GUB Journal of Science and Engineering (GUBJSE)
p-ISSN: 2409-0476
vol. 10, no. 01, 2023

Evaluation of Performance Enhancement in Garment Industry Using Lean Tools

Mehnaz Jebin[1], Md. Mazharul Helal[1], Md. Kaikobad[1], Md Mutasim Uddin[1], Md. Mahbubur Rahman[1]

1 Department of Textile Engineering, Green University of Bangladesh (GUB), Bangladesh.

*Corresponding author's email: mehnaz@tex.green.edu.bd

Received: 27/02/2023
Accepted: 01/12/2023
Published: 15/07/2024

Data Availability: The data are available on request from the corresponding author.

Competing Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DOI: 10.3329/gubjse.v10i1.74943

Abstract

The comprehensive idea of lean manufacturing emphasizes the identification and removal of wastes related to production. Increased productivity, shorter lead times, improved line balancing, lower work in progress (WIP), higher quality, more adaptable designs, lower costs, etc. are all major objectives of applying lean tools. This study aims to investigate how lean manufacturing techniques might enhance manufacturing efficiency in Bangladeshi RMG sector. The sewing section of a small scale garment industry was the focus of this study. In the study, the existing line layout of a trouser style was examined using value stream mapping which contributed to the identification of numerous waste in the existing layout. In order to change the current status of the sewing section, the workplace was organized by 5S tools to remove wastes identified by VSM followed by altering the conventional longer line layout into three cell of work station as suggested by cellular manufacturing. After implementation of these lean tools, results observed include, production output is increased by 17.80%, efficiency is increased by 12.46%, SMV of product is standardized to 18.68 min., defects per hundred units is reduced to 10% and order change over time is reduced by 37%. The conclusions reached during the execution of this implementation study are realistic and applicable in industries with similar structures.

Keywords: Lean tools, productivity, SMV, value stream mapping, cellular manufacturing, 5S.

Highlights

- Increased production output by 17.80%.
- Efficiency boosted by 12.46%.
- Defects reduced to 10%.
- Order changeover time cut by 37%.

Acknowledgements

The research would not have been possible without the financial support of the Department of Textile Engineering at the Green University of Bangladesh.

1 Introduction

In the highly competitive manufacturing climate of today, businesses are always seeking for methods to improve [1]. The trend of fluctuating demand in global market conditions makes the apparel industries searching for a shift in the paradigm of manufacturing. As a result, the philosophy of lean manufacturing arose to increase industry competition by removing waste [2]. Over the years, lean manufacturing, supply chain, and overall operations strategies have been promoted as solutions to challenges including inefficiencies, lost productivity, poor quality, and waste. Similar issues are known to plague Bangladesh's ready-made garment (RMG) manufacturing sector, which is based on exports and has made enormous strides toward capturing a sizeable market portion of the world's clothing market. This is due to, almost every industry in Bangladesh runs in a conventional way which makes the country induce unacceptable level of risks to sustain in global apparel business competition [3]. Lean manufacturing comprises of best practices, tools, and techniques from various industries with the goals of minimizing waste and optimizing the flow and efficiency of the entire system to attain the highest level of customer satisfaction. A different way to define lean is that it strives to produce the same amount of output with less resources, including less time, less space, less human labor, less machinery, less material, and less money [4]. To achieve these, there have been several lean initiatives, tools, approaches, and practices developed over time like 5'S, Just In Time (JIT), Value Stream Mapping (VSM), Cellular manufacturing, Kaizen, etc. [1], [3]. Due to the accessibility of inexpensive labor, the garment manufacturers in developing nations place a greater emphasis on the sourcing of raw materials and lowering delivery costs than on labor productivity. Because of this, developing nations have poorer labor productivity [5]. Lean manufacturing practice focuses primarily on enhancing productivity, product quality, manufacturing cycle times, inventory management, lead times, elimination of manufacturing waste and the creation of value [6].

