference was identified between the conventional line and the lean line.

5.1 Comparison between SMV

Figure 3 shows the comparison of SMV between conventional line and lean line. It is seen that conventional line's SMV is 6.84 and lean line's SMV is 5.94. Reducing non-value added activities, unwanted movement between operators, waiting time for work and transportation time SMV decreased by 0.9 minutes.

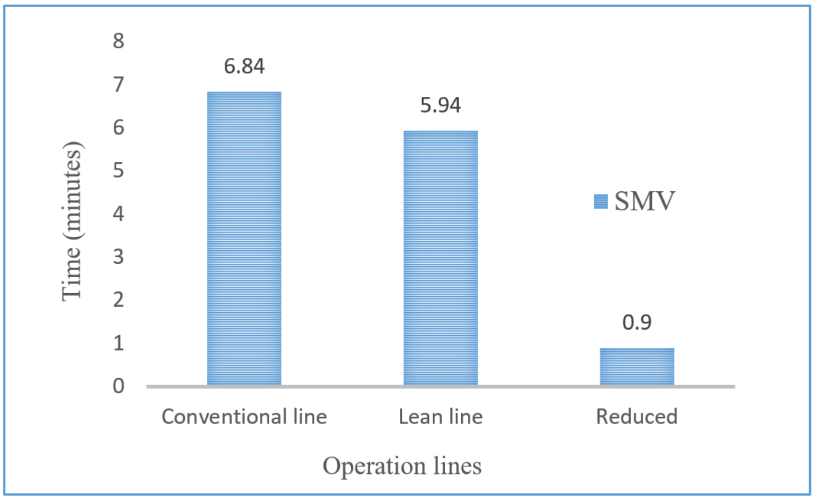

Figure 3. Comparison of SMV between conventional line and lean line

5.2 Comparison between production

Figure 4 shows the comparison of production quantity between the conventional line and the lean line. It is seen that the production per month in the conventional line is 29,328 pieces and in the lean line is 30,992 pieces. Decreased SMV as well as the implementation of lean tools- line balancing, JIT, and 5S has increased production by 1,664 pieces per month.

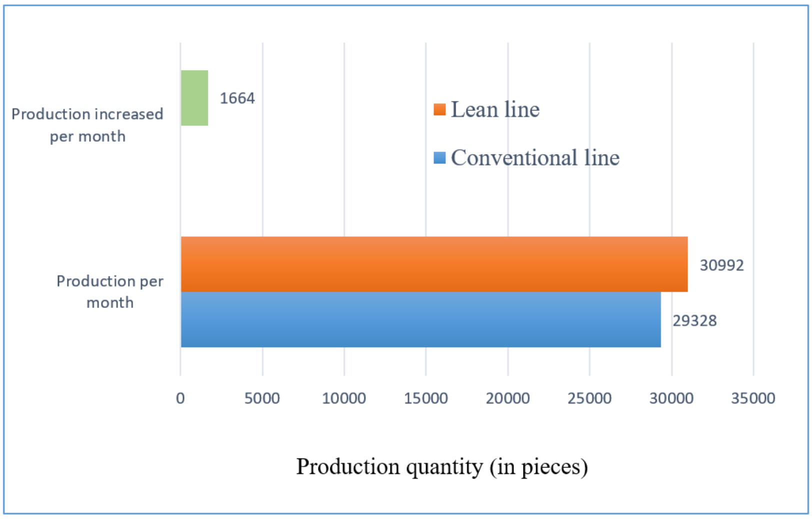

Figure 4. Comparison of production quantity between conventional line and lean line

5.3 Comparison between manpower requirement

Figure 5 shows the comparison of manpower requirements between the conventional line and the lean line. It is seen that the manpower (no. of workers) requirement in the conventional line is 23 and in the lean line is 21. With capacity study and the implementation of line balancing, researchers analyzed that 21 workers are enough to achieve the line target.

