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Improvement of the Line Efficiency of a T-Shirt Manufacturing Unit Using Eight Waste of Lean Tool

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Abstract: *Lean manufacturing is a systematic approach accepted worldwide to improve a production system by identifying and eliminating wastes in the form of non-value-added activities through continuous supervision. As garment exports has been one of the major driving factors of Bangladesh's economy, so improvement in garment manufacturing process has become need of the hour for emerging and sustaining as a global leader in this sector. This study focuses on the utilization of a lean tool to analyze the performance of each operator also identifying the lowest-performing operators and improving their performance thus increasing the efficiency and productivity of knitwear (t-shirt) manufacturing unit. This work has identified different problems regarding wastes and weaknesses of operators existing in the sewing section using 8 wastes of the lean tool. The work of each operator has been measured using work measurement tools such as time study and method study and measures were taken to resolve the issues that hindered the efficiency of that production line. After implementation of the lean tool and with the help of time study, the standard minute value of operations was reduced. Likewise, the non-value-added activities nonproductive time of operators were reduced, hence the operator's performance and line efficiency were improved.This research was conducted to increase the productivity of a garment sewing unit using the lean tool so that this will help improve the operator's performance and also have a positive impact on the overall t-shirt manufacturing process.*

Key Words*:Knit garment; Lean manufacturing; Operator performance; Productivity; Time study*

Introduction

Bangladesh's RMG industry now accounts for more than 70% of the country's overall export profits and employs roughly 40% of the country's manufacturing workers [1]. Bangladesh's RMG sector has just begun embracing lean manufacturing to minimize lead time, which is critical for long-term growth stability. Lean is a set of tools that aid in the identification and removal of wastes by improving day by day [2]. The basic goal of lean manufacturing tool is to reduce waste as well as by minimizing the variability from suppliers to customers' end. Lean manufacturing is an idea which is derived from "The Toyota Production System"[3]. It is simple, adaptable, ergonomic, small, low-cost, well-fitting, environmentally friendly, and energy-efficient productivity improvement tool [4]. In today's competitive environment, manufacturers must focus on time, pricing, quality, and delivery to attract well-known buyers [5]. Lean manufacturing incorporates several philosophies and approaches, with an aim of eradicating waste and activities that does not add any value to a production system to maximize customer happiness and productivity [6]. The process of implementing lean varies from one organization to other. [7]. It increases an organization's performance by reducing non-value-added operations[8]. L. Muluget studied that the adoption of new manufacturing methods may result in improved product quality and increased employee involvement in attempts to improve not only the production

processes but also the organization [9]. Wahab et.al stated that companies who adopt lean manufacturing as a working principle in their system, can increase their operational performance significantly, even if in a modified version that best suits their particular corporate culture [10]. Nunesca et.al found that both workers and the company benefit from the use of lean manufacturing tools. If non-value-added operations are decreased, that results in increased production. 100% efficiency can be attained after lean implementation, and the rejection rate can also be lowered. Lean tools makes major improvements in creating a smooth process flow and productive operations, which helped the organization achieve its goals, and deliver high-quality products at the correct time and place [11]. V. P. Jaganathan studied that the use of lean manufacturing technologies and processes will considerably increase productivity. The problem of batch processing of existing data is solved by moving WIP in single pieces. The flexibility of rework minimization and online packing are two major advantages noted [12]. Y. Lartebet al studied that different lean tools, such as problem-solving methods, production flow, 5S, and standardization, are applied in practice [13]. G. L. Hodge et al conducted a research to find a lean tool for the textile industry in the United States to minimize waste and non-value added activities and improve customer satisfaction [14]. Vorkapić et al. investigated the implementation of lean manufacturing ideas, tools, and procedures to boost productivity in the textile sector. The main target of the study was to conduct a thorough literature review on lean and garment manufacturing to create a generic, theoretical model that depicted the possibility of boosting productivity [15].

The purpose of the project is to investigate the effects of eight wastes of lean manufacturing tool on garments manufacturing process to improve line efficiency, to reduce cycle time, to eliminate waste and problems and to improve productivity of knitwear manufacturing.

