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Prospect of implementation of lean manufacturing for apparel industries in Bangladesh

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ABSTRACT: *Lean manufacturing is a systematic approach to identifying and eliminating wastes (non-value added activities) through continuous improvement by conveying the product at the pull of the customer in pursuit of production. In a more basic term, more value with less work. Traditionally operated garment industries are facing problems like low productivity, longer production lead time, high rework and rejection, poor line balancing, low flexibility of style changeover etc. These problems are addressed by the implementation of lean tools like cellular manufacturing, single piece flow, work standardization, just in time production, visual lighting system etc in a lean line and compare with a traditional line for analyzing productivity as well as increasing sewing line efficiency. After implementation of lean tools, results observed were highly encouraging. Some of the key benefits entail production cycle time decreased by 8%, Waiting time reduced average 35%, number of operators required to produce equal amount of garment is decreased by 14%, rework level reduced by 80%, Transport time saves about 20%, production lead time comes down to a significant level, work in progress inventory stays at a maximum of 100 pieces from around 500 to 1500 pieces. Apart from these tangible benefits operator multi-skilling as well as the flexibility of style changeover has been improved. Considering all those facts this paper provides a roadmap as well as a framework to those manufacturing companies who are really operating significantly below their potential capacity.*

Keywords: *Key productivity indicator comparisons and limitations, Lean philosophy, Productivity comparisons, Tools, Waste minimization*

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I. INTRODUCTION

Lean is a term to describe a system that produces what the customer wants, when they want it, with minimum waste - it is based on the Toyota production system. Lean manufacturing is a manufacturing philosophy that shortens the time between the customer order and the product build/shipment by eliminating sources of waste. The apparel industries must produce momentous quantities in shorter lead times. Apparel product is highly correlated with high level of productivity; sewing line should be balanced in shorter possible time and effective way for each style and quantity. To survive in the competitive market, the goal of any manufacturing industry is to produce goods at the lowest time possible and the lowest cost. In some cases it has been observed that, industries have been running in a traditional way for years and are rigid to change[1]. They are happy as long as they are sustaining their business. They don't have much confidence and will towards innovation over old processes. Now the time has come to struggle with global market demand and niche market in garment industries if they want to run it further. This project is mainly based on productivity Analysis where to hit upon various wastes and costs in Traditional line and also to overcome those by applying tools on lean lines that increase the whole sewing line efficiency.[2]

II. MATERIALS AND METHODS

Comparing Productivity: For comparing productivity, we collected data from sewing floor of INTERSTOFF CLOTHING LIMITED. We considered two lines (traditional & lean line) & differentiate between them. To calculate standard time for each operation, time study is conducted in the shop floor. To do this, the standard tank top is selected as a base line because operations differ from style to style and it is difficult to correlate all these operations of individual styles. After that, at least two operators were selected for each operation so that the difference in timing can be cross checked from the observed data of these two operators. To get better results, each operation time is taken for at least 10 cycles[3]. Once time study is made by collecting raw data the performance rating is given to each operator and actual time is calculated for particular operation. Finally the Personal Fatigue and Delay (PFD) component is added on the calculated time and the operation time is standardized. The format of time study data collection sheet is attached below. While conducting time study some parameters are kept fixed (for example machine speed, stitches per inch, type of machine used etc.) to get consistent results. The PFD factor is taken as 15% of total time. This PFD is a little bit higher than normal industry standard; it is taken higher considering the standing operation and operator's movement inside the cell. Similarly the average performance rating is taken 100% for the ease of calculation only. This rating is adjusted average of actual ratings.[4]

