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Increase the Efficiency and Productivity of Sewing Section through Low Performing Operators Improvement by using Eight Wastes of Lean Methodology

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Abstract- This paper represents the use of some tools and techniques to increase the efficiency and productivity of an apparel sewing section through low performing operators' improvement. Now a day's apparel manufacturing industries are trying to develop their current production system and situation and continuously looking for new production tools and techniques to keep swiftness with the rapid changes of the trend in consumers of apparel products. To deal with the current situation and fulfill customer demand within lead time, whole production system should be more capable and efficient. Full apparel is produced based on the performance and contribution of individual workforce. There is no doubt that operators are selected and appointed on the specific tasks based on their evaluation and performance level where they are capable. But with the rapid changes of apparel products style, excessive pressure on sewing floor & imbalance in the sewing section, sometimes some operators can't keep pace with the desired production processes. If we observe a garments production line, we will see that there are lots of in-process inventories and wait time between almost every sequential operation. The materials used to travel an extensive distance from the input receiving to needle check and disposal. Many movements and handlings are practiced by the operators which are unnecessary. Sometimes reworks are increasing the total completion time. As a result, the productivity is hampering in the sewing section. In this paper, the wastes firstly found out from some selected operations, and then some tools and techniques have been implemented to eliminate those wastes, and by applying these techniques, significant improvements in the sewing section have been achieved. The manufacturers of homogeneous apparel industries can expand the findings in future.

Keywords: workstation layout, low performer, sewing section efficiency, worker capacity, time study, eight wastes of lean, performance%, line balancing, bottleneck, productivity.

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I. Introduction

The Ready Made Garments (RMG) industry is the significant export – base (77%) for Bangladesh and it has a major impact on country's economy, as well as on society, because of a substantial number of worker involvement [8]. The RMG industries are continuously providing the single source of growth in Bangladesh's rapidly developing economy. Because of being technologically labor dependent, it has a large number of worker involvement, and most of them are female workers, so it helps in socio-economical development of the poverty-stricken fraction of the population of the country. Many reputed buyers prefer this country for manufacturing for lesser labor cost with high quality of products [2]. The RMG industries are getting very competitive to attract the well-known buyers, and in today's competitive era, the manufacturers mainly need to be concerned about time, cost, quality, and delivery [10]. It is obvious that assembling apparel is a highly laborious process where a great number of people participate. But it is a matter of consideration that all the labors performance and capability are not same. So capacity variation occurs very frequently as working capacity differs from man to man. As a result, the production system often gets very problematic to ensure its smoothness. In case of running the smooth production, sometimes some operators have been highlighted as the low performers who are producing less as well as creating problems for the others. The combination of the machines to the operators is needed to specify to make the best use of both of them. Taiichi Ohno, considering the father of Toyota Production System, created a lean manufacturing framework, which was on the basis of the idea of preserving (or increasing) value with less work. Anything that doesn't increase profit in the eye of the customer must be considered waste, or "Muda," and every effort should be made to eliminate that excess [9]. The acronym for the eight wastes is TIM WOODS. TIM WOODS stands for: Transport, Inventory, Motion, Waiting, Overproduction, Over-processing, Defects & Skills. Elimination of these eight wastes from production

floor can help the manufacturers to produce the quality product with less material, higher efficiency, shorter lead time, and in a timely manner. The manufacturers can reduce approximately 43% lead time by implementing the lean technique in the sewing industry [1]. This paper addresses the application of these eight wastes of lean to identify the reasons for being a low performer and then the implementation of necessary tools and techniques to eliminate those findings.

II. Literature Review

a) Productivity

Productivity is the measure of output per unit of input [3]. In garments sewing section, the operation breakdown of a garment consists of several long, medium and short operations and operators also allocated on those specific operations based on their performance and grade. Generally, critical procedures are taken care of by grade – A operators while semi-critical by grade – B and the grade – C operators appointed to other types of working. The productivity of them can be measured by how they are using their allocated resources in a worthwhile manner e. g. time, energy, skill, etc. to achieve established goals based on the relationship between inputs and outputs. If operators don't make the best possible use of those resources skillfully and wisely, they can't get the results and accordingly line's total production and efficiency will fall. So, productivity improvement of individual operators is very superior.

b) Line Layout

The sewing line layout is a formation where sewing workstations are placed on the sewing floor to form a line (or batch) that works on a single style. Materials start flowing from the back to the front in a sequential order. All part sub-assemblies are started at the right time to be ready at the required time and kept moving until the finished product is available at the end of the assembly line. The line to be followed by the product during travel may be straight, U-shaped, circular or zigzag and the machines lay in the order in which they are to be used [3].

c) Workstation Layout

Workstation layout is the arrangement of the required items in a specified way at a designated area where specific job or jobs are performed. To do the operations within the least possible time, their handling movement needs to be the minimum. The components need to place within the nearest hand distance to the operators so that they can pick them simply. In the apparel industry, an ideal workstation layout should consist of minimum picking and disposal area, least movements and minimum length of every action.

d) Line Balancing

The total work to be performed at a workstation is equal to the sum of the tasks assigned to the workstation. Balancing the line means jobs assigned to the workstations in a specified way so that each workstation has no more than can be done in the workstation cycle time, and so that unassigned (idle) time across all workstations minimizes. In a balanced line, materials will flow smoothly and no time will be lost in waiting for work. An appropriate balancing of a sewing line depends on the mechanism of work cell deign and it needs to be linked with the other decisions to function well.

e) Time Study

Time study is a method of measuring work for recording the times of accomplishing specific tasks or its elements carried out under specified conditions. An operator does same operation throughout the day. Time study helps to define how much time is necessary for an operator to carry out the job at a defined rate of performance. The aim of time study is to establish a time for a qualified worker to do definite work under stated conditions and at a stated amount of working.

f) SMV (Standard Minute Value)

SMV stands for Standard Minute Value, which indicates a standard period, and within that a required amount of work needs to be done through following the standard procedure with worker's "standard performance". For measuring how much time is required for doing a definite amount of workload, proper SMV set up is needed in garments production floor.

Standard Time = (Average observed time X Rating %) + Allowance%

g) Progressive Bundle System

Bundles consist of garment parts need to complete a specific operation of garment component [11]. In readymade garment manufacturing plants, the manufacturers install various types of sewing systems. Operation head chooses these systems depending on the volume of production, product categories and cost-effectiveness of high tech machines. Among those "Progressive Bundle System (PBS)" is mostly installed sewing system till date. In this production system, bundles of cut pieces (bundle of 5, 10, 15, 20 or 25 pieces) are moved manually to feed the line. Then inside the line, an operator himself drags the bundle from the side table and transfers the bundle to the next operator after completion of the work. Quality inspectors track the bundles if they are coming sequentially.

h) Bottleneck in Production Line

In a production sewing line, where supply gathered, production goes under capacity and lots of

garment's parts on specific workstation remain unattached, those areas are termed as bottleneck areas and which works as a constraint for smooth flow of production is termed as bottleneck [2].

i) Low Performers

A company's overall performance depends on the contribution of every employee, and a company is only as strong as its lowest-performing employees. Low performers are those who struggle to do his/her job according to the standard method and who is causing problems to the other operators in the whole section. The operators who normally take more time than established, produce lesser than target and causing bottlenecks, causing defects while doing the operation and reworks needed to be done, etc. are termed as low performers. Operation management can improve the low performers through identifying the causes they are facing and eliminating those and giving them the proper training so that they can understand their job very well.