Anything that does not help change a part to meet the needs of the consumer or add value in manufacturing is considered waste [7]. Seven main types of waste considered in lean system include transportation, over processing, waiting, over production, excess inventory, defects and excess motion [8]. Overproduction refers to producing more than what is necessary for the subsequent process, as well as earlier or more quickly than necessary. The equivalent Lean manufacturing idea is to use a pull system, or to produce goods exactly as needed [9]. Excess inventory lengthens lead times, takes up less production area, impedes communication, and slows down problem diagnosis [10]. Material not moving through value-added procedures is waiting. This includes holding out for supplies, data, tools, equipment, etc. Lean requires that all resources be given just-in-time (JIT) - not too soon, nor too late. Wasteful motion is any motion that does not improve the product in any way. Poor layout, housekeeping, workflow inconsistencies, and undocumented work procedures all contribute to unnecessary motion [10]. To recognize this type of waste, VSM is used. Defects occurred in the manufacturing stage is termed as waste. It is a waste of time and effort to fix defective parts, manufacture defective parts, or replace parts that are of poor quality, etc.[7]. Transportation waste is frequently produced by poor workplace design, excessively massive machinery, or mass production. Unnecessary mobility of employees or machines is what causes the inefficiency. The idea is to cut out time-consuming or expensive phases in the transit process [9]. Over processing waste means going above and beyond what the client requests. Doing more than is required is regarded as an expensive and useless action [7], [9].

Lean manufacturing prioritizes minimizing the non-value-added component of lead time while attempting to maximize the value-added component by practicing various lean techniques [1]. In the clothing industry, there are four basic steps in the production process: designing/pattern creation, cutting, sewing, and packing. The sewing sector, which involves more activities, is the most crucial and vital aspect of the apparel industry. This case study highlights the numerous wastes in the apparel business that can be minimized to increase productivity, including inventory, lead time, and quality issues. As a result, lean tools like VSM, 5S, JIT and cellular manufacturing aid in visualizing wastes in an organization and their potential for elimination or reduction [11]. Value Stream Mapping is a method that demonstrates how to add value to the flow of information and materials throughout the entire production process, assists managers in this understanding. VSM implementation seeks to eliminate waste and non-value-adding operations in the beginning and explores opportunities for lead time, production time, and inventory level improvements [1], [12]. The amount of time needed to accomplish a task or operation while adhering to a standard procedure and level of efficiency is known as the Standard Minute Value (SMV) [13]. The five pillars of 5S stand for Sort (Seiri), Simplify (Seiton), Shine (Seiso), Standardize (Seiketsu), and Sustain (Shitsuke) [8]. Cellular manufacturing, also known as cellular or cell production, organizes factory floor labor into multi-skilled, semi-autonomous teams, or work cells, that produce finished goods or intricate components. A well designed and

operated cell may manage processes, faults, scheduling, equipment maintenance, and other manufacturing concerns more effectively than a standard mass-production line [4].
The goal of this study is to investigate how lean manufacturing techniques can be applied to the discrete production system and to assess their value in a particular situation. The specific aim has been to assess the current state of sewing section of selected garment industry in terms of the following parameters: operation process flow; value stream mapping, cellular manufacturing and 5S practices. The appropriate Lean tools for implementation have been identified, and their effectiveness has been examined.

2 Methodology

2.1 Methods

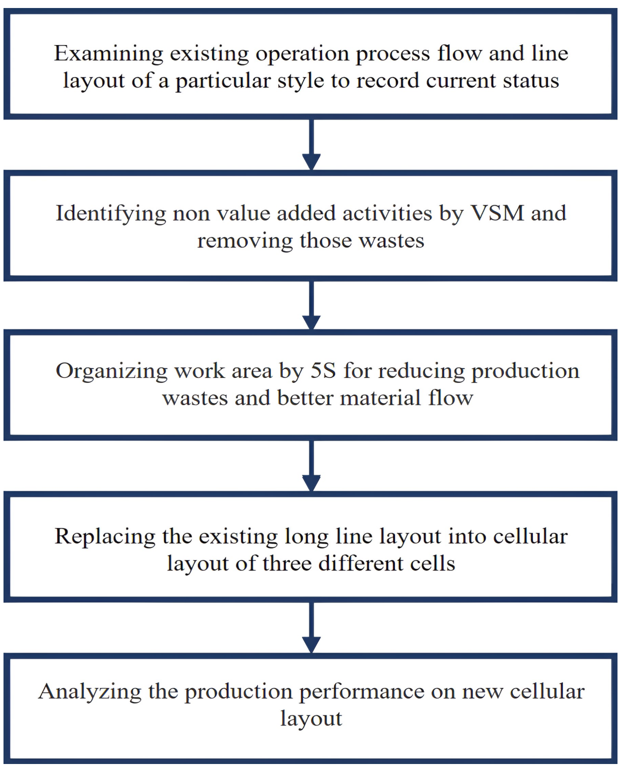

Fig 1. Steps followed in the study.