Materials and Methods

Materials

The fabric used for producing the half sleeve t-shirts for this research work was collected from Metro Knitting & Dyeing Mills Ltd. The collected fabric was 100 % cotton single jersey knitted fabric. The GSM was 180 and shade was white. 100% polyester white colored sewing thread was used for sewing.

Figureno 1: Half sleeve knitted t-shirt

Methodology

A time study was conducted to determine the standard minute value (SMV) of the product being produced on that unit. Each sewing operator was subjected to time study. Data was collected for 5 cycles of each operator to get the basic time, which was then multiplied by the factory allowance to determine the SMV of each operation and the overall product SMV. For a given period, productions of each operator was recorded. During the time of recording, each operator's non-productive time was taken. To avoid any changes in their natural performance, the operators were kept in the dark about the study. The recorded data was utilized to calculate each operator's performance percentage for a shift. From the obtained data the operators with the lowest performance percentage were identified.

The eight wastes of lean tools were implemented on the five operators who had the lowest performance percentage. The challenges the operators faced during production were thoroughly investigated and remedies were provided based on technical expertise. The solutions were applied to the operators in a variety of ways to improve their performance.After applying lean tools and resolving the difficulties of each of the five operators a time study was done again on these five operators to see how their performance had changed. Different parameters regarding the productivity and efficiency of a sewing line were calculated using following formulas like: Operator's performance percentage per shift,

$$= \left\{ \frac{\text{Total production per shift} \times \text{Operation SMV (min)}}{\text{Available time per shift (min)} - \text{Nonproductive time per shift (min)}} \times 100 \right\} \%$$

$$\text{Average performance percentage} = \frac{\text{Sum of Performance Percentage of Each Operator}}{\text{Total No.of Operators}} \%$$

$$\text{Sewing line efficiency} = \left\{ \frac{\text{Total Production per shift (pcs)} \times \text{Product SMV (min)}}{\text{Total Manpower} \times \text{Working hour per shift} \times 60} \times 100 \right\} \%$$

Table no1: Performance percentage calculationof each operator.

Sr. No.	Name of the Operator	Name of the Operator	Machine Used	Average Cycle Time (min)	Observed Rating (%)	Basic Time (min)	Allowance	SMV (min)	No. of Production (pcs per shift)	Non- productive Time (min/ shift)	Performance Percentage (%)
01	Shorifa	Shoulder join	OL	0.30	80	0.24	0.03	0.27	1375	45.1	60
02	Sharmin	Shoulder join	OL	0.40	80	0.32	0.05	0.37	1210	14.74	69
03	Taslima	Rib Tuck	PM	0.13	80	0.10	0.02	0.12	2200	31.35	42
04	Jamil	Rib Servicing	FL	0.14	90	0.12	0.02	0.14	3300	129.9	87
05	Motin	Neck Rib Join	OL	0.19	95	0.18	0.03	0.21	2310	49.28	79
06	Alamin	Back Tape Join	FL	0.13	85	0.11	0.01	0.12	2750	33	52
07	Monju	Back Tape End Close	PM	0.17	85	0.14	0.02	0.16	2090	18.26	52
08	Bilkis	Neck Top Stitch	FL	0.14	90	0.12	0.02	0.14	2310	58.43	53
09	Lucky	Label Make	PM	0.16	90	0.15	0.02	0.17	3300	26.4	88
10	Farjana	Back Tape Top Stitch	PM	0.26	90	0.24	0.03	0.27	1430	77	66
11	Taslima	Back Tape Top Stitch	PM	0.39	75	0.29	0.04	0.33	1320	184.91	91
12	Mina	Sleeve Join	OL	0.48	90	0.43	0.07	0.50	1155	9.46	88
13	Lokman	Sleeve Join	OL	0.49	85	0.42	0.06	0.48	1155	58.3	92
14	Alpona	Side Seam Join	OL	1.26	75	0.94	0.14	1.08	396	38.06	68
15	Ismail	Side Seam Join	OL	0.71	90	0.64	0.09	0.73	660	91.3	84
16	Sewly	Side Seam Join	OL	0.79	90	0.71	0.10	0.81	715	41.03	93
17	Tanjila	Side Seam Join	OL	0.57	90	0.51	0.07	0.58	770	34.43	71
18	Saiful	Sleeve Hem	FL	0.39	95	0.37	0.05	0.42	1100	17.27	71
19	Soniya	Sleeve Hem	FL	0.34	80	0.28	0.04	0.32	1100	167.97	71
20	Mithun	Body Hem	FL	0.21	95	0.21	0.04	0.25	2200	52.1	90

[N.B: Highlighted rows indicate the operators with lowest performance percentage]

Table no 2: The measures taken against the problems found after lean implementation.