j) Eight (8) Wastes/Mudas of Lean

There are eight types of wastes which are following:

i. *Transportation*

Waste caused by moving things around. Too much transportation tends to increase costs, wastes time, increases the likelihood of product damage and deterioration and can result in poor communication. Limiting transportation waste can be easily addressed by sound judgmental efforts such as simplifying processes, repairing physical layouts, handling products less often, and making distances between workstations as short as possible.

ii. *Inventory*

Work in Process (WIP) Inventory is material between operations due to large lot production or processes with long cycle times. This waste occurs when there is supply more than real operators' demand, which masks real production. Approximately 60% of wastes occur in garments industry due to inventory [5].

iii. *Motion*

Any excess movement that doesn't add value to the product, service or process [9]. The motion includes any unnecessary physical motions or walking by workers which diverts them from actual processing work.

iv. *Skill*

Not or under-utilizing peoples' talents, skills, and knowledge can have a detrimental effect on an organization. Companies can experience great benefits when recognizing the value of skills and breakthrough performances from all levels and can suffer when not effectively engaging in the process.

v. *Waiting*

This occurs whenever work has to stop for some reasons: because the next person in line is overwhelmed, because something broke down, because operators are waiting for approval of materials, or because they've run out of something.

vi. *Overproduction*

Unnecessary production of more quantities than required can be termed as overproduction [1]. In some organizations, workers just blindly keep producing, even when those who receive their output either aren't ready for it or don't need it. Line balancing and improved work design can contribute primarily to reduce the waste of overproduction.

vii. *Over-processing*

When a revise or redone of procedure or product happens for something because it wasn't correct at the first time or taking unneeded steps to process the parts, inefficiently processing due to the poor tool and product design, causing unnecessary motion and producing defects [10]. In the apparel industry, this waste relates to defects because operators often produce alterations on their operations and so rework needed to be done regularly.

viii. *Defects*

Mistakes that require additional time, resources, and energy to fix. In a manufacturing process, a defect might involve a defective part that worker has to redo. Production of faulty parts or correction, repair or rework, scrap, replacement production, errors in paperwork, provision of incorrect information about the product, late delivery, and inspection mean extravagant handling, time, and effort.

III. Methodology & Experimental Work

This study was carried out in a reputed woven (top) garment industry situated at My mensingh in Bangladesh. In this study, a woven shirt (Men's Flannel shirt with two pockets and flaps) was analyzed, and the critical points were identified. There a line was selected where production was minimum compared to the others.

a) Data Analysis of the experimented sewing line

Here ten cycle times for each operation was recorded, and at the same time, the name of the operator or helper, attachment used and machine type was recorded in a time study template sheet. Before starting the time study, the breakdown of the progress of operation was done. After recording ten cycle times; average cycle time was calculated from which basic time or cycle time was found. Then from cycle time, the potential capacities per hour and performance% were calculated.

b) Identification of low performers

The calculated data visibly highlighted the low performers based on their performances and capacities and bottleneck areas were found out. Analyzing the data, seven (7) operators were selected for whom bottlenecks creation and less production were happening. They were selected for the further experimentation to be improved. The picked seven low performers with their potential capacity and performance against standard time data are given below:

Table 1: Low performers with potential capacity and performance% against standard time

Sl. No.	Operator Name	Operation Name	Machine Code	SMV	Capacity CT	Capacity/Hr	Performance%
1	Julekha	Attach Collar Band to Collar	1N2TLS-EC	0.56	0.85	71	65.88%
2	Khaleda	Make Front Left Placket (Top Placket)	4N8TCS-Kan	0.35	0.69	87	50.72%
3	Nasrin	Press Pocket (Auto)	Creasing m/c	0.41	0.83	72	49.40%
4	Lily	Attach Pocket to Front	2N4TLS-UBT	1.22	2.45	24	49.80%
5	Sharmin	Attach Pocket to Front	2N4TLS-UBT	1.22	2.59	23	47.10%
6	Rokeya	Attach Sleeve to body	2N4TCS	0.93	1.83	33	50.82%
7	Tahmina	Attach Cuff with 2 Pleats	1N2TLS-UBT	0.81	1.46	41	55.48%

c) Implementation of tools & techniques to find out the reasons for low performance

For the improvement purposes, low performers can be defined as someone who is not achieving necessary QUALITY or QUANTITY; this could be either a trainee or a line machinist. An action flow chart is followed to observe what needs to take into consideration of the performing procedures. The flow chart is in the following:

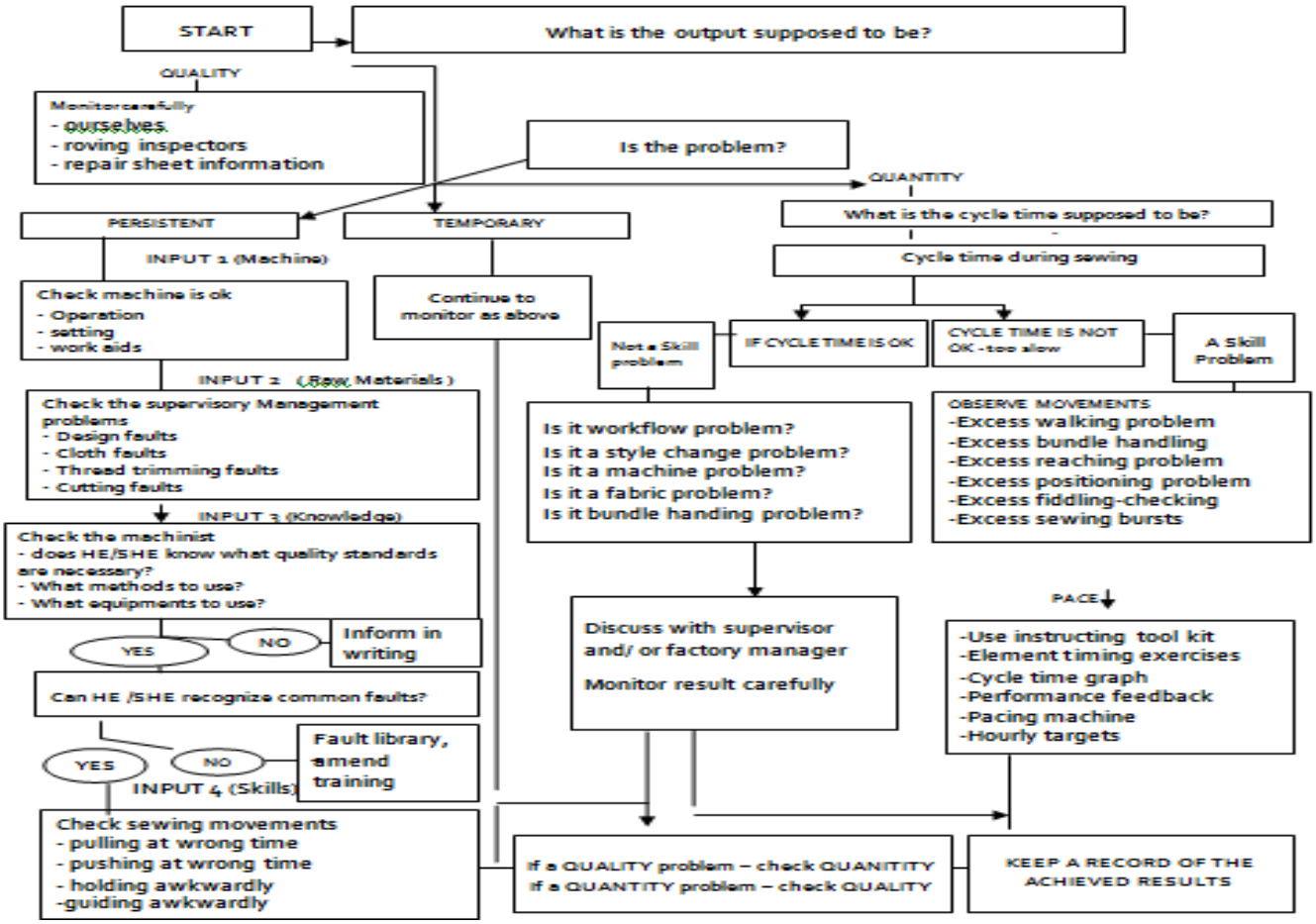

Fig. 1: Low performing operation monitoring chart

After that lean tool of wastes has been applied and the findings of every operation are listed below:

Table 2: The findings after implementing lean tool of wastes for low performers

Sl. No.	Operator Name	Operation Name	8 Wastes of Lean	Effective (Y/N)	Findings
1	Julekha	Attach Collar Band to Collar	Transportation	Y	After 2-3 bundle completion, operator herself needs to go to the collar band rolling operator to collect the next bundles
			Inventory	Y	The made collars from collar make operator and the lower part from cutting section stored beside her on the center table
			Motion	Y	Using trimmer 4-6 times for levelling the parts accordingly during the operation
			Waiting	N	
			Over Production	N	
			Over Processing	Y	As the bundles parts remain randomly on the center table, operator is matching the all 3 parts with one to another according to the cutting serial no. and bundle no.
			Defects	Y	Notch uneven
			Skills	N	
2	Khaleda	Make Front Left Placket (Top Placket)	Transportation	N	
			Inventory	Y	Front parts directly coming from the cutting department gathered right beside her
			Motion	Y	Approximately taking 5 bursts to complete each operation
			Waiting	N	
			Over Production	N	
			Over Processing	Y	Operator has to control the fabric during operation because the fabric is slipping out from the machine and affter completion of every bundle, she is checking if the check matches with each other
			Defects	Y	Raw edge out, Check match uneven, High-Low
			Skills	N	
3	Nasrin	Press Pocket (Auto)	Transportation	Y	At the end of bundle completion, operator has to stand & move towards the center table to dispose the pressed parts.
			Inventory	Y	Approximately 3-6 bundles stored on her side from pocket hemming operator
			Motion	Y	She is picking the pocket parts from the inside of the body parts and also disposing it into the front body parts after the operation
			Waiting	N	
			Over Production	N	
			Over Processing	Y	At the end of every pocket pressing, she is unwrapping paper or tissue everytime
			Defects	N	
			Skills	N	
4	Lily	Attach Pocket to Front	Transportation	N	
			Inventory	N	
			Motion	Y	Excess movement to check match and to match the diamond shapes
			Waiting	Y	Waiting to recieve bundles from the pressing operator
			Over Production	N	
			Over Processing	Y	Bundles coming to her by being half folded, she needs to open up, take the pocket parts, straighten the front parts, align & then sew
			Defects	Y	Check mismatch, High-Low in pockets, Slanted in diamond shapes etc.
			Skills	N	
5	Sharmin	Attach Pocket to Front	Transportation	Y	Far from pressing operator and so relying on the other operator to pass her the next bundle
			Inventory	N	
			Motion	Y	Taking 7 instead of 4 standard bursts
			Waiting	Y	Waiting to recieve bundles from the pressing operator
			Over Production	N	
			Over Processing	Y	Bundles coming to her by being half folded, she needs to open up, take the pocket parts, straighten the front parts, align & then sew
			Defects	Y	Check mismatch, Pocket alignment uneven etc.
			Skills	N	

Sl. No.	Operator Name	Operation Name	8 Wastes of Lean	Effective (Y/N)	Findings
6	Rokeya	Attach Sleeve to Body	Transportation	N	
			Inventory	N	
			Motion	Y	Excessive handling motion where she doesn't follow the basic instructions
			Waiting	N	
			Over Production	N	
			Over Processing	Y	Cutting the sleeve pair for separation before starting the operation
			Defects	Y	Pleated, Down Stitch etc.
			Skills	N	
7	Tahmina	Attach Cuff with 2 Pleat	Transportation	N	
			Inventory	Y	Center table beside her gathered fully with unattached cuffs
			Motion	Y	Slow hand movement and excessive motion taken
			Waiting	N	
			Over Production	N	
			Over Processing	Y	Cuffs arent's sorted out according to sizes and numbers, operator needs to find out the right cuff pairs
			Defects	Y	Lob uneven, Pleat depth uneven etc
			Skills	N	

The above study elucidated information that operators are working with many types of wastes in their workstations. The primary problems came out from the research were excessive motion, poor methods following and line unbalancing, unorganized workstation layout and high defect rates, etc. By using the lean tool, the wastes which were unnecessary in the sewing section had been found out. Those wastes were working as barriers against faster and improved production. By eliminating of those wastes, operators overall performance improvement, their capacity enhancement, performance improvement can be perceived, and with the improvement of those individual operators, the ultimate line's productivity could be increased. But after finding the wastes, then some steps needed to take into action to remove those specific problems and operators also should know those barriers what were hindering themselves not to reach to their goals.

d) Actions taken to eliminate wastes

Several actions were taken to rectify the problems from each operator.

To remove the wastes, the applied actions are presented in the following table.

Table 3: Actions were applied to remove the wastes from the low performing operations

Sl. No.	Operator	Operation	Actions Taken
1	Julekha	Attach Collar Band to Collar	1. Change the Line Layout where the band hemming operation is placed beside Collar band attach operation in a zigzag way.
			2. A stand placed at the operators right side
			3. Fix the standard of using 2-3 pokes by trimmers for alignment during the operation
			4. The extra capacity of the Collar Band Hemming operator & Collar Midline T/S is used to match the all 3 parts
			5. Trained the standard method by trainer & technician and bigger pattern is introduced instead of shorter one to the operator and check the next 20 pieces if the same defect comes again
2	Khaleda	Box Placket	1. Supervisor instructed to place only 5 bundles beside that operator in order to keep the workstation free and clean
			2. A special attachment of rubber mat is attached on the m/c so that fabrics can't slip out and operator doesn't need to pay extra attention to control the fabric during her operation
			3. This operator is mainly facing problem because of her coming defect rates. She is struggling to match the horizontal and vertical checks and thats why she is confused and taking extra time also to check after the operation. So she is again sent to the training room for relearning.
3	Nasrin	Pocket Press	1. Two stands at operator's both side are placed; one for the pocket parts placement and the other for disposal
			2. Change in method: Previously she has to take the pocket parts from the inside of the bodies where bodies being half folded & has to dispose like the same way. The new method involves body parts directly will go to pocket attach operation after top & bottom placket operation. So, pocket press operator will receive the pocket parts only from the pocket hemming operator.
			3. Operator previously responsible to unwrap the paper after pressing. Now according to new way, operator won't unwrap the paper, it will directly go to pocket attach operators & they will responsible for unwrapping by themselves.