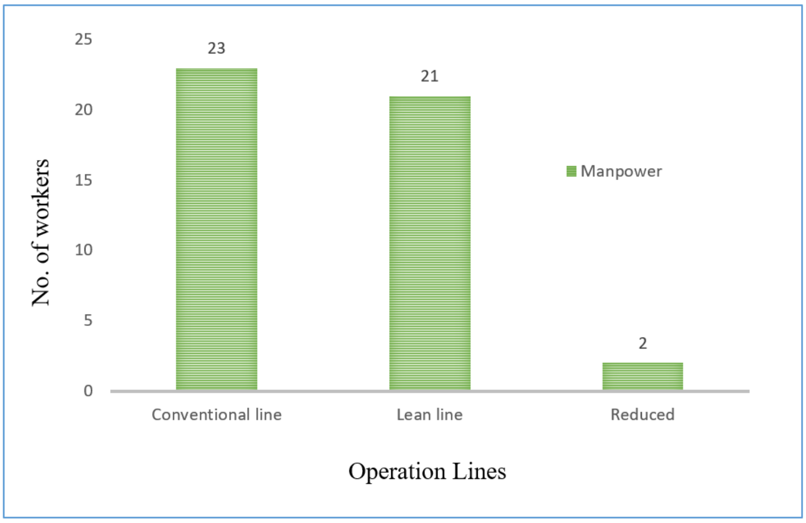

Figure 5. Comparison of manpower requirement between conventional line and lean line

5.4 Comparison between rework quantity

Figure 6 shows a comparison of rework quantity between the conventional line and the lean line. The altered quantity in the lean line was reduced by a significant number by the application of the Traffic Light System. It is seen that alter quantity in the conventional line is 54 pieces and alter percentage is 5.02%. After applying Traffic Light System in the lean line, the altered quantity was reduced to 47 pieces and alter percentage to 4%.

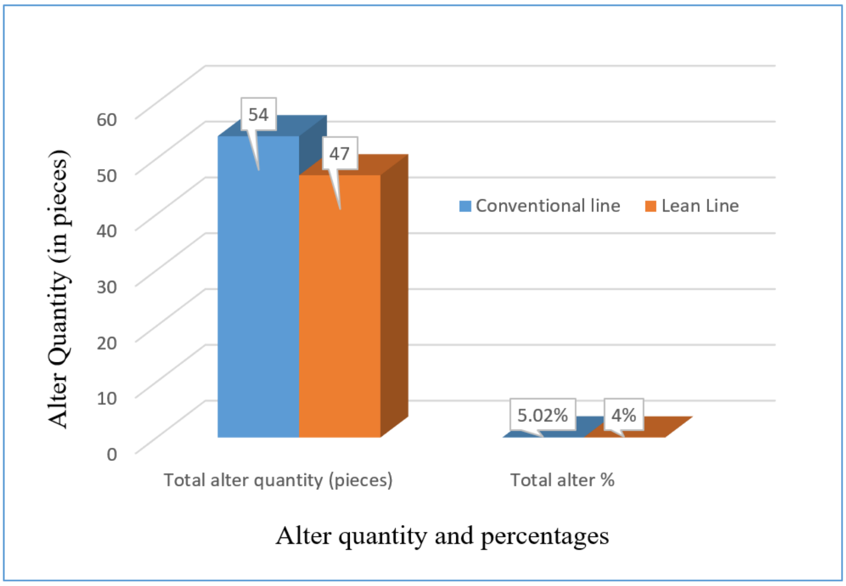

Figure 6. Comparison of rework quantity between conventional line and lean line

5.5 Comparison between spot quantity

Figure 7 shows the comparison of spot quantity between the conventional line and the lean line. The spot quantity in the lean line was reduced by a great number by the application of the 5S system. It is seen that the spot quantity in the conventional line is 44 pieces and the spot percentage is 3.77%. After applying 5S System in the lean line, the spot quantity was reduced to 21 pieces and the spot percentage to 1.80%.