Name of the Operator (OperationName)	Eight Wastes of Lean	Problems Found	Measures Against Problem
Shorifa (Shoulder Join)	Transportation	Yes	Two idle machines were placed behind her close input table in line configuration. Idle machines were removed from the production line.
	Inventory	Yes	To maintain the workplace tidy and clean, only two bundles of cut panel were placed alongside that operator.
	Motion	Yes	She was given instructions to reduce excessive handling movement. As a result, a consistent technique of functioning was ensured.
	Waiting	Yes	Input man provided required bundles to her on time.
	Over Production	No	N/A
	Over Processing	Yes	A helper was assigned to cut the extra shoulder tape.
	Defects	No	N/A
	Unutilized Talent	No	N/A
Taslima (Rib Tuck)	Transportation	No	N/A
	Inventory	No	N/A
	Motion	Yes	She was given instructions to reduce excessive handling movement. As a result, a consistent technique of functioning is ensured.
	Waiting	No	N/A
	Over Production	No	N/A
	Over Processing	Yes	There was a helper assigned to the task. He was there to assist the operator and examine the bundle card.
	Defects	No	N/A
	Unutilized Talent	No	N/A
Alamin (Back Tape Join)	Transportation	No	N/A
	Inventory	No	N/A
	Motion	No	N/A
	Waiting	Yes	He had to wait for bundles because the neck joining operator was underperforming. As a result, a more experienced operator took the place of the neck join operator.
	Over Production	No	
	Over Processing	Yes	A helper was assigned to cut the back tape.
	Defects	No	N/A
	Unutilized Talent	No	N/A
Monju (Back Tape End Close)	Transportation	No	N/A
	Inventory	No	N/A
	Motion	Yes	Changed the workstation layout so that the operator does not have to walk to the back-tape operator to get the next bundle.
	Waiting	Yes	She had to wait for bundles since the neck joining operator was underperforming. As a result, a more experienced operator took the place of the neck join operator.
	Over Production	No	N/A
	Over Processing	No	N/A
	Defects	No	N/A
	Unutilized Talent	No	N/A
Bilkis (Neck Top Stitch)	Transportation	No	N/A
	Inventory	No	N/A
	Motion	Yes	She was given instructions to reduce excessive handling movement. As a result, a consistent technique of functioning is ensured.
	Waiting	No	N/A
	Over Production	No	N/A
	Over Processing	No	N/A
	Defects	Yes	The operator's improper handling of materials occasionally resulted in problems. The trainer and line quality controller gave her instructions.
	Unutilized Talent	Yes	The trainer advised her to improve her abilities.