The methodology of this research work is a case study research. To conduct this research, sewing section of a small scale garment factory was chosen. A knitted trouser production line was selected for lean implementation. The study provides insight into the current scenario of production performance of the sewing line. The numerous wastes of the industry are discussed in this paper, with a focus on waste of time, money and manpower etc. The current state of production line is investigated using VSM lean tool followed by implementation of 5S and cellular manufacturing respectively. The steps followed to carry out the case study are represented in the Fig. 1.
As the first step of the study, the current status of the sewing line of the selected garments industry has been collected for a particular style. The existing production data is shown in the Table 3 & Table 4. To record the current data, the operation process flow and line layout were examined for that style. The overall SMV and production efficiency were 20.98 and 46% respectively. After analyzing the current state map using VSM, the non-value added and unnecessary activities were identified by using value stream mapping. Different wastes found in the sewing section which led to poor efficiency and defects in products were removed by VSM and 5S implementation. Finally, a new layout based on cellular manufacturing was trailed to observe the changes in terms of production, efficiency, SMV, order changeover etc.

2.2 Lean Tools Implementation

This study was conducted using three lean tools. The implementation sequence of the tools are displayed in Fig. 2.

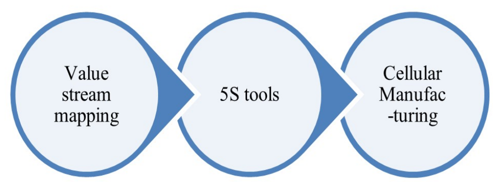

Fig 2. Sequence of lean tools implementation.

2.2.1 Value Stream Mapping

VSM helps in identifying the value added and non-value added activities in a current state map and thus helps visualize the future state map. In this study, the task of VSM involves observing current process layout and finding non-value added activities and other wastes (NVAA) in the process layout while recording production data like cycle time of each operation, WIP in between processes, total output as well as production efficiency etc. The NVAA found in the study and the time consumed by these activities are shown in Table 1

Table 1. Time wasted by NVAA in the existing layout

Activities adding no value in current state map	Average time waste/day production
Waiting idly due to successive operators' delay in job completion	15.30 minutes
Moving materials from one operator to another in longer line layout	17.50 minutes
Bundle opening & sorting	8.0 minutes
Counting of batch of parts by operator to forward to next process	9.60 minutes
Total Average time wasted /day	50.40 minutes

In the current layout, it is observed that operators begin creating parts continually at maximum efficiency, regardless of what is needed for the next operation. Having unbalanced work load, this leads to a significant volume of work in progress between processes, which causes mistakes in production and thus increase the chances of WIP rejection. The level of WIP found in between processes is shown in Table 3.

2.2.2 5S Tools

5S tools promotes a clean and organized work environment leading to reduction in defects and rejection rate and increase in productivity. In this study, after analyzing the current state of sewing line by VSM, the next step followed was to organize the sewing area to eliminate defects occurring due to poor 5S in the workspace. The work sequence is as following:
Sort - Unnecessary objects are separated and removed from sewing part which results in more space availability.
Set in Order- After sorting, the products are arranged according to their level of utilization during the production process allowing for easy material movement.
Shine- Dust, dirt and all machines, tools and equipment in the sewing floor were cleaned according to time schedule.
Standardize- A list of activities for 5S implementation were made and followed the guidelines for marking the sewing floor. The procedures were standardized.
Sustain- Monitored all the 4S's activities continuously. Work discipline were maintained with the help of employees.The action taken for workspace organization by 5S is shown in Table 2.

2.2.3 Cellular Manufacturing

In this study, while analyzing current status of sewing line by VSM it was found that the longer line layout was responsible for the generation of wastes like process waste, defects, transportation waste, rework etc. Hence, the existing single line layout of sewing line for trouser was replaced into cellular layout. Cellular manufacturing, also known as cell production, organizes factory floor labor into multi-skilled, semi autonomous teams, or work cells, that produce finished goods or intricate components. For the selected trouser style, three different cells were formed-front part operations, back part operations and assembling cell. The trial new layout on which the further investigation carried on is shown in Fig. 3.

Table 2. 5s implementation in sewing section

Problems identified in sewing section by 5S analysis	Action Required by 5S tools
Unnecessary objects	Sort
Leftover items	Sort
Misplacement of goods	Set in order
Partial marking of sewing floor	Set in order
Insufficient rack, bin & trolleys	Set in order
Uncleaned workspace & machineries	Shine
Undefined pathway for material passage	Standardize
Undisciplined practices of workers	Sustain

3 Results & Discussions

3.1 Overall Results of Lean Manufacturing

Implementation of lean tools -VSM, 5S and cellular layout in the sewing section has contributed to the overall increase in production performance. Based on the present state map, a number of imrpovements were identified for future state map by VSM. As indicated by Table 4, significant changes are developed in the future state, including a decrease in production time, non-value added time, WIP, defects and inventory time and increase in efficiency, production output . The organization gains from the changeover time when transitioning to a new product family in cellular layout.