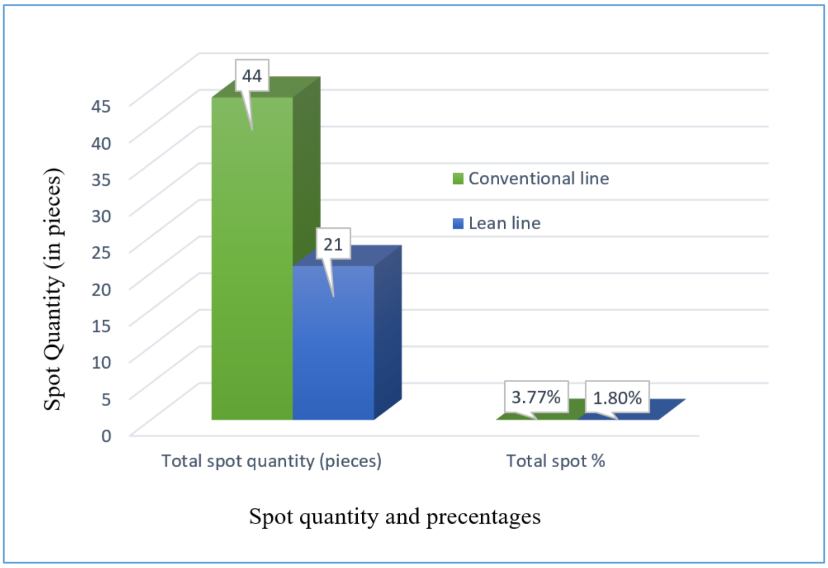

Figure 7. Comparison of spot quantity between conventional line and lean line

5.6 Comparison between rejection quantity

Figure 8 shows the comparison of reject quantity between the conventional line and the lean line. Motivation, rewards, and the 5S system reduced rejection quantity to the large extent in the lean line. In the conventional line, the rejected quantity is 15 pieces and the reject percentage is 1.41%. On the other hand, in the lean line the rejected quantity is reduced to 9 pieces, and reject percentage is 0.68%.

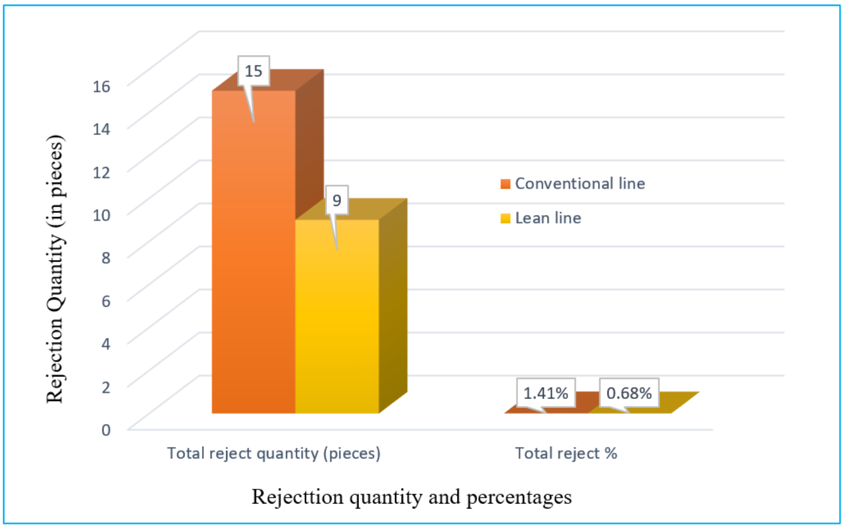

Figure 8. Comparison of reject quantity between conventional line and lean line

5.7 Comparison between average WIP quantity

Figure 9 shows the comparison of average WIP quantity between the conventional line and lean line. The average WIP quantity in the lean line was reduced by a great number by the application of the lean tool JIT. It is seen that the average WIP quantity in the conventional line is 10 pieces and in the lean implemented line is 3 pieces. Therefore, 7 (seven) pieces were reduced.