Sl. No.	Operator	Operation	Actions Taken
4	Lily	Attach Pocket to Front	1. Operator previously received bundle in a randomly manner where body parts being half folded consisting of pocket parts inside. Now, they will receive pocket parts only from pressing operator according to bundle number where front parts will be received from the Top & Bottom Placket operators in a straight formation according to the sizes and same bundle no.
			2. The extra capacity of side label attach operator sometimes used to unwrap the paper from the pocket parts.
			3. This operator's wrong handling movement causing defects sometimes. Besides extra time is taken to align the parts. So standard method & operational breakdown time is ensured.
5	Sharmin	Attach Pocket to Front	1. Change in line layout and workstation layout to fix the operator's position nearer to the pocket pressing operator so that she doesn't have to wait so long to receive.
			2. Operator previously received bundle in a randomly manner where body parts being half folded consisting of pocket parts inside. Now, they will receive pocket parts only from pressing operator according to bundle number where front parts will be received from the Top & Bottom Placket operators in a straight formation according to the sizes and same bundle no.
			3. The extra capacity of side label attach operator sometimes used to unwrap the paper from the pocket parts.
			4. This operator is also performing low because of high defect rates. So she is instructed by the trainers, technician & line quality controller.
6	Rokeya	Attach Sleeve to Body	1. The operator is taking approximately 18-20 bursts to do one operation. So she is instructed where she is taking the extra bursts & how can she reduce them.
			2. Previously operator has to cut the sleeve pairs firstly before starting the operation. Now sleeve match operator is instructed to do it.
			3. A trainer is allocated there to teach her the proper instruction
7	Tahmina	Attach Cuff with 2 Pleat	1. One rack is arranged where all unattached cuffs will be gathered accordingly.
			2. The sleeve placket attach operators instruected to stitch one tack at sleeve and then cuff join operator has to stitch one tack only with joining
			3. The extra capacity of cuff top st. Operator is used to sort out the cuff with bodies according to sizes and numbers.
			4. Sleeve match operator is instructed to give a mark in the sleeve pairs so that cuff join operator can join the cuffs with sleeves evenly.

e) Workstation layout standardization

A well-designed workstation is essential for productive work. Most garment workers repeat the same or similar tasks throughout each shift, which, if performed efficiently and quickly, can result in higher productivity. Further, each workstation should be designed to suit the needs of the particular worker (dependent upon height, reach, size, etc.) and take into account the types of machine they are using and the works they are performing [4]. A well-organized workstation (and workplace) that is well-lit, free from chemical hazards and noise, and that minimizes material handling, will improve efficiency and reduce worker fatigue. Sometimes even minor ergonomic changes in the design of equipment, workstations or job tasks, which cost very little can make significant improvements in worker comfort, health, safety, and productivity. The most workstation layouts of the low performing operators were unorganized and to improve their productivity, workstation layout must need to be updated. The changes in workstation layouts with upgraded methods for low performing operators are attached below:

i. *Operator – Julekha, Operation- Attach Collar Band to Collar*

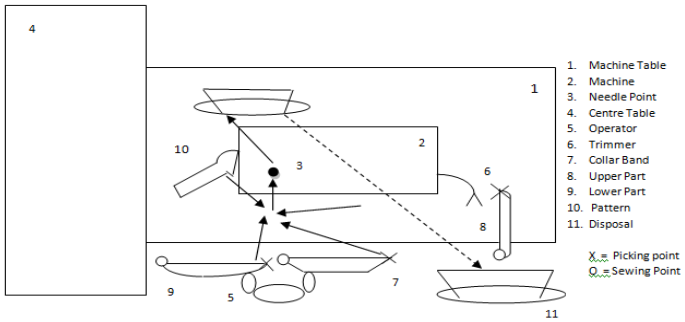

Fig. 2: Previous Layout

Previous Method Operator followed –

1. Pick the lower part
2. Pick the collar band
3. Pick the upper part
4. Pick the pattern
5. Align
6. Sew
7. Align
8. Sew
9. Turn the Pattern
10. Align
11. Sew
12. Trim
13. Dispose

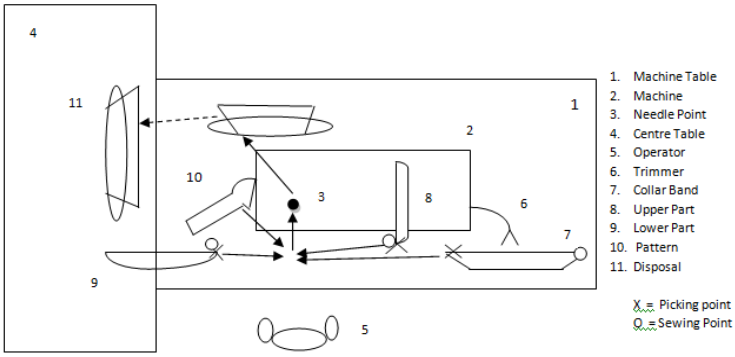

Fig. 3: Updated Layout

Updated Method –

1. Pick the Collar Band with right hand & the lower part with the left at a time
2. Pick the upper part
3. Pick the pattern
4. Align
5. Sew
6. Align
7. Sew
8. Turn the pattern
9. Align
10. Sew
11. Trim
12. Dispose

ii. *Operator – Khaleda, Operation – Top Placket*

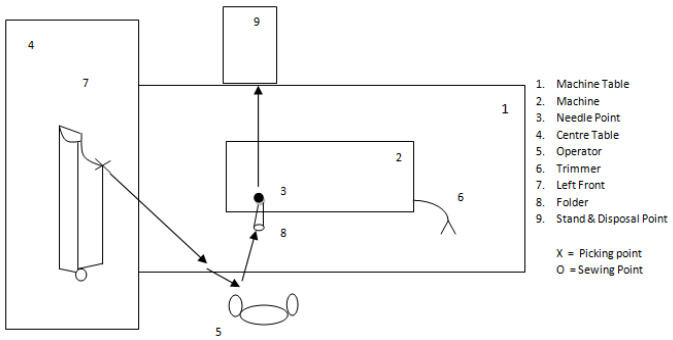

Fig. 4: Previous Layout

Previous Method –

1. Pick
2. Turn the front part
3. Insert the front part into the folder
4. Sew
5. Align
6. Sew
7. Align
8. Sew
9. Align
10 Sew
11. Trim
12. Dispose

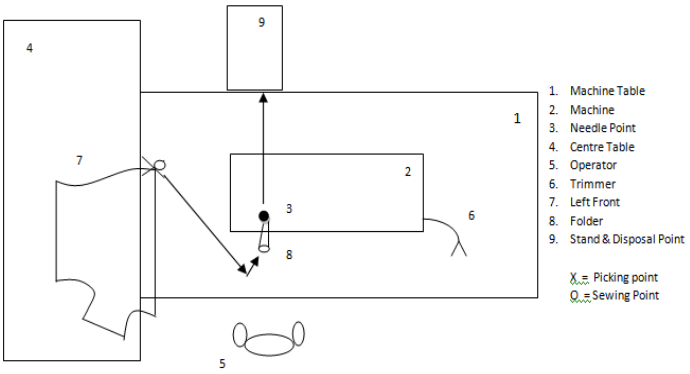

Fig. 5: Updated Layout

Updated Method –

1. Pick
2. Insert the front part into the folder
3. Sew
4. Align
5. Sew
6. Trim
7. Dispose

iii. *Operator – Nasrin, Operation – Pocket Press (Auto)*

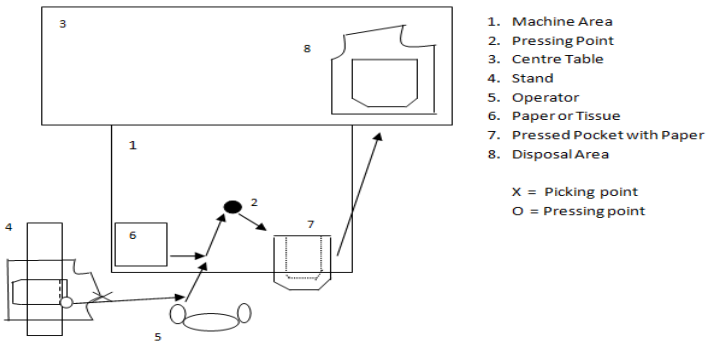

Fig. 6: Previous Layout

Previous Method –

1. Pick the pockets from the inside of the front part
2. Pick the paper
3. Align the pocket with paper
4. Press
5. Unwrap the paper
6. Place the pressed pocket inside the front part
7. Dispose