3.2 Comparison of production output

By changing the existing layout into cellular layout and 5S practices, the per day production output increased from

Table 3. Operation breakdown of a trouser for current & future state

SL no.	Operation Description	Name of m/c	Current state map			Future state map		
			Man power Required (Before)	SMV (Before)	WIP in between processes	Man power Required (After)	SMV (After)	WIP in between processes
Front Part (Cellular layout)- Cell 1								
1	Pocket Facing-4, D/F tack & turn & over lock	O/L	1	0.55	18	2	0.42	6
2	Lower facing Join at Pocket bag	S/N	1	0.45	20	1	0.35	3
3	Upper facing join,	S/N	1	0.45	17	1	0.31	2
4	Front Part O/L with S/F	O/L	1	0.48	22	1	0.33	2
5	Waiting			0.15			Eliminated	
6	S/F 1/16 Top stitching	S/N	1	0.30	6	1	0.37	4
7	Sew "J" Stitch	S/N	1	0.35	3	1	0.33	2
8	D/F Join & Top stitch	S/N	2	0.35	7	1	0.40	5
9	Front Rise Close & Top Stitch	S/N	1	0.45	21	1	0.38	4
10	Pocket bag Join at body	S/N	2	0.55	16	2	0.42	3
11	Pocket opening top stitch	S/N	2	0.55	16	2	0.40	3
12	Pocket Tack & Top stitch	S/N	1	0.50	20	1	0.43	4
13	Close Pocket Bag	O/L	1	0.38	12	1	0.35	3
14	Pocket Bag Turn & ¼ Top stitching of Pocket Bag	S/N	2	0.38	6	1	0.38	5
15	Quality inspection		No operation			1	0.37	
Back Part (Cellular layout) – Cell 2								
16	Back Yoke Join	O/L	1	0.35	16	1	0.37	7
17	Yoke top stitch	C/S	2	0.38	13	1	0.28	5
18	Close back rise	O/L	1	0.37	15	1	0.30	4
19	Back Rise top stitch	C/S	1	0.38	16	1	0.27	2
20	Waiting			0.18			Eliminated	
21	Back pocket mouth rolling	S/N	1	0.40	23	1	0.35	3
22	Back Pocket Iron	Helper	1	0.51	12	1	0.57	5
23	Mark Pocket Join Position	Helper	1	0.50	9			
24	Back Pocket Join at body	S/N	2	0.54	8	2	0.55	7
25	Quality Inspection		No operation			1	0.37	3
ASSEMBLY (Cellular layout)- Cell 3								
26	Matching front & back & loop match	Helper	1	0.45	20	1	0.37	5
27	Close inseam	O/L	2	0.54	16	1	0.48	6
28	Inseam top stitching	F/L	1	0.55	21	1	0.43	5
29	Waiting			0.12			Eliminated	
30	Close side seam	O/L	2	0.42	14	2	0.37	4
31	Care level join	S/N	1	0.30	5	1	0.30	3
32	Side top stitch	S/N	1	0.35	8	1	0.35	3
33	Loop tack	F/L	2	0.45	4	2	0.40	3
34	Mark loop & waistband join position	Helper	1	0.38	8	1	0.40	5
35	Loop join	S/N	1	0.30	6	1	0.33	3

36	Loop support join	S/N	1	0.38	9	1	0.40	3
37	Waistband (W/B) make	Kansai	1	0.38	8	1	0.43	3
38	Waistband mark	Helper	1	0.42	12	1	0.30	2
39	Waistband mark & matching	S/N	1	0.43	13	1	0.38	2
40	Waistband join	S/N	2	0.38	7	1	0.35	4
41	Waiting			0.15				
42	Hole-2 with mark	B/H	2	0.40	11	1	0.43	3
43	Elastic insert	S/N	1	0.38	10	1	0.40	3
44	Elastic tack	S/N	2	0.37	6	1	0.50	5
45	Waistband mouth tack	S/N	1	0.43	9	1	0.41	4
46	Waistband folding tack-5	S/N	2	0.42	5	2	0.32	2
47	Waistband top stitch upper	C/S	1	0.50	18	1	0.40	3
48	Waistband top stitch lower	C/S	2	0.31	11	2	0.30	2
49	Mouth top stitching	S/N	2	0.32	5	1	0.30	3
50	Label tack at Waistband	S/N	2	0.43	10	2	0.38	2
51	Body turn	Helper	1	0.40	16	1	0.32	2
52	Bottom hem	S/N	2	0.50	13	2	0.45	5
53	Bartack-16	B/T	2	0.57	16	2	0.40	4
54	W/B, S/F, D/F, fusing elastic cut	Helper	2	0.45	11	1	0.48	5
	Total		**67**	**20.98**		**60**	**18.68**	