Traditional operational break down

Table 1: Style name: polo shirt

SL. NO	Operations	No of wor-kers	Machine	Std. SMV	Actual Time in second	Allo wance 20% (s)	Std. Time Sec.	Capacity
1	Front part Folding	1	Table	0.18	11	2.2	13.2	277
2	Front part placket making	1	Table	0.21	7	1.4	8.4	450
3	Placket rulling	1	Lock stitch	O.31	15	3	18	200
4	Placket marking	1	Table	0.40	12	2.4	14.4	257
5	Placket attaching	1	Plain m/c	0.26	17	0.3	20.4	180
6	Loose tuck	1	Plain m/c	0.18	9	1.8	10.8	327
7	Front bach matching	1	Table	0.19	12	2.4	14.4	257
8	Shoulder matching	1	Over lock	0.31	10	2	12	300
9	Label joining	1	Plain m/c	0.30	21	4.2	25.2	144
10	Collar marking	1	table	0.28	11	2.2	13.2	277
11	Collar joining	1	Plain m/c	0.30	28	5.6	33.6	106
12	Collar scissoring	1	Over lock	0.27	3	0.6	3.6	900
13	Collar joining	1	Plain m/c	0.15	25	5	30	120
14	Sleeve match	1	table	0.28	8	1.6	9.6	360
15	Sleeve join	1	Over lock	0.24	8	1.6	9.6	360
16	Collar shining	1	Cutter	0.28	17	3.4	20.4	180
17	Collar binding	1	Plain m/c	0.25	10	2	12	300
18	Collar top stitching	1	Plain m/c	0.40	11	2.2	13.2	277
19	Placket close	1	Plain m/c	0.12	11	2.2	13.2	277
20	Placket close	1	Plain m/c	0.16	12	2.4	14.4	257
21	Placket box	1	Plain m/c	0.40	19	3.8	22.8	157
22	Placket box stitch	1	Plain m/c	0.52	12	2.4	14.4	257
23	Placket box stitch	1	Plain m/c	0.30	34	6.8	40.8	88
24	Collar top stitch	1	Plain m/c	0.30	21	4.2	25.2	144
25	Side joining	1	Over lock	0.13	28	5.6	33.6	106
26	Side joining	1	Over lock	0.26	21	4.2	25.2	144
27	Collar tuck	1	Plain m/c	0.12	11	2.2	13.2	277
28	Thread cut	1	table	0.23	2	0.4	2.4	1200
29	Bottom hem	1	Flat lock	0.15	9	1.8	10.8	327
30	Sleeve hem	1	Flat lock	0.30	12	2.4	14.4	257
31	Button holing	1	Button holing m/c	0.14	7	1.4	8.4	406
32	Button attaching (5)	1	Button attach- ing m/c	0.2	12	2.4	14.4	257
33	Thread cutting	5	table	0.3	36	7.2	43.2	82
		37		7.78			511.6	

Productivity:

= output/input x100%

=110/160 x100%

=68.75

SMV= 511.6/60

=8.53

SMV increased=(8.53-7.78)/7.78x100%

=9.6 %

Efficiency% of line= (Total productionxsmvx100)/(No of working Hourx6o)

= (110x8.53x100)/ (37x1x60)

= 42.27%

SMV target fulfillment**:** (110-160)/160x100%

= 100%-31.25%

68.75%

Basic peace time (B.P.T) =Total time/total manpower

=511.6/37

=13.827 sec.

Capacity/hr=3600/13.827

=260 pcs

Lean line operation Break Down

SL. No.	Operations name	Machine	No of wor- kers	Actual Time Sec	Allow -ance	Std. Time Sec	Cap- acity
1	Placket mark	table	1	11	2.2	13.2	277
2	Placket rull +body match	Over lock m/c	1	12	2.4	14.4	258
3	Attach placket	Plain m/c	1	15	3	18	200
4	Placket fold tuck	Plain m/c	1	9	1.8	10.8	333
5	Front back matching	Table	1	9	1.8	10.8	333
6	Shoulder join+cut	Table	1	16	3.2	19.2	187
7	Care label attach	Plain m/c	1	20	4	24	150
8	Collar marking	Table	1	17	3.4	20.4	177
9	Collar join	Plain m/c	1	19	3.8	22.8	157
10	Sleeve match	table	1	4	0.8	4.8	750
11	Sleeve join With body	Overlock	1	35	7	42	86
12	Sleeve join	Overlock	1	23	4.6	27.6	130
13	Collar binding	Plain m/c	1	15	3	18	200
14	Binding cut+over	Table	1	12	2.4	14.4	250

	turn						
15	Collar top stitch	Plain m/c	1	14	2.8	16.8	214
16	Placket close(r)	Plain m/c	1	16	3.2	19.2	188
17	Placket close(l)	Plain m/c	1	15	3	18	200
18	Make placket box	Plain m/c	1	42	8.4	50.4	71
19	Make placket box	Plain m/c	1	29	5.8	34.8	103
20	Arm hole join	Flat lock m/c	1	16	3.2	19.2	188
21	Side join	Overlock m/c	1	40	8	48	75
22	Side join	Overlock	1	33	6.6	39.6	91
		m/c					
23	Plucket tuck	Plain m/c	1	19	3.8	22.8	157
24	Body hem	Flat lock	1	13	2.6	15.6	230
25	Sleeve hem	Flat lock	1	19	3.8	22.8	157
27	Button holing	Button holing m/c	1	18	3.6	21.6	167
28	Button attaching	Button attachin—g m/c	1	5	1	6	600
29	Thread cutting	cutter	2	45	9	54	67
			=29			=649.2	