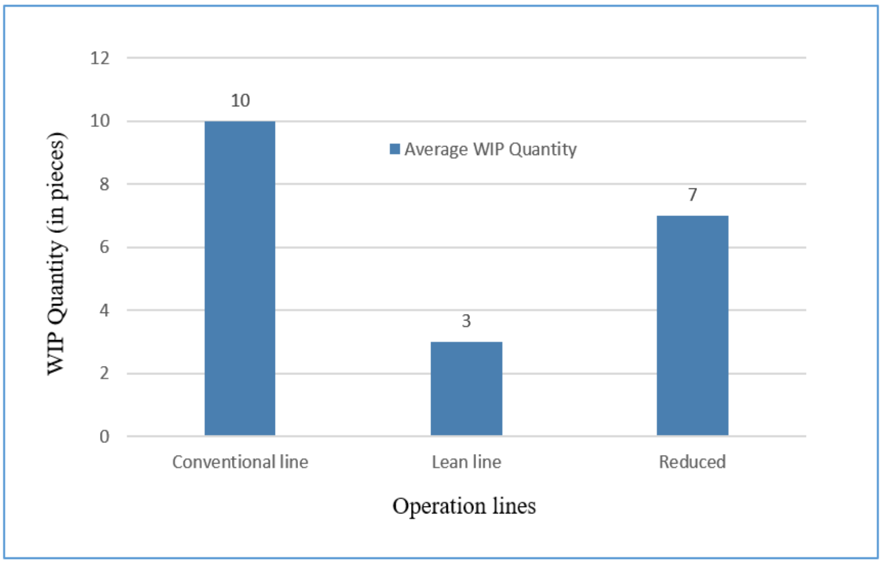

Figure 9. Comparison of average WIP quantity between conventional line and lean line

5.8 Comparison between line efficency

Figure 10 shows the comparison of efficiency between the conventional line and the lean line. Lean tools (Line Balancing) plays an important role to increase line efficiency in lean lines. It is seen that line efficiency in the conventional line is 67.11% and in the lean line is 69.08%. Therefore, line efficiency increased by 1.97%.

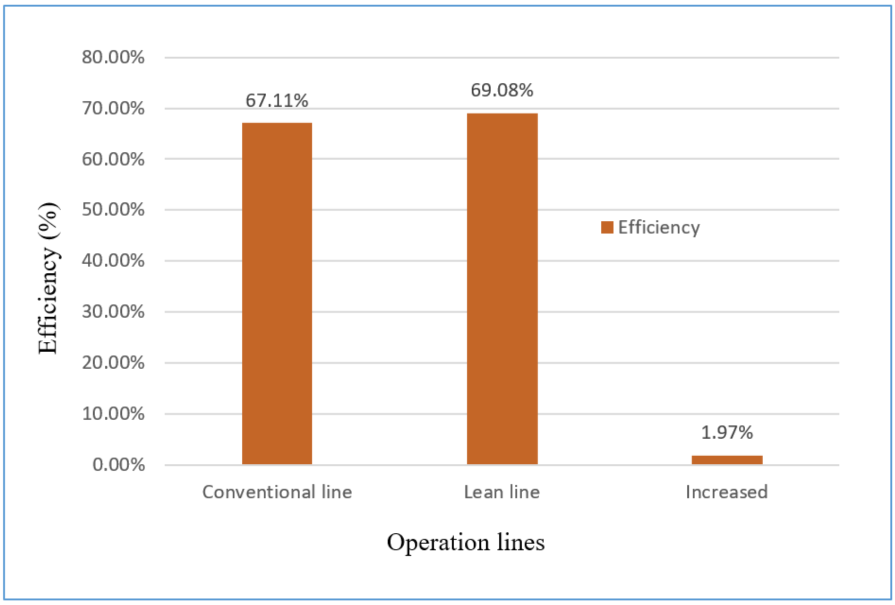

Figure 10. Comparison of efficiency between conventional line and lean line

From the figures above (Figure 3 to Figure 10), the impact of lean manufacturing in the sewing line is perceptible. It reduces SMV, manpower requirement, spot quantity, rejects quantity, alters quantity, and WIP which helps to increase total productivity. Therefore, the implementation of lean manufacturing in the RMG industry leads to profit maximization.