Indications: O/L- Overlock machine, S/N- Single needle Lock Stitch, B/T- Bartack machine, F/L- Flatlock machine, C/S- Chain stitch

Table 4. Overall performance for lean implemnetation

Performance parameter	Before Lean Implementation	After Lean Implementation
Production output	764 pcs per working day	900 pcs per working day
Defect per hundred unit (D.H.U)	11.26%	10%
Order changeover time	350minutes	220minutes
Efficiency	46%	58.46%

764 to 900 pcs. Smooth material passage & handling ensured by 5S and the flexibility of workers to do multiple operations in a cell helped in reduction in cycle time of each operation and increase in production rate. Because of cellular layout, NVAA like waiting & manual counting were removed and unbalanced workload was balanced by enabling operators work in a group which increased production output per day.

3.3 Comparison of SMV

By rearranging the process flow, balanced workload for each operator was ensured. Also, organized workspace reduced throughput time. The cellular layout reduced unnecessary movements of sewers and other non-value activities. Due to the flexibility to do multiple works within the work cell by operators, it ensured reduction in total SMV of the product. The total SMV for the style reduced from 20.94 to 18.68 which is 10.96% reduction in percentage. Similarly, for front part, back part & assembly operation, the reduction percentage in SMV is 11.03%, 16.84% and 9.58% respectively.

3.4 Comparison of Efficiency

Production efficiency of the sewing line has increased by new line layout. This has been achieved by removing unnecessary work, manpower, and creating multi- skilled worker and by combining some operation and cleaning work area. Efficiency increased in 1st day by 14% and monthly efficiency increased by 12.46%. The change in efficiency is shown in Fig. 6.

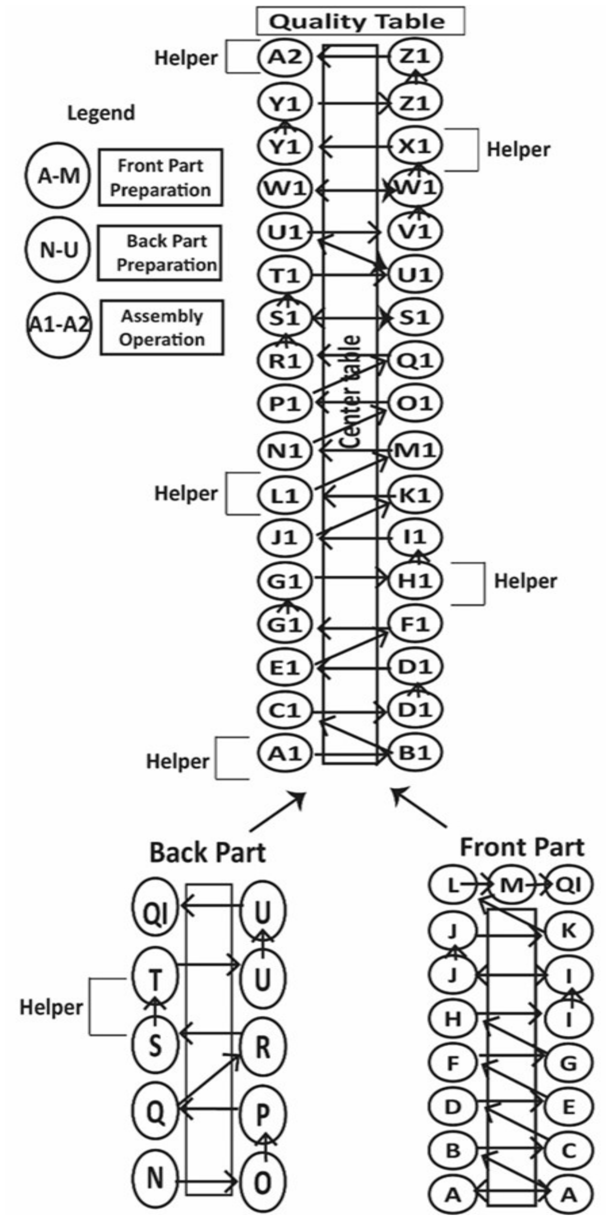

Fig 3. Suggested new cellular layout.

a cell layout. The comparison of man- power before and after lean implementation is shown in Fig. 7.