Productivity: output/input x100%
=140/160 x100%

=87.5

SMV= 649.2/60

=10.82

Standard SMV=12.94

SMV decreased=(12.94-10.82)/10.82x100%

=19.6 %

Efficiency% of line=(Total productionxsmvx100)/(No of OP x working hourx60)
= (140x10.82x100)/ (29x1x60)

= 87.05%

SMV target fulfillment:

=(140-160)/160x100%

=100%-12.5%

=87.5%

Basic peace time (B.P.T) =Total time/total manpower

=649.2/29

=22.38 sec.
Capacity/hr=3600/B.P.T

=3600/22.38

=160 pcs

TABLE 2: Productivity analysis

Topic	Traditional line	Lean line
Productivity	68.75%	87.5%
Line efficiency	42.27%	87.05%
SMV reduction	-9.6%	19.6%
SMV target Fulfillment	68.75%	87.5%
No of worker	37	29
Bottlenecks	2	Nil
Capacity/hr utilization	110 out of 160	140 out of 16

Key productivity Comparing: The critical starting point for lean thinking is value. Value can only be defined by the ultimate customer, and it is only meaningful when expressed in terms of a specific product which meets the customer's needs at a specific price at a specific time. Value is created by the producer. From the customer's point of view, this is why producers exist. Everything that does not add value to the product is waste, and is something that the customer is not willing to pay for.

2.4.1 Transport Analysis: Transportation waste includes all the unnecessary transportations of material, work in process and components, which do not add any value to the product. It also adds manufacturing lead time. In a well designed system, work and storage areas are positioned to minimize the transportation work (quantity*distance). It is necessary to distinguish between rationalization of transportation and a removal of the need for transport. Automating transport is fine, but eliminating the need for transport is even better. For instance, if machines can be grouped together in a cell-based layout, the physical connection of the flow of products makes product useless. Unnecessary transportation is often a consequence of bad layout. However it's not easy to find the optimal layout and a lot of trade-offs has to be done [5]. The layout in many factories is designed from a mass production perspective. Equipment and machines are often grouped together on a functional basis, e.g. milling in one area and iron sheet presses in another. The functional layout often causes a lot of transportation between the functional areas (Slack et al, 2001).

Table 3: Transport analysis

No.	From	To	Dis- Tance inFeet	what	Qua- ntity pcs	Method of transport	Time Min	Time In a day
1	Relax- ation store	Cutt- ing	16	fabric	30,000	Manual	0.25	250
2	Cutt- ing	Sew- ing	54	Cutt- ings	30000		1.5	750
3	Sew- ing	Iron- ing	42	Garm- ent	25000		1	417
4	Iron- ing	Final QC	3		25000		0.05	25
5	Final QC	Pack- ing	109		25000		3	1250
								=2692

Transport time wasted in traditional: 2692 min/day or
=44.87 hrs/day

Cost in traditional transport= 44.87x150 tk

=6730.5 tk /day or 174992 tk/month
Transport time wasted in lean line

=2692x2.10/100

=565.32 min/day or 9.422 hrs/day Cost in lean production:9.422x150 tk
=1413.3 tk/day or 36745.8 tk/month Cost reduced=(174992-36745.8)tk/month
=138246.2 tk/month or 1658954.4 tk/yr

Table 4: Transport analysis

KPI	Unit of Measure	Traditional line	Lean line	Improvement	Remarks
Transportation	Feet	208	99	210.10%	Reduced 2.10 times