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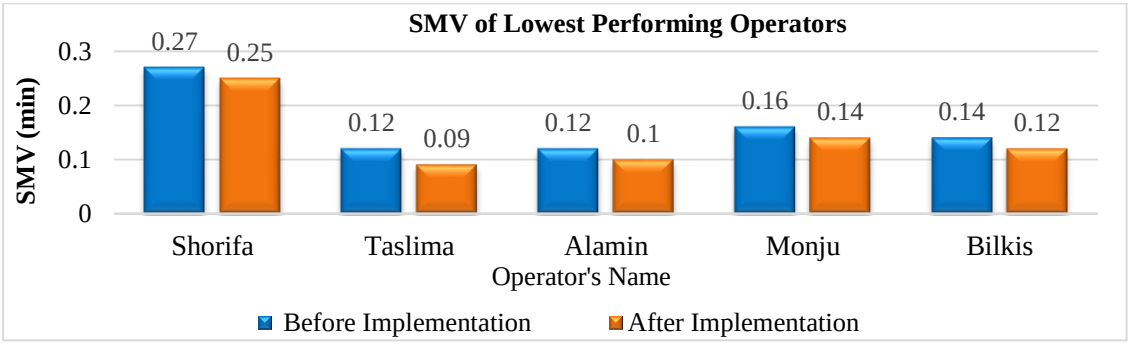
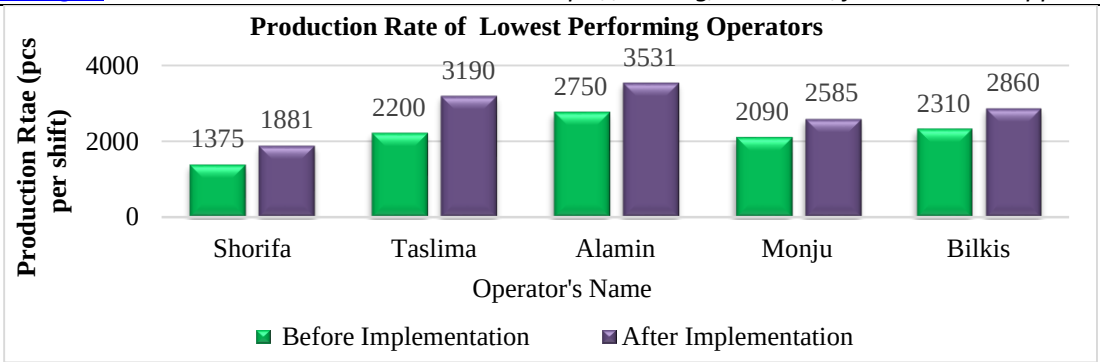
Figureno 2:(a) Before implementation of lean; (b) After implementation of lean.

I. Results and Discussion



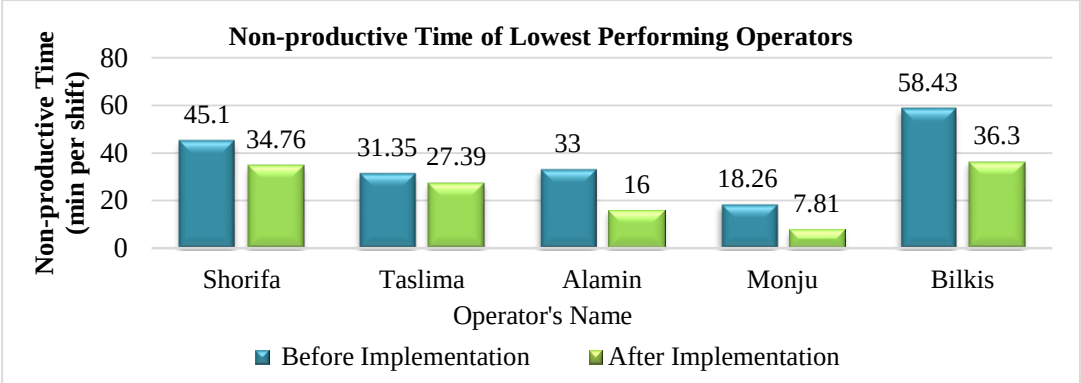
Figureno 3: Bar diagram for SMV ofsewing operators.

Figureno 3 indicatesthe difference in SMV of the operators with lowest performance percentage before lean implementation and after lean implementation. Before implementation, operators' SMV was high. Some operators had transportation problem, motion and waiting problem, inventory problem and over processing problem.Operators' cycle time was reduced by applying eight wastes of lean tool on them that resulted in a positive impact on the SMV of the operators.



Figureno 4: Bar diagram forproduction rate of sewing operators.

Figureno 4 indicates therate of production of the operators which depends on several factors such as time needed to do the operation, availability of materials, SMV etc. Prior to lean implementation, operators moved unnecessarily, some operators had to wait for the next bundle; some had to do over processes. During lean implementation operator's problems were found out and solutions were given and the effect is shown in the figure.



Figureno 5: Bar diagram for non-productive time of sewing operators.

Figureno 5 indicates that,initially five operators named above had significant amount of non-productive time due to many reasons stated earlier. By implementing lean on them, their problems were solved and as a result their non-productivetime was decreased.