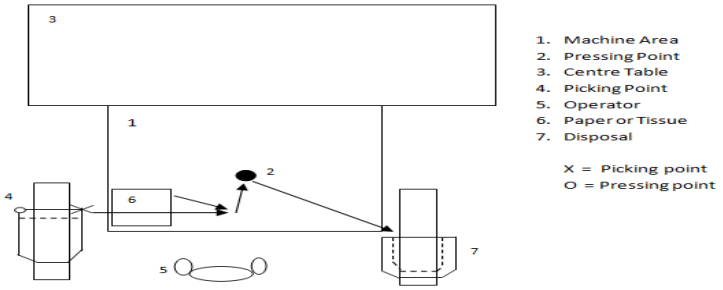

Fig. 7: Updated Layout

Updated Method –

1. Pick the pocket & paper at a time using both hands
2. Align
3. Press
4. Dispose

iv. Operator- Lily & Sharmin, Operation – Attach Pocket to Front

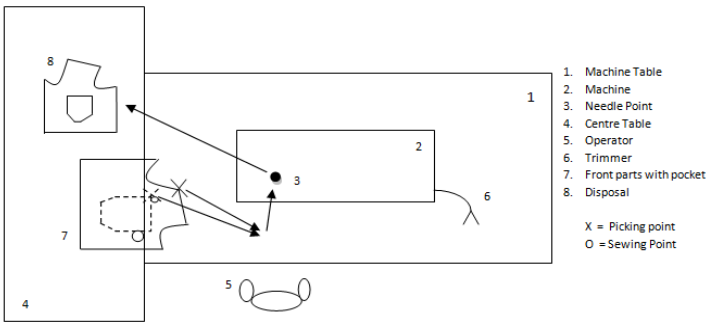

Fig. 8: Previous Layout

Previous Method –

1. Pick the front part & pocket
2. Turn the front part
3. Align
4. Sew
5. Align
6. Sew
7. Align
8. Sew
9. Align
10. Sew
11. Align
12. Sew
13. Align
14. Sew
15. Trim
16. Dispose

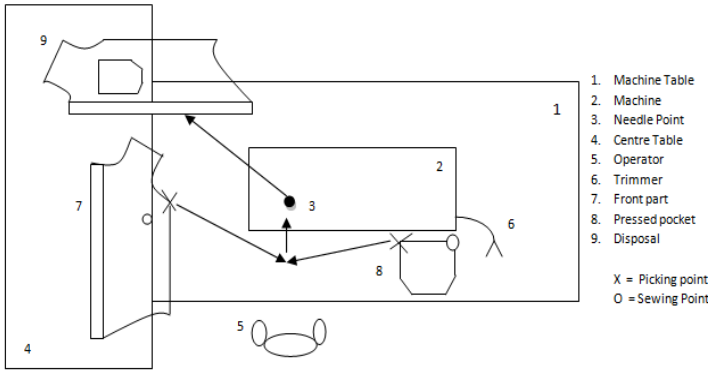

Fig. 9: Updated Layout

Updated Method –

1. Pick the front part with left hand & pocket part with the right hand
2. Align
3. Sew
4. Align
5. Sew
6. Align
7. Sew
8. Align
9. Sew
10. Align
11. Sew
12. Trim
13. Dispose

v. *Operator – Rokeya, Operation – Attach Sleeve to Body*

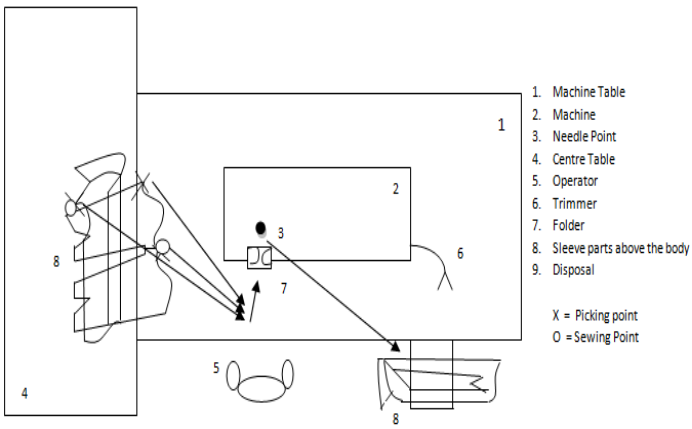

Fig.10: Previous Layout

Previous Method –

1. Pick the sleeve pair
2. Trim the link
3. Pick the body part
4. Place inside the folder
5. Sew
6. Align
7. Sew
8. Trim
9. Dispose

Note: Sew & Align continue for several times

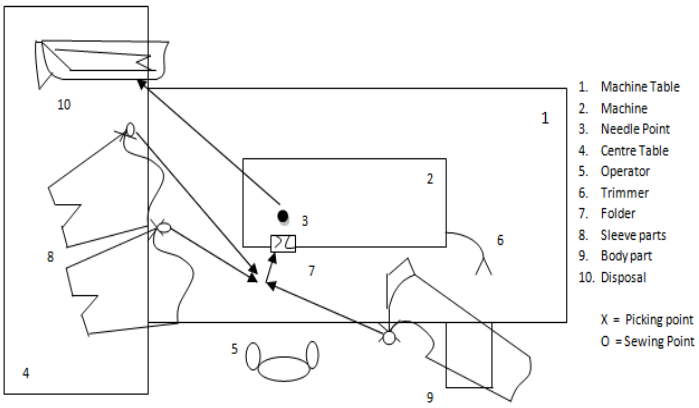

Fig. 11: Updated Layout

Updated Method –

1. Pick the sleeve & Body
2. Place inside the folder
3. Sew
4. Align
5. Sew
6. Align
7. Sew
8. Align
9. Sew
10. Trim
11. Dispose

vi. *Operator – Tahmina, Operation – Attach Cuff with 2 Pleat*

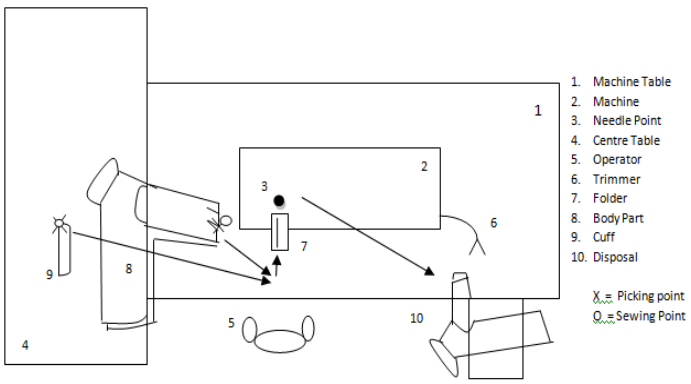

Fig.12: Previous Layout

Previous Method –

1. Pick the body
2. Pick the cuff
3. Align
4. Place into the folder
5. Sew
6. First pleat & Align
7. Sew
8. Second Pleat & Align
9. Sew
10. Trim
11. Dispose