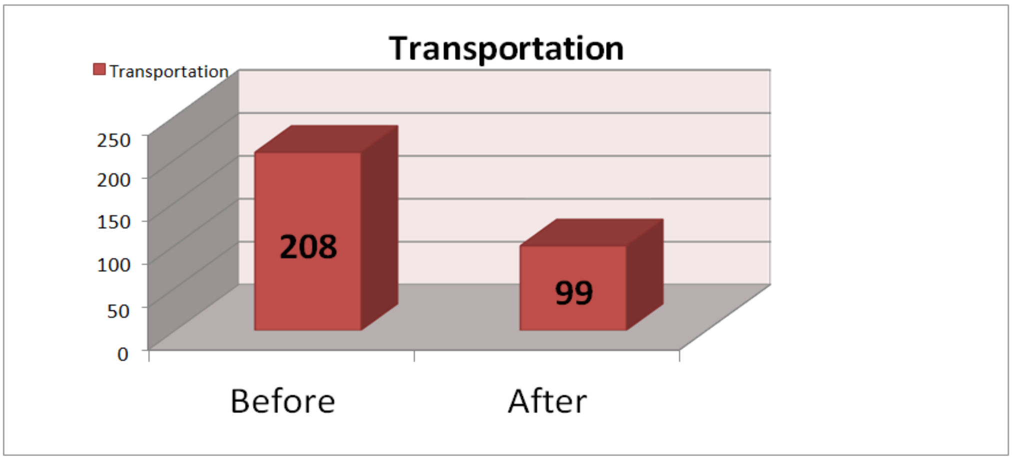

Figure 1: Transportation analysis traditional vs lean

2.4.2. Waste of time: Waste of time occurs in many different forms. Waiting for correct information, products waiting to be processed, machines waiting for their operator and waiting for material to arrive are examples of waste of time. One of the most common wastes of time is products waiting in inventory. An investigation of a product's flow through the factory often shows that it is only being processed a few percent of the total throughput time. The rest of the time is waiting in inventory, which is pure waste. Reducing inventory is an important issue when reducing waiting time. Waste of time occurs in many different forms. Waiting for correct information, products waiting to be processed, machines waiting for their operator and waiting for material to arrive are examples of waste of time. One of the most common wastes of time is products waiting in inventory. An investigation of a product's flow through the factory often shows that it is only being processed a few percent of the total throughput time. The rest of the time is waiting in inventory, which is pure waste[6]. Reducing inventory is an important issue when reducing waiting time.

Table 5: Through put time analysis

KPI	Unit of measure	Traditional line	Lean line	Improvement	Remarks
Throughput time	Minute	195	68	286.73%	Reduced 2.87 times

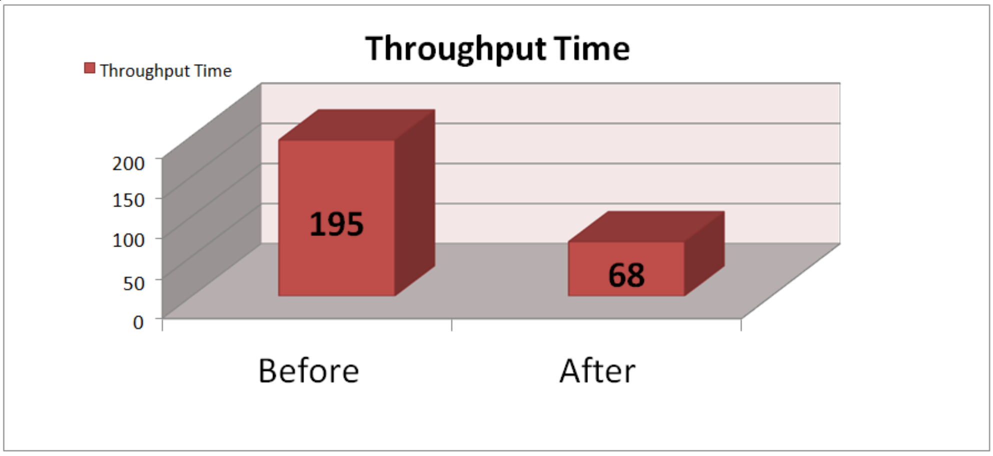

Figure 2: Throughput time traditional vs. lean.

Inventory: Keeping parts and products in inventory do not add value to them. In manufacturing, inventory in the form of work in process is especially wasteful and should therefore be reduced. Apart from being wasteful itself, inventory also hides other problems and prevents their solutions. The effects of reducing work in process therefore go beyond that of reducing capital employed. However, it is not advisable to eliminate inventory mindlessly. Instead, the reasons for the existence of inventory must first be removed.

Two types of inventory are common in manufacturing; work in process (WIP) and part storages. WIP is the inventory kept between operations or products being processed. The definition of WIP is here narrowed to only include the inventory kept between operations, and not the products being processed. Part storages are the raw material and components that have been delivered from the main warehouse out to the workstations[7].