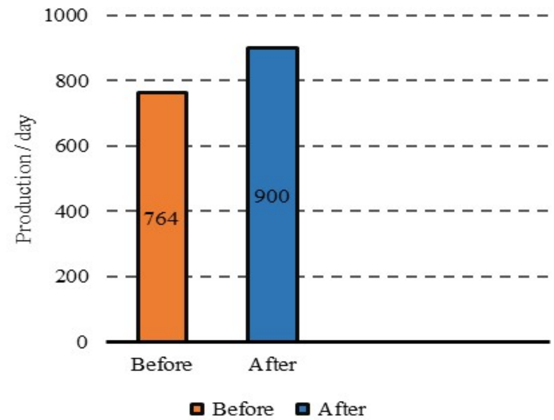

Fig 4. Increase in production output after lean implementation.

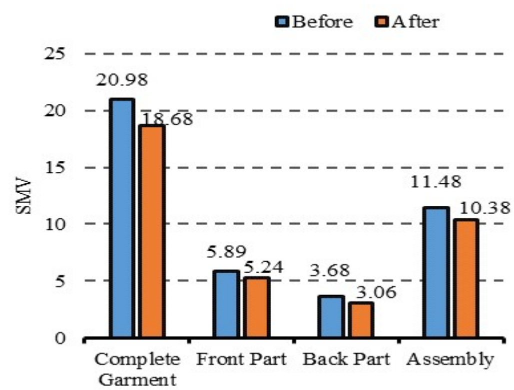

Fig 5. Change of SMV in cellular layout.

3.5 Comparison of Manpower

In the new layout, the number of operators needed to complete a job is reduced by 10.45% by reducing operators in few operations & also eliminating some non-value added operations from the process like thread cutting, transporting material from one place to another. The existing layout required 67 manpower to complete the selected style which reduced to 60 manpower in the cellular line layout. Balanced workload in the cells has made it possible to reduce manpower as the operators do multi task in

3.6 Order Changeover

Order change and equipment repair is rated at an average of 40 changes per month and 350 minutes of waste per activity. After the implementation of lean concepts, monthly order changeover rate per line per order changed to 220 minutes from 350 minutes. That indicates 130 minutes reduction, 37% achievements in order changeover time. The before and after order changeover are shown in the table 5.

Table 5. Improvement in Order Changeover Time

Performance Measure	Before	After	Achievement
Change over per line/ order(per month)	350 minutes	220 minutes	37% (130 minutes)

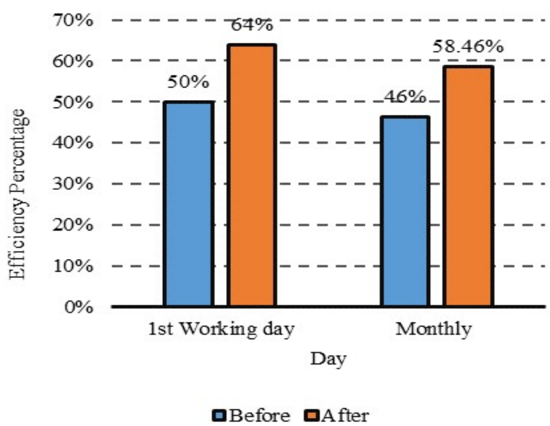

Fig 6. Increase in Production Efficiency after lean tools implementation.

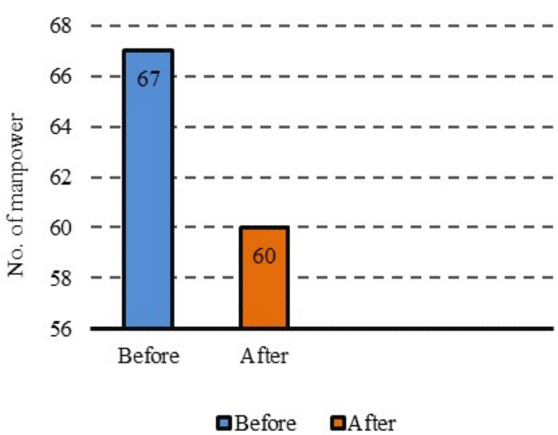

Fig 7. Reduction of manpower by implementation of new layout.

3.7 Comparison of D.H.U.

The D.H.U., which stands for Defects per Hundred Units, has dropped compared to recent trends. In the existing layout, due to poor 5S practices, the common defects found were mismatch of buttons, labels & sizes, damaged WIP due to dirt, stain etc. Practicing 5S has contributed to the reduction of these defects. The D.H.U level in current manufacturing is roughly 11.26%, but after using the suggested plan, it has dropped to 10%. The reason behind the decrease in rework are the reduction in WIP and the creation of balanced work cells. Due to the minimal inventory, mistakes are easily seen, and if a garment has a defect, it will be corrected in-line before the piece is released as a finished good.