6.0 MODIFIED PROCESS FLOW

After analyzing the collected data and the conventional line's process flow, a new process flow of a full-sleeve t-shirt is designed. It is found that two operators can be eliminated from the current process flow. Besides, it is possible that the 12th and 13th operations can be done by a single operator at a time which will reduce another manpower requirement and will save time and cost. Figure 11 shows the modified process flow with SMV.

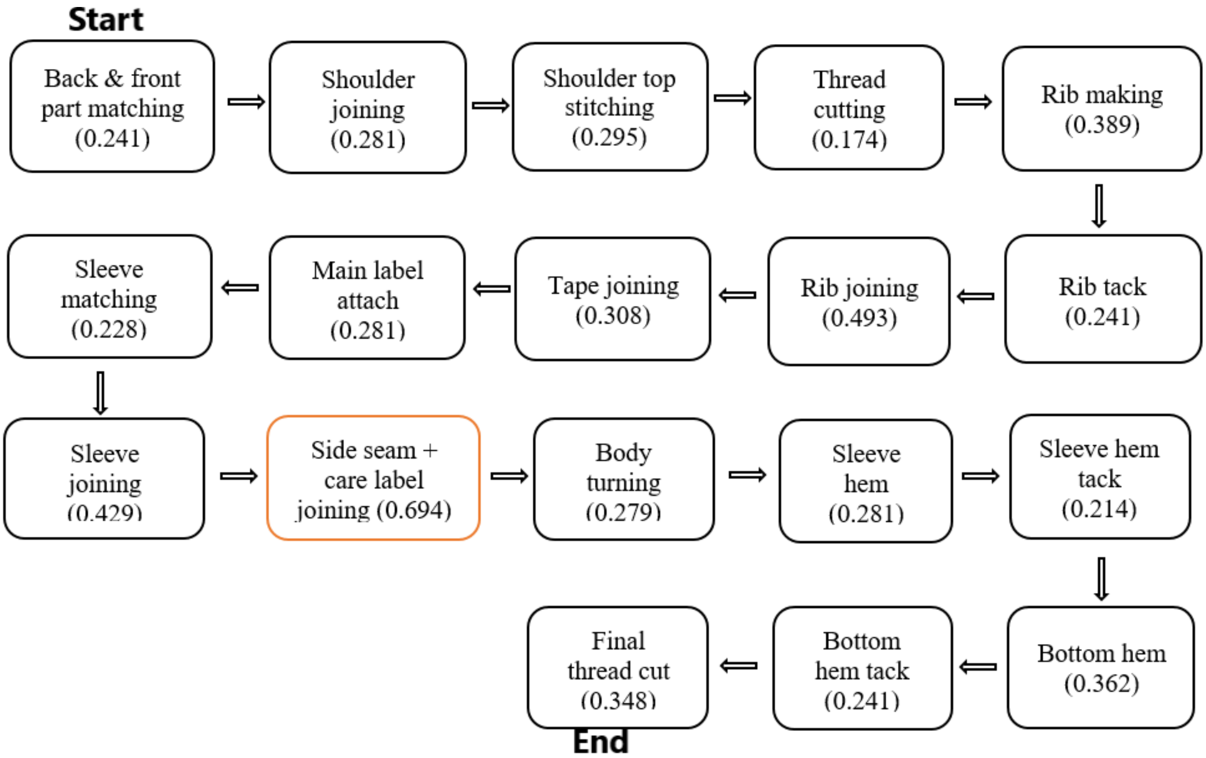

Figure 11. Modified process flow with SMV

7.0 PROPOSED LAYOUT

After analyzing the collected data and results, a new layout have been developed for the sewing line as shown in Figure 12. This layout is more efficient and cost effective. It is found that 19 operations have been done by 21 operators and helpers for making the same product i.e. full-sleeve t-shirt. In this proposed layout, Operation 11 is performed by 1 operator and Operation 12 is performed by 2 operators. Morever, it is determoned that Operation 12 and 13 can be done by single operator which refer to reduce another operator that results in cost minimization.