Lean manufacturing emphasizes the importance of reducing inventory, since it is considered to hide productivity problems caused by unwanted variation and complicated set-up procedures. Inventory can be reduced by either reducing buffers (buffer inventory) or batch sizes (cycle inventory). Buffer inventory is reduced by eliminating unwanted variation and cycle inventory is reduced by decreasing set-up costs and bath sizes.

Table 6: WIP analysis

KPI	Unit of measure	Traditional line Unit ofmeasure	Lean line	Improvement	Remarks
Inventory/WIP	Quantity	796	352	226.14%	Reduced 2.26 times

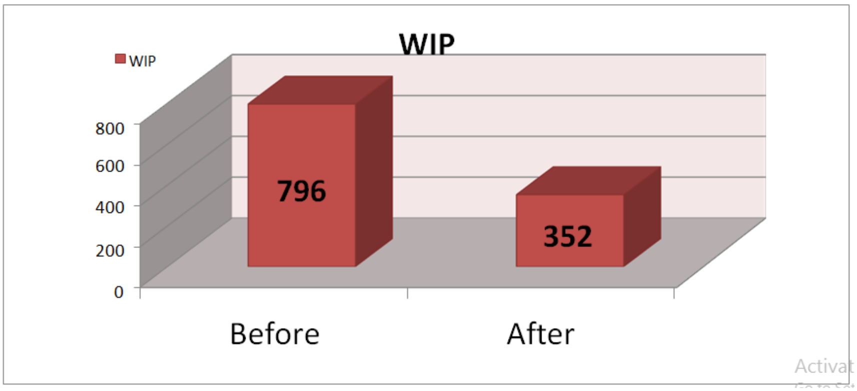

Figure 3: WIP analysis traditional vs. lean.

Team organization: Creating multifunctional teams is a good tool against hierarchical systems, as teams often achieves better results than individuals working on their own. Leveling the organization might lead to a more flexible production, as tasks can be decentralize to the shop floor workers. Teamwork is not only about production tasks but also indirect functions like maintenance and material handling. By delegating tasks to the team on the production line, indirect labor costs can be reduced. The minimization of indirect work is one of the main issues with lean manufacturing[8].

Table 7: Productivity man-hr analysis

KPI	Unit of measure	Unit of measure	Lean line	Improvement	Remarks
Productivity/ Man-hr	Quantity	8.87	20.9	135.63%	Productivity increased 1.35 times(based on 100 pcs)

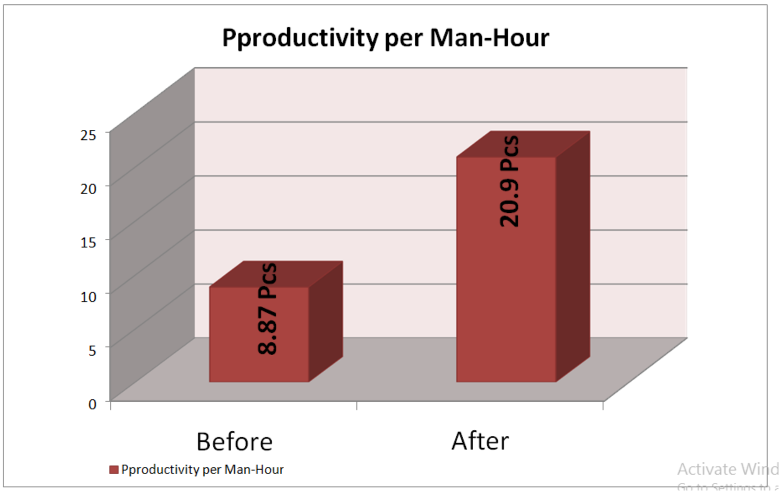

Figure 4: Productivity per man-hr

2.4.5. Space utilization: Implementing lean in production system ensures maximum space utilization and thus reduces cycle time & increases efficiency.