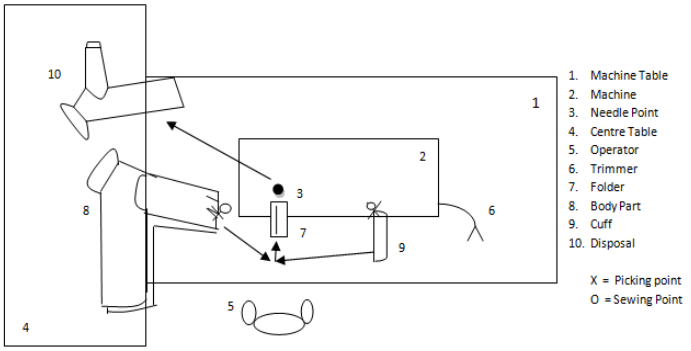

Fig.13: Updated Layout

Updated Method –

1. Pick the body & Cuff
2. Align
3. Place into the folder
4. Sew
5. Make the second pleat of the cuff & Align
6. Sew
7. Trim
8. Dispose

Here with changing operator's workstation layout, they also sent to training to improve their performance and handling movement and also motivation was done to improve their activity level. A change in operation breakdown & line layout was also done. Finally to improve their working condition and to increase the overall sectional productivity, some workloads were given to the higher capacity workers considering the layout. Thus the bottlenecks were solved; the changes improved the performance and capacity of those low performers because of the reduction of their working operation time and the enhancement in productivity. The following tables in result & discussion section show the updated outcome of the examined operators, the summary of the operators' performance & capacity improvement and overall line's productivity and efficiency improvement.

IV. Results & Discussion

By analyzing the sewing line's condition and operator's psychology, training arranged to motivate the workers as well as they trained on how to work consciously and efficiently. On that training, they learned about the reasons for being low performers and what steps to take to avoid the condition. Operators were taught about the operational procedure standardization, maintain the quality and quantity on the required time and how to reduce the excessive movements to avoid fatigue. Supervisors also trained on understanding operational breakdown, operation bulleting, line balancing and the ways to monitor the operators effectively.

a) Calculations

Here the improvements regarding capacity, efficiency, productivity and performance of the operators as well as the sewing line after the actions of method standardization, process improvement, line balancing and training took place are stated in the following.

b) Calculation of Sewing Line Efficiency

Line Efficiency = (Total Production X SMV X 100) / (No. of Operator X Working Hour X 60)

Before improvement line efficiency:

= (58 X 28.38 X 100) / (51 X 1 X 60) = 53.79%

After improvement line efficiency:

= (66 X 28.38 X 100) / (51 X 1 X 60) = 61.21%

Efficiency improved through the rise of the production/hr by improving the operator; balancing the line and reducing bottleneck.

i. *Calculation of Sewing Productivity*

Productivity = (Output amount / Input amount) X 100%

Before Improvement Productivity = (58 / 200) X 100% = 29.00%

After Improvement Productivity = (66 / 150) X 100% = 44.00%

With the improvement of line's productivity and efficiency, operators per hour production capacity

increased. Besides, operators defect rates also reduced. Rework times for fixing the defects was also decreased and thus operators could use the maximum time provided to her to reach their goals. Summaries based on time study charts before and after the actions, changes due to the improvement to the line as well as operators and bar chart on the low performing operator's performance improvement are shown in the following.

Table 4: Previous time study chart (Yellow marks indicating the low performers)

Sl. No.	Operator Name	Operation Name	S.M.V	M/C	Capacity Cycle Time	Potential Capacity/Hr	Performance (%)
1	Rozina	Collar Make	0.45	1N2TLS-UBT	0.58	103	77.59%
2	Tanzina	Trim, Turn & Press Collar	0.35	Collar Press	0.4	150	87.50%
3	Rubina	Collar Top St	0.34	1N2TLS-UBT	0.37	162	91.89%
4	Ruzina	Hem Cuff	0.45	1N2TLS-UBT	0.56	107	80.36%
5	Ruzina	Hem Collar Band	0.26	1N2TLS-UBT	0.35	171	74.29%
6	Rima	Cuff make	0.55	1N2TLS-EC	0.72	83	76.39%
7	Robina	Press Cuff	0.26	Cuff Press M/C	0.29	207	89.66%
8	Rohima	Cuff top st.	0.39	1N2TLS-UBT	0.47	128	82.98%
9	Julekha	Attach Collar Band to Collar	0.56	1N2TLS-EC	0.85	71	65.88%
10	Taslima	Collar Midline top st. with turn	0.44	1N2TLS-UBT	0.48	125	91.67%
11	Nurunnahar	Trim excess collar	0.16	1N3TOL	0.19	316	84.21%
12	Shanta	Mark at Collar Band	0.17	Collar Notcher	0.21	286	80.95%
13	Abdul Alim	Press Front Flap	0.5	Press M/C	0.59	102	84.75%
14	Moriom	Flap top st	0.88	2N4TLS-UBT	1.19	50	73.95%
15	Ruma	Flap top st	0.88	2N4TLS-UBT	1.32	45	66.67%
16	Suma	Bottom placket	0.3	1N2TLS-UBT	0.43	140	69.77%
17	Kohinur	Attach Side label	0.39	1N2TLS-UBT	0.44	136	88.64%
18	Khaleda	Box placket	0.35	4N8TCS-Kan	0.69	87	50.72%
19	Sabina	Press Front Right Placket	0.16	FUMC	0.18	333	88.89%
20	Mala	Pocket hem	0.35	1N2TLS-UBT	0.45	133	77.78%
21	Nasrin	Press Pocket	0.41	Creasing M/C	0.83	72	49.40%
22	Eity	Attach Pocket to Front	1.22	2N4TLS-UBT	1.65	36	73.94%
23	Sharmin	Attach Pocket to Front	1.22	2N4TLS-UBT	2.45	24	49.80%
24	Lily	Attach Pocket to Front	1.22	2N4TLS-UBT	2.59	23	47.10%
25	Lakhy	Flap attach	0.42	2N4TLS-UBT	0.69	87	60.87%
26	Romicha	Attach Back Yoke with Pleat use folder	0.65	2N4TLS-UBT	0.78	77	83.33%
27	Chameli	Attach Main Label	0.39	1N2TLS-UBT	0.52	115	75.00%
28	Moriom	Join Shoulder by Folder	0.72	2N4TLS-UBT	0.95	63	75.79%
29	Asma	Join Shoulder by Folder	0.72	2N4TLS-UBT	1.02	59	70.59%
30	Taslima	Attach Collar to Body	0.56	1N2TLS-UBT	0.71	85	78.87%
31	Papiya	Collar close to Body	0.59	1N2TLS-UBT	0.79	76	74.68%
32	Fatema	Attach Sleeve Tape	0.28	1N2TLS-UBT	0.39	154	71.79%
33	Amena	Tack Sleeve Tape with Cut Excess	0.26	1N2TLS-UBT	0.3	200	86.67%
34	Sabrina	Press Sleeve Placket	0.2	FUMC	0.24	250	83.33%
35	Amina	Attach Sleeve placket	0.49	1N2TLS-UBT	0.55	109	89.09%
36	Moushumi	Attach Sleeve placket	0.49	1N2TLS-UBT	0.58	103	84.48%
37	Asha	Match Sleeve to Body	0.23	Plain Table	0.29	207	79.31%
38	Rokeya	Sleeve attach	0.93	2N4TCS	1.83	33	50.82%
39	Marufa	Sleeve attach	0.93	2N4TCS	1.42	42	65.49%
40	Fahima	Side seam	0.88	2N4TCS-FOA	1.23	49	71.54%
41	Ojufa	Side seam	0.88	2N4TCS-FOA	1.42	42	61.97%
42	Momena	Bottom Hem	0.69	1N2TLS-UBT	0.89	67	77.53%
43	Mahmuda	Bottom Hem	0.69	1N2TLS-UBT	0.95	63	72.63%
44	Tahmina	Cuff join	0.81	1N2TLS-UBT	1.46	41	55.48%
45	Monira	Cuff Join	0.81	1N2TLS-UBT	1.33	45	60.90%
46	Jesmin	Button Hole	0.66	1N2TLS-BH	0.71	85	92.96%
47	Kona	Collar and Placket holing	0.67	1N2TLS-BH	0.73	82	91.78%
48	Rukhsana	Bartack	0.48	1N2TLS-BT	0.53	113	90.57%
49	Tulshi	Mark Button Attach	0.38	Plain Table	0.42	143	90.48%
50	Akhi	Button Attach	0.68	1N2TLS-BA	0.74	81	91.89%
51	Ruma	Button attach on neck and sleeve placket	0.63	1N2TLS-BA	0.69	87	91.30%