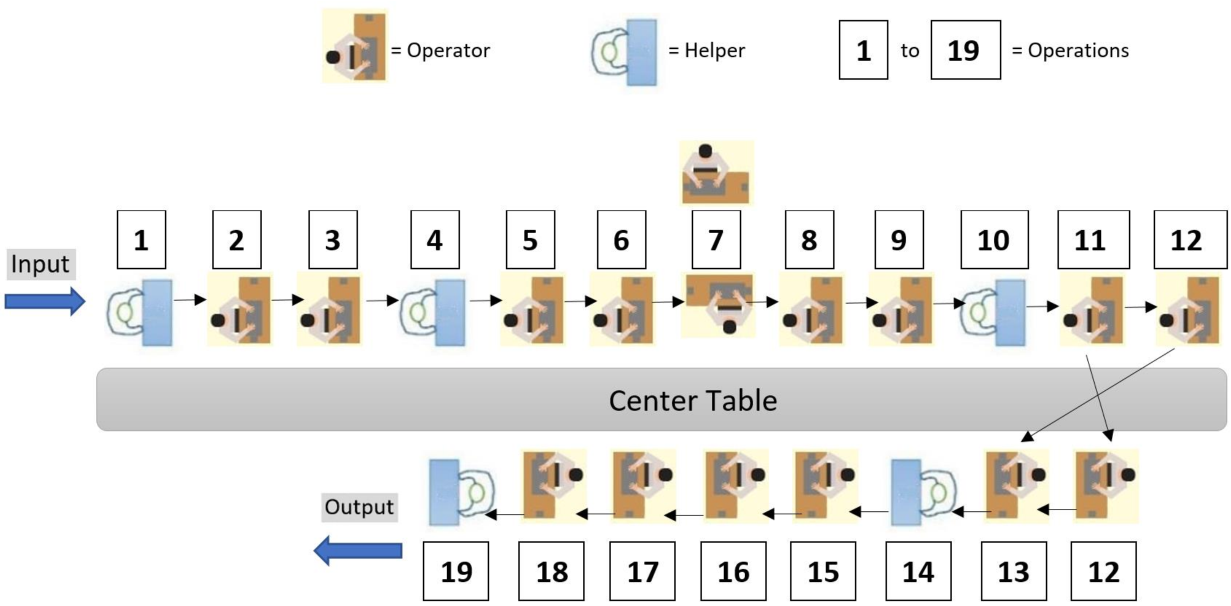

Figure 12. Proposed layout

8.0 CONCLUSION

Every garment industry focus to produce the items in a cost effective way where consumer wants to purchase the item with zero defect and resonable pricing. In this case, lean manufacturing is the ultimate solution as it satisfies both the manufacturers requirement and customers need. For this study, lean manufacturing tools and techniques are studied and used for a sewing line of a garment industry. The study has shown the advantages when applying lean principles to the sewing line. Using lean tools and techniques in sewing line has a great importance specially for decrease SMV, total alter quantity minimization, total spot quantity reduction, total reject quantity reduction etc. To maximize the production with zero defect, application of lean manufacturing is a prior requirement. In this study, it is shown that after lean implementation, SMV is decreased, total number of operators are decreased, alter percentages are reduced, spot quantity is reduced, rejection rate is reduced, WIP is decreased and higher efficiency is achieved. Lean application in the sewing line ensures SMV, smooth process flow, and productive operations with modified layout that finally made a significant contribution to achieve production targets.

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