Table 8: Space utilization analysis

KPI	Unit of measure	Traditional line	Lean line	Improvement	Remarks
Space utilization	minute	4.22	3.62	116.57%	Reduced1.17 times

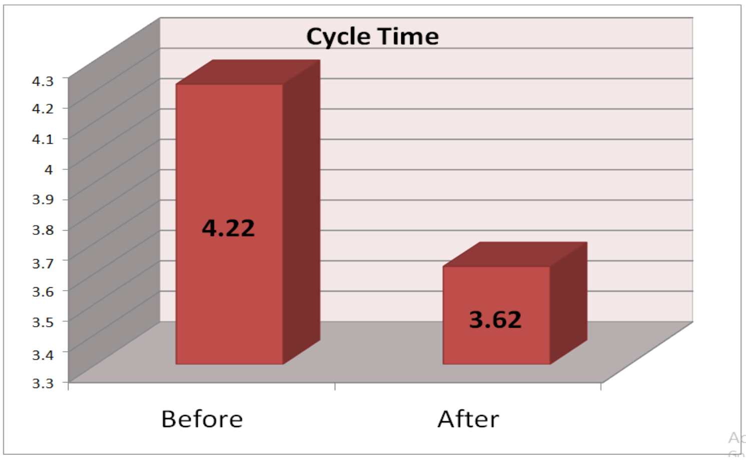

Figure 5: Space utilization traditional vs. lean

Work procedures at stations: The work at the stations in the factory will to high extent be influenced by the implementation of lean. Some procedures will probably have to be changed and improved, and it is therefore necessary to map the current work at the stations. Standardization, material handling, visualization and environment are investigated in this area.

Table 9: Workstation analysis

KPI	Unit of measure	Traditional line	Lean line	Improvement	Remarks
WORK STATION	Quantity	20	8	222.22%	Space reduced 11 times

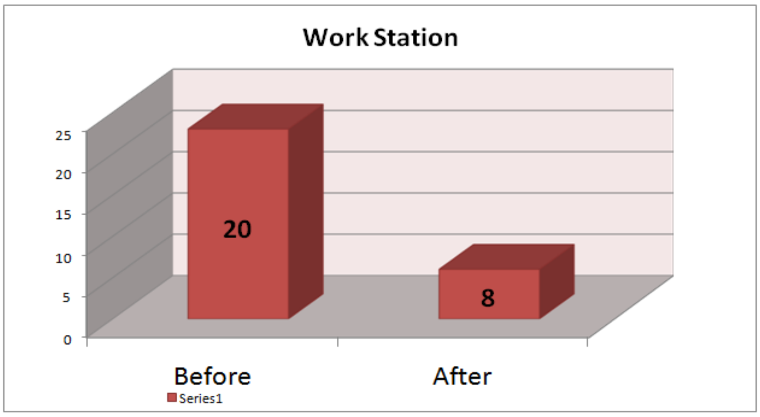

Figure 6: Work station traditional vs. lean.

Defects: Poor quality and the resulting defects are a major source of cost for many companies. This is also a cost that is often under reported as there are direct and indirect effects of defects. A defect is any error in a process that makes a product or service less valuable to a customer, or that requires additional processing to correct the defect. The adoption of lean at many companies started with a focus on quality. Total Quality Management was a major manufacturing initiative before lean was adopted on a widespread basis. It was easy for a company to recognize that defects were wasteful. As a result, quality initiatives designed to reduce and eliminate defects are often some of the most mature lean initiatives in a company.

Table 10: Defects analysis

No. of line	Daily avg. mistake%	No. of mistakes	Avg. cycle time /mistake(min)	Total time waste for all lines
Traditional :19	7.5%	228	2.3	525
Lean:4	4%	26	2.3	60

Total Wasted minute in Traditional line:
=525 min/day or 8.75 hour per day or 227.50 hours/month Cost = 8.75x150 taka
=1312.5 taka per day or 34125 taka month Total Wasted minute in lean line:
=60 minutes/day or 1 hr/day or 26 hr/month Cost: 1 x 150taka
=150 tk /day or 3900 tk/month

III. RESULTS AND DISCUSSIONS

Since the 1990's researchers have set out to better understand the relationship between Lean and traditional manufacturing systems, given that both systems focus centrally on the elimination of waste. Our Bangladeshi RMG sector is one of the global competitors in the textile world. We are standing at the 2nd position regarding global textile market share. Our competitors are India, Pakistan, Turkey, Vietnam etc. It is a too tough job for us to compete those countries because raw material is our main problem. Producing quality products with a less price is considered one of the main ways to sustain. But this is possible only when we will be able to eliminate waste and make the best use of material and man power.