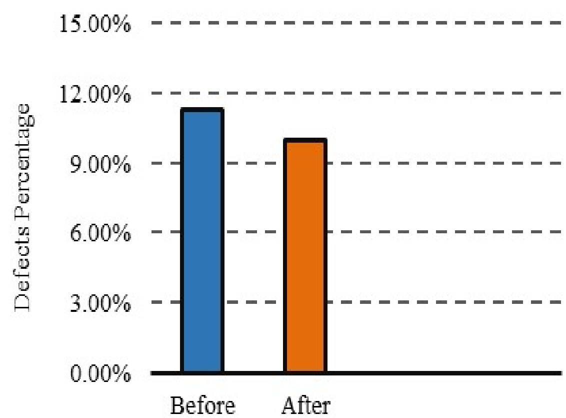

Fig 8. Reduction of defects implementing 5S & cellular manufacturing.

4 Conclusion

Through this case study investigation, an overall picture of the sewing sector of the selected apparel industry has been inferred. Using the typical production system, the case study garment manufacturing company is experiencing issues with unsatisfactory production performance. Longer line layout has been identified as the root cause of the most wastes occurred in this garment sewing section. VSM has worked as the most appropriate lean tool in finding those wastes and other non-value activities in the process flow. New designs for workspaces and workflows that boost productivity and reduce expenses are eventually proposed. Small work cells instead of long lines of process flow have helped reduce process effort by more than 80%, improve material flow, and boost overall productivity. Greater labor and factory floor utilization have also been obtained by using the suggested plan.
However, this investigation has been carried out in the sewing line only of the chosen industry. Implementation of lean tools in the entire enterprise still may be found as a challenge to the management. VSM has also been partially implemented, fully implementation of VSM would derive a future state map for the entire production process. Lean tools have been used to identify waste, although it is generally recognized that tool application is confined

to a single product group. The application of lean tools to the remaining product families inside an organization can be studied further. Focus can be further extended on the adaptation of Just in Time, Kanban tools in combination with cellular manufacturing in the future study.

References

[1] R. M. Nunesca and A. T. Amorado, "Application of lean manufacturing tools in a garment industry as a strategy for productivity improvement," *Asia Pacific Journal of multidisciplinary research*, vol. 3, no. 4, pp. 46–53, 2015.

[2] D. V. Kumar, G. M. Mohan, and K. Mohanasundaram, "Lean tool implementation in the garment industry," *Fibres & Textiles in Eastern Europe*, 2019.

[3] S. Hasan, G. Khan, M. R. Hoque, F. Hassan, and N. Ahmed, "Lean practices in the bangladeshi readymade garments industry and global significance," *International Journal of Logistics Research and Applications*, vol. 25, no. 3, pp. 309–327, 2022.

[4] R. Kumar Chakrabortty and S. Kumar Paul, "Study and implementation of lean manufacturing in a garment manufacturing company: Bangladesh perspective," *Journal of Optimization in Industrial Engineering*, vol. 4, no. 7, pp. 11–22, 2011.

[5] F. Ferdousi and A. Ahmed, "An investigation of manufacturing performance improvement through lean production: A study on bangladeshi garment firms," *International Journal of Business and Management*, vol. 4, no. 9, pp. 106–116, 2009.

[6] U. Bristi and M. Al-Mamun, "Productivity improvement of cutting and sewing section by implementation of value steam method in a garments industry," *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, vol. 54, no. 1, pp. 185–202, 2019.

[7] R. Kumari, T. Quazi, and R. Kumar, "Application of lean manufacturing tools in garment industry," *International Journal Of Mechanical Engineering And Information Technology*, vol. 3, no. 1, pp. 976–982, 2015.

[8] J. H. Mridha, A. R. Alam, T. Mahmud, and T. Ahmed, "Contrivance of 5s system to effectuate higher productivity in apparel industries," *Global Journal of Researches in Engineering, February*, pp. 21–28, 2020.

[9] A. G. Kennedy, "An assessment of the use of research methods in lean manufacturing environments: An introduction to the relational theory of continuous improvement and the seven wastes of lean research," 2011.

[10] R. Karim and C. M. Rahman, "Application of lean manufacturing tools for performance analysis: A case study," in *Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management (IEOM), Istanbul, Turkey*, 2012.