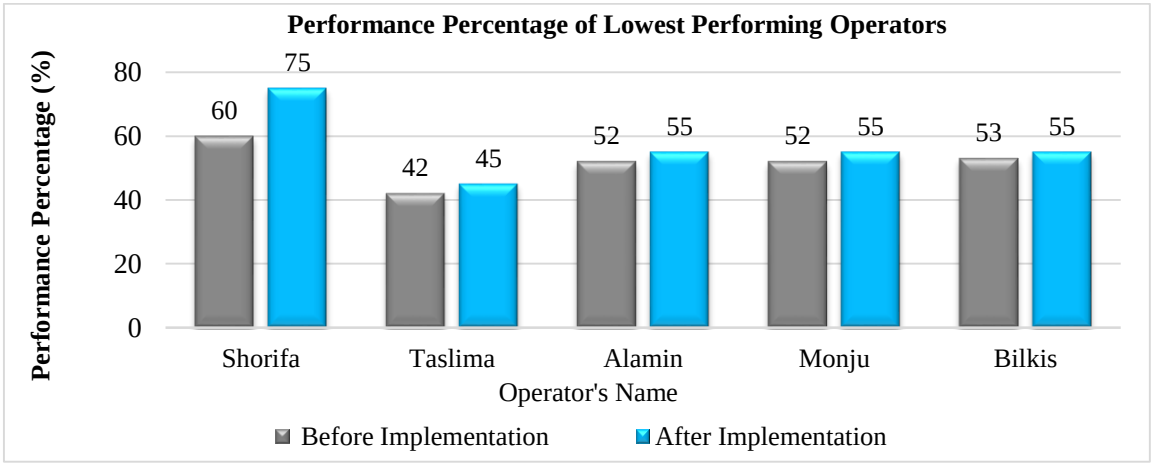


Figure no 6: Bar diagram for performance percentage ofsewing operators.

Figure no 6 indicates the performance percentage of operators before lean implementation and after lean implementation. The different reasons behind thelaggings in performance of operators were identified and solved.The reduction in cycle time and SMV of the operators affected the performance of the operators. Their improvement in performance is shown in the form of performance percentage in the above mentioned figure.

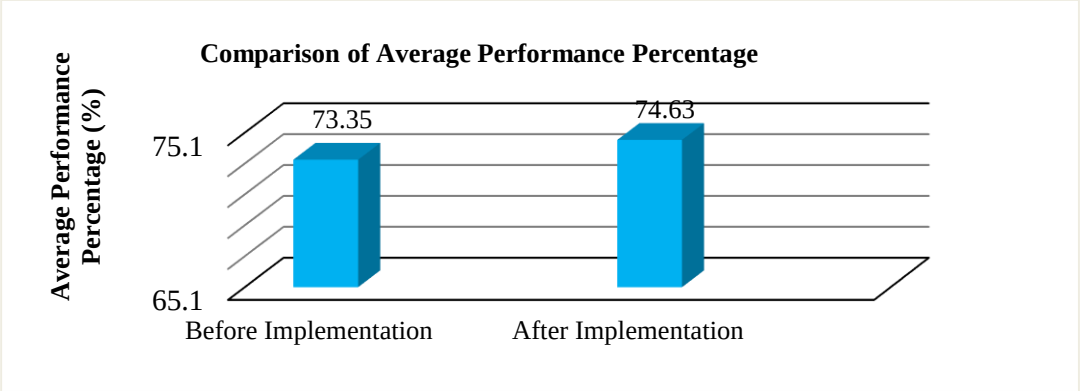


Figure no 7: Improvement on average performance percentageof operators.

Figure no 7 indicates the average performance percentage of the operators in the sewing line. Before lean implementation, some operators had very low performance percentage. By implementing lean, their problems were solved and their performance percentage increased. Hence there was an increase of 1.28% in average performance percentage of sewing line after lean implementation.