Our research to place on the basis of a idea-

- Using time study to balance a sewing line. Calculate productivity by using the method. Arrange the line according to lean manufacturing system. Now observe the productivity. Using time study for increasing productivity:

Time study is a part of work study. It implements the use of SMV calculation to identify the points where production has gone below the standard level and the places where the production is above the standard. Then it is balanced to remove bottle neck in order to increase productivity. This system was effective and helpful.

- Considerable improvement observed by using time study as a line balancing technique changing form traditional layout to balanced layout model.
- The exchanges of work between the operator & helper caused a significant change in line results of reducing wastage of time, minimum no. of worker and which caused high productivity in the manufacturing process.
- This balancing process also leads to increased output per day, labor productivity, machine productivity and overall line efficiency.
- The overall results relay on maximum profit of the company with effective use of its available resources.

Our efforts and analysis says it is an effective method that helps to increase productivity. It is easy and can be applied in a simple way. But to sustain in the competitive market we need to gear more productivity. Here lean can help us to get the right results as it has some more potential tools and systems.

Table 11: Comparing key productivity indicator

Topics	Unit of measure	Traditional line	Lean line	Impro- vement	Remarks
Transpor- tation	Feet	208	99	210.10%	Reduced 2.10 times
	Tk/ month	174992	36745.8	210.10%	Reduced 138246.2 tk/month
Through Put time	Minute	195	68	286.73%	Reduced 2.87 times
Inventory	quantity	796	352	226.14%	Reduced 2.26 times
Manpower	person	22	6	366.67%	Reduced 3.67 times
Productivity/ Man-hr	quantity	8.87	20.9	135.63%	Reduced 13.56 times
Space utilization	Min	4.22	3.62	116.57%	Reduced 1.17time
Work station	quantity	20	8	222.22%	Reduced 11 times
Defects	Number (for 1 line)	12	6.4	187.5%	Reduced 18.75 times
	Tk/month	34125 tk	3900 tk	875%	Cost saving= 30225 tk

Table 12: Productivity analysis

Topic	Traditional line	Lean line
Productivity	68.75%	87.5%
Line efficiency	42.27%	87.05%
SMV reduction	9.6%	19.6%
SMV target Fulfillment	68.75%	87.5%
No of worker	37	29
Bottlenecks	2	Nil
Capacity/hr utilization	110 out of 160	140 out of 16

Lean results increased productivity: The factors of lean are related to each other. The high inter-correlation between the factors lends further support to the "configuration" argument and suggests that managers are able to discern the close relationship and yet make distinctions between them. More specifically, our results indicate that practicing different tools and factors give a consistent production result.
Productivity is described as a comparison of input and output. It can be achieved in two ways: Way1: If output is increased after keeping fixed input.
Way2: It output is increased or same after decreasing input.

In our project we worked with following the 1st way. During traditional system our input was 160pcs/hr and output was 110 pcs/hr with a productivity of 68.75%. But when we applied lean system then our input was same but the system was so efficient that we got an increase output of 140 pcs/hr. This is a clear indication for increasing productivity.
Reasons of increased productivity:

- A better level of labor productivity will automatically upgrade the level of value added activities and thereby can reduce waste and increase productivity.
- A better level of labor productivity will automatically upgrade the level of value added activities and thereby can reduce waste and increase productivity.

Reasons for waste Reduction:

- Due to use effective tools.
- Due to Skillness of the operators and training facilities.
- Due to incentives and other facilities

Where traditional system gives 67.8% efficiency there we have got 94% efficiency in lean manufacturing system. Actually efficiency is broad concept. An efficient working environment ensures efficient production system. The increase of efficiency is highly concerned with different types of tools. Reduced waste, use of just in time system and a good Resulting increased efficiency.Team work ensures good efficiency of works make the right layout and the layout has the sufficient contribution in increasing efficiency.

We followed the following concepts to make it better:

1. Higher utilization of space, equipment, and people.
2. Improved flow of information, material or people.
3. Improved employee morale and safer working conditions.

IV. CONCLUSION

We have completed our project work successfully by the grace of almighty Allah. From this project work we got flavor of actual production environment and got an idea how our future working environment is going to be. We concentrated the wastes that results a remarkable improvement in quality and productivity and hence the profit. It is also emphasized that the lean line is made without any extra investments on the machine or materials and it is merely an implementation of lean methods. Awareness must be created among the workers and supervisors to control the other deadly wastes such as over processing, more inventories, etc. In short, implementing lean manufacturing in apparel industry will certainly make Bangladesh a paragon to textile world.

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