Time study chart after the improvement:

Table 5: After improvement, time study chart

Sl. No.	Operator Name	Operation Name	S.M.V	M/C	Capacity Cycle Time	Potential Capacity/Hr	Performance (%)
1	Rozina	Collar Make	0.45	1N2TLS-UBT	0.58	103	77.59%
2	Tanzina	Trim, Turn & Press Collar	0.35	Collar Press	0.4	150	87.50%
3	Rubina	Collar Top St	0.34	1N2TLS-UBT	0.37	162	91.89%
4	Ruzina	Hem Cuff	0.45	1N2TLS-UBT	0.56	107	80.36%
5	Bilkis	Hem Collar Band	0.26	1N2TLS-UBT	0.39	154	66.67%
6	Rima	Cuff make	0.55	1N2TLS-EC	0.72	83	76.39%
7	Robina	Press Cuff	0.26	Cuff Press M/C	0.29	207	89.66%
8	Rohima	Cuff top st.	0.39	1N2TLS-UBT	0.47	128	82.98%
9	Julekha	Attach Collar Band to Collar	0.56	1N2TLS-EC	0.73	82	76.71%
10	Taslima	Collar Midline top st. with turn	0.44	1N2TLS-UBT	0.48	125	91.67%
11	Nurunnahar	Trim excess collar	0.16	1N3TOL	0.19	316	84.21%
12	Shanta	Mark at Collar Band	0.17	Collar Notcher	0.21	286	80.95%
13	Abdul Alim	Press Front Flap	0.5	Press M/C	0.59	102	84.75%
14	Moriom	Flap top st	0.88	2N4TLS-UBT	1.19	50	73.95%
15	Ruma	Flap top st	0.88	2N4TLS-UBT	1.29	47	68.22%
16	Suma	Bottom placket	0.3	1N2TLS-UBT	0.43	140	69.77%
17	Kohinur	Side label	0.39	1N2TLS-UBT	0.44	136	88.64%
18	Khaleda	Box placket	0.35	4N8TCS-Kan	0.53	113	66.04%
19	Sabina	Press Front Right Placket	0.16	FUMC	0.18	333	88.89%
20	Mala	Pocket hem	0.35	1N2TLS-UBT	0.45	133	77.78%
21	Nasrin	Press Pocket	0.41	Creasing M/C	0.62	97	66.13%
22	Eity	Attach Pocket to Front	1.22	2N4TLS-UBT	1.65	36	73.94%
23	Sharmin	Attach Pocket to Front	1.22	2N4TLS-UBT	1.85	32	65.95%
24	Lily	Attach Pocket to Front	1.22	2N4TLS-UBT	2.18	28	55.96%
25	Lakhy	Flap attach	0.42	2N4TLS-UBT	0.69	87	60.87%
26	Romicha	Attach Back Yoke with Pleat use folder	0.65	2N4TLS-UBT	0.78	77	83.33%
27	Chameli	Main Label	0.39	1N2TLS-UBT	0.52	115	75.00%
28	Moriom	Join Shoulder by Folder	0.72	2N4TLS-UBT	0.95	63	75.79%
29	Asma	Join Shoulder by Folder	0.72	2N4TLS-UBT	1.02	59	70.59%
30	Taslima	Attach Collar to Body	0.56	1N2TLS-UBT	0.71	85	78.87%
31	Papiya	Collar close	0.59	1N2TLS-UBT	0.79	76	74.68%
32	Fatema	Attach Sleeve Tape	0.28	1N2TLS-UBT	0.39	154	71.79%
33	Amena	Tack Sleeve Tape with Cut Excess	0.26	1N2TLS-UBT	0.3	200	86.67%
34	Sabrina	Press Sleeve Placket	0.2	FUMC	0.24	250	83.33%
35	Amina	Attach Sleeve placket	0.49	1N2TLS-UBT	0.63	95	77.78%
36	Moushumi	Attach Sleeve placket	0.49	1N2TLS-UBT	0.69	87	71.01%
37	Asha	Match Sleeve to Body	0.23	Plain Table	0.38	158	60.53%
38	Rokeya	Sleeve attach	0.93	2N4TCS	1.59	38	58.49%
39	Marufa	Sleeve attach	0.93	2N4TCS	1.42	42	65.49%
40	Fahima	Side seam	0.88	2N4TCS-FOA	1.23	49	71.54%
41	Ojufa	Side seam	0.88	2N4TCS-FOA	1.42	42	61.97%
42	Momena	Bottom Hem	0.69	1N2TLS-UBT	0.89	67	77.53%
43	Mahmuda	Bottom Hem	0.69	1N2TLS-UBT	0.95	63	72.63%
44	Tahmina	Cuff join	0.81	1N2TLS-UBT	1.08	56	75.00%
45	Monira	Cuff Join	0.81	1N2TLS-UBT	1.33	45	60.90%
46	Jesmin	Button Hole	0.66	1N2TLS-BH	0.71	85	92.96%
47	Kona	Collar and Placket holing	0.67	1N2TLS-BH	0.73	82	91.78%
48	Rukhsana	Bartack	0.48	1N2TLS-BT	0.53	113	90.57%
49	Tulshi	Mark Button Attach	0.38	Plain Table	0.42	143	90.48%
50	Akhi	Button Attach	0.68	1N2TLS-BA	0.74	81	91.89%
51	Ruma	Button attach on neck and sleeve placket	0.63	1N2TLS-BA	0.69	87	91.30%

c) Effects of implementing the tools & techniques

From the above discussion and time study charts, it is noticeable that by improving the low performers, manufacturers can achieve the overall line's progress.

By applying time study technique, method improvement, balancing techniques, and training the bottleneck operations were developed as well as the line efficiency improved from 53.79% to 61.21%. Line's productivity previously was 29%,

which lately upgraded to 44%. Besides, lines sewing operators & helper's average capacity & performance also increased through those improvements. The following table with bar chart shows a comprehensible indication:

Table 6: Changes due to improvement actions were taken to the line

Parameter	Before	After
Line Efficiency	53.79%	61.21%
Line Productivity	29%	44%
Operators Avg. Performance	76.16%	77.05%
Bottleneck	5	0

Summary of the improvement of the low performing operators:

Table 7: Low performers improvement regarding operational time, performance% & capacity

Sl. No.	Operator Name	Operation	Cycle Time (in second)		Performance Improvement %	Potential Pieces	
			Before	After		Before	After
1	Julekha	Attach Collar Band to Collar	51	43.8	10.83%	71	82
2	Khaleda	Box Placket	41.4	31.8	15.32%	87	113
3	Nasrin	Press Pocket	49.8	37.2	16.73%	72	97
4	Sharmin	Attach Pocket to Front	147	111	16.15%	24	32
5	Lily	Attach Pocket to Front	155.4	130.8	8.86%	23	28
6	Rokeya	Sleeve Attach	109.8	95.4	7.67%	33	38
7	Tahmina	Cuff Join	87.6	64.8	19.52%	41	56
Average Improvement					13.58%		