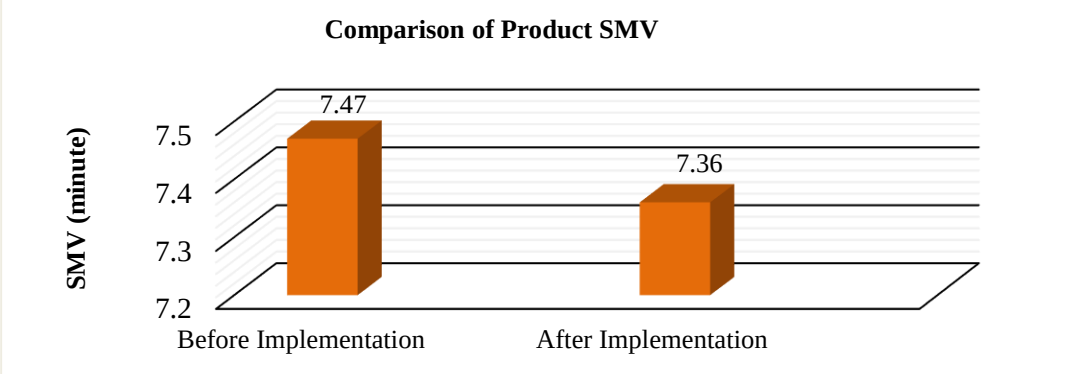


Figure no 8: Reduction in productSMV.

Figureno 8shows that, before lean implementation the SMV of t-shirt was higher meaning more time required to produce a product. The SMV of t-shirt decreased by 0.11 minute due to implementation of lean. T-shirt's SMV was 7.47 minute before lean implementation and 7.36 minute after lean implementation. The product SMV decreased as an outcome of decrease in individual SMV of some operators.

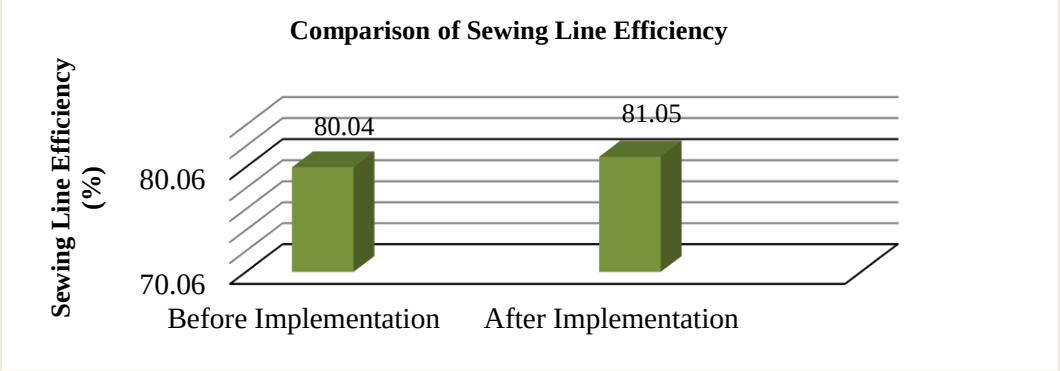


Figure no9: Improvement on efficiencyof the sewing line.

In the figureno 9, the efficiency of sewing line before lean implementation and after lean implementation is illustrated. When lean was applied on lowest performing operators, the SMV of t-shirt decreased, non-productive time also decreased and the performance percentage with rate of production of operators increased. Numerically the efficiency increased by 1.01%, but due to some restrictions at factory end improvement was limited to some extent.

II. Conclusion

This research represents the outcome of a study conducted on the operators of a t-shirt sewing line where lean tool was applied to improve the operator's performance by finding out the limitations of the production process. Improvements in operator performance were made both individually and on overall line efficiency. Before lean tool implementation, individual operators' SMV and non-productive time were high, the rate of production was lower, average performance percentage and efficiency of the sewing line were also low due to some problems faced by operators. The problems were solved by applying 8 wastes of lean tool. Lean implementation on a t-shirt manufacturing sewing line had a thriving impact on the overall performance of that line which ultimately benefits the operators in developing their work and in a greater sense benefits the manufacturing unit.

III. Acknowledgement

This research would not be possible without the support of Mr. Subrata Das Gupta (Assistant General Manager of Admin, HR, and Compliance) and Sayeed Mahmud (Deputy Manager, IE) of Metro Knitting & Dyeing Mills Ltd. (Factory-2). We would like to express our cordial thanks to them for their kind permission to conduct this research work at their factory premises and for their thoughtful suggestion and surveillance during the entire period of this research work.

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