[11] E. Akçagün, V. Dal, and A. Yilmaz, "Using value stream mapping at apparel industry: A case study," in *International Textile, Clothing & Design Conference-Magic World of Textiles*, 2012, pp. 1–6.

[12] J. Bhamu and K. Singh Sangwan, "Lean manufacturing: Literature review and research issues," *International Journal of Operations & Production Management*, vol. 34, no. 7, pp. 876–940, 2014.

[13] F. B. Alam and M. M. Hasan, "Analysis on smv to increase productivity in sewing section: A case study on t-shirt manufacturing in banglad-esh," *International Journal of Research in Engineering and Science (IJRES)*, vol. 6, no. 08, pp. 18–24, 2018.

Mehnaz Jebin is working as a lecturer at the Department of Textile Engineering in Green University of Bangladesh. She has completed her BSc degree from Bangladesh University of Textiles (2018). Currently she is pursuing her MSc from the same university in the field of Apparel Engineering. Prior to this, she also worked as a merchandiser in Esquire knit composite limited, a renowned textile industry. She completed her industrial training from Viyellatex Ltd. Till now, she has published 6 research papers in the reputed national and international journal and conferences. Her research interests include sustainable textile production, circular fashion, nanotechnology, smart textiles, protective clothing.

Md. Mazharul Helal was born in Narsingdi, Dhaka, Bangladesh in 1995. He received the B.S. degree in Textile Engineering (Major: Apparel Engineering) from Bangladesh University of Textiles (BUTEX) in 2018 and his M.S. is ongoing in the same institution. Prior to it, he completed his HSC from Notre Dame College, Dhaka. His SSC from Brahmondi K.K.M. Govt. High School, Narsingdi. He completed his industrial training from Masco Industries Limited, Gazipur. Since 2018, he has been a Lecturer with the Textile Engineering Department, Green University of Bangladesh. He is a member of Institutional Quality Assurance Cell (IQAC) of the Department of Textile Engineering, Green University of Bangladesh. He published 03 journal articles and 06 conference papers. His research interests include wearable technology, connected modern textiles, sustainable textile production, denim etc.

Md. Kaikobad was born in Kishoreganj, Bangladesh on 5th January, 1997. Currently, he is working as Lecturer at the Department of Textile Engineering in Green University of Bangladesh. He received his B.Sc. in Textile Engineering degree in 2018 from Bangladesh University of Textiles (BUTEX) and he is now pursuing his M.Sc. in Textile Engineering from the same Institution. Prior to that, he completed his HSC and SSC from Aftab Uddin School & College, Kishoreganj, Dhaka in 2014 and 2012 respectively. Previously, he worked as an Executive at research and development department in Epyllion Group. Till now, he has published 08 research papers in reputed national and international journals and conferences. His research interest are Functional Materials, Textile Design, Smart Textiles, Technical Textiles, Nanotechnology and Composites.

Md Mutasim Uddin was born in Dhaka in the year 1994. He has completed his B.Sc. in Textile Engineering from Bangladesh University of Textiles (BUTEX) in 2017. His area of specialization was textile wet processing. He completed industrial attachment in Rupa Knitwear limited and started his career as an R&D officer in A Plus Group, Banglamotor, Dhaka. Prior to joining Green University of Bangladesh, he was a lecturer in the Department of Textile Engineering, Uttara University, Dhaka. Currently, he is working as a Lecturer in the Department of Textile Engineering, Green University of Bangladesh (GUB). Besides, he is a running student of M.Sc. in Textile Engineering from Bangladesh University of Textiles (BUTEX). His research interest includes special printing, solvent dyeing, eco-friendly dyeing, sustainable textile processing etc.

Md. Mahbubur Rahman was born in Narsingdi on 02 December 1988. At present, he is working as an Assistant Professor in the Department of Textile Engineering of Green University of Bangladesh. He received the degree M.Sc. in Textile Engineering from Dhaka University of Engineering and Technology (DUET), Gazipur in 2022. He also completed his B. Sc in Textile Engineering from Primeasia University Gazipur in 2010. He has published 23 research papers in reputed national and international journals and conferences. He is the Head, Institutional Quality Assurance Cell (IQAC) of the Department of Textile Engineering, Green University of Bangladesh. His research interests include application of natural dyes, technical textiles, smart textiles, effluent treatment plant (ETP), and environment friendly dyeing technology. Mr. Mahbubur Rahman was a recipient of the Gold Medal Award in the International Exhibition from Multimedia University (MMU) at the Research Innovation Commercialization & Entrepreneurship Showcase 2021. He also receipts Silver Award from GUB Research Exhibition (GEX 2021) for the outstanding project work.