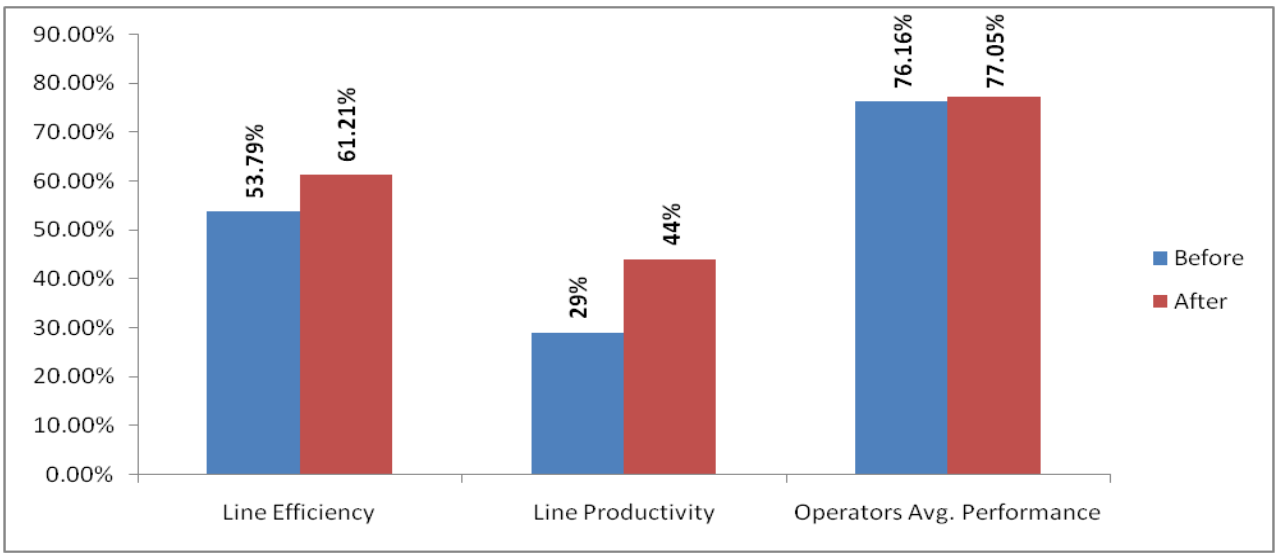

Fig. 14: Bar chart showing the improvement of the line

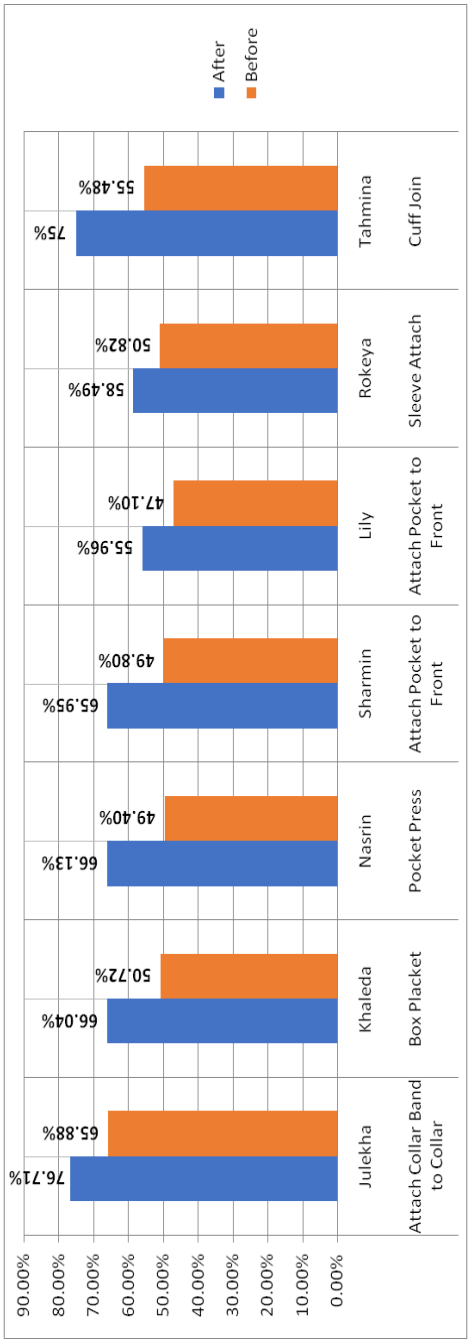

Fig. 15: Bar chart showing the individual operators performance before & after the improvement

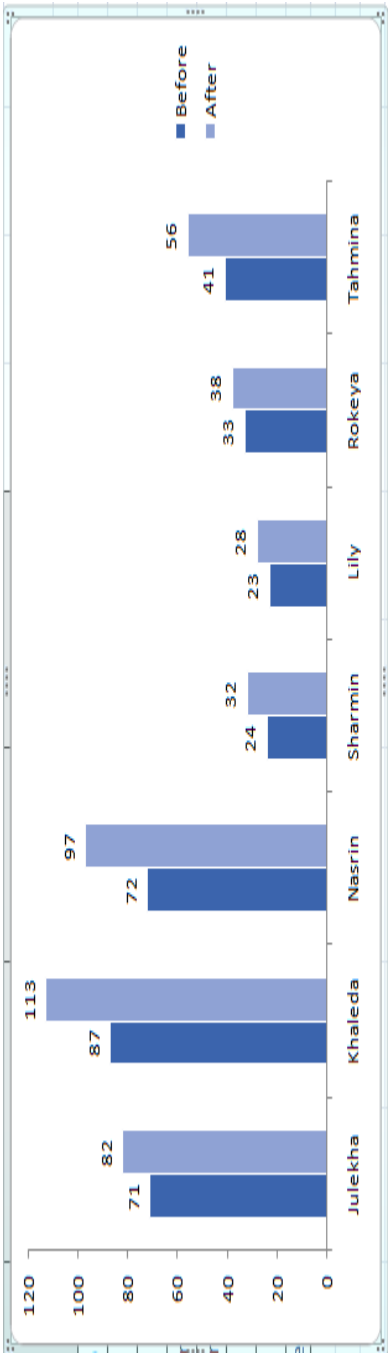

Fig. 16: Bar Chart showing low performing operators improvement based on potential capacity per hour

V. Conclusion

In apparel industries, it is sometimes very complicated to identify the causes behind the low performance of the operators, and also the key areas to select and improve, which can change the current system and process. In today's competitive world, delivering the high-quality garments at low cost in shorter lead times are the uppermost challenges faced by apparel manufacturers [6]. So the maximum capacity utilization of the operators needs to be ensured to meet the target. Generally, operators have to do their operations in a hurry and mostly by being in a fixed position, which is unlike from their natural life [7]. So the work environment needs to be suited and well-organized to them as much as possible. Considering these facts, working station standardization to make operators comfortable and feel them free to work is very much necessary to receive the maximum output with acceptable quality from them. In addition to these, sewing line also needs to be very much balanced to maximize hourly production capacity. By ensuring the proper work distribution among the operators, the targeted output can be achieved without having

overtime. Even a minor policy change to the sewing floor or any specific operation can result in very positively. Therefore, the similar type apparel industries, those who want to recognize and rectify their problems, and expect for the better production efficiency through the improvement of the low performing operators, the research outcomes can be worthwhile and beneficial to them.

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