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Study of a Sewing Line of an RMG Factory and Productivity Improvement through Line Balancing

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Abstract - **The RMG industries play a major role in the economic development of Bangladesh. However, in the current business environment, like every other country all over the world, this sector also faces some troubles related to resource constraints like time, cost, materials, etc. So, to ensure the sustainability and competitiveness of the RMG industries of Bangladesh, productivity improvement becomes the key factor. For this reason, this research aims to measure and improve the productivity of other performances of a sewing line of a selected RMG industry. This study uses time study, expert opinions, and the line-balancing method. This research finds that before improvement in the line efficiency, total idle time, and the number of workstations is 43.04%, 9.401 minutes per cycle, and 19 respectively. But after improvement in the line efficiency, total idle time and number of workstations become 81.78%, 1.6087 minutes per cycle, and 10 respectively. Thus, the findings of this research prove that implementing a line-balancing strategy in the sewing section of RMG industries can boost productivity. So, this research can be useful for other RMG industries for future implementation**.

Keywords: **Productivity, Line Balancing, Line Efficiency, Workstation, Idle Time**

I. INTRODUCTION

The quick improvements in information systems and management technologies have made current businesses much more dynamic and competitive. In this competitive environment, manufacturing industries have to face several challenges related to rapidly changing product types, changing technologies, complex product flow, reworks, etc. Besides, in the current situation, manufacturing companies also face energy as well as materials constraints for several reasons. So, to survive in this new era, most manufacturing companies focus on their manufacturing strategies to minimize their product cost, increase productivity and customer satisfaction as well as improve product quality and delivery time performance. These factors can be achieved by applying operations management tools.

In the current competitive world, the RMG industries of Bangladesh which is a key driver of the economic development of the country also face some challenges regarding quality, on-time delivery, and cost. To improve in these aspects, productivity improvement is necessary. Besides, although the RMG industry contains cutting, sewing, and finishing sections, the lion's share of worker work in the sewing section. So, proper use of the line-balancing technique can help the sewing section to achieve better productivity [1]. For this reason, the study has been carried out in a selected sewing line of the RMG industry. So, the objectives of this research are to assess the current status of the existing assembly line and to improve the productivity of the sewing line using the necessary management tool.

II. LITERATURE REVIEW

Productivity is a measure of output from a production process, per unit of input [2]. On the other sense productivity is an economic measure of efficiency that summarizes the value of output relative to the inputs used to create them. So, in the following five ways, productivity can be improved.

1. Increase input but gets a greater increase in output.
2. Maintain input but increase output.
3. Decrease input with a smaller decrease in output.
4. Decrease input but maintains output.
5. Decrease input but increase output.

Work study is the systematic examination of the methods of carrying on activities so as to improve the effective use of resources and to set up standards of performance for the activities being carried out. [3]. One of the major branches of work-study is Work measurement (WM) which tries to investigate and eliminate ineffective time, whatever may be the cause. It measures the time taken in the performance of an operation or series of operations and differentiates the ineffective time and effective time [4]. There are some techniques for work measurement.

However, time study is the prominent one. Time study seeks to determine how much work a fully skilled operator can complete in a specific length of time. To perform a time, study the operation is at first broken down into elements. The operator must do the work according to a certain method, under certain conditions and at a certain pace which will produce a certain physical reaction. Certain allowances for personal and other delays are provided. Time study uses a stopwatch to observe and analyse each element of operation to develop a standard time. There are three common methods for recording time with a stopwatch, as follows:

1. Fly Back Time

For each element task, the stopwatch recording is reset to zero and permitted to begin right away. This allows for the direct measurement of each element's duration.

2. Cumulative Timing

Throughout the study, the watch runs continually. The watch reading is noted after each element. Subsequent subtractions yield the individual element timings. Generally, by employing the cumulative method, a high level of accuracy is achieved in a quick manner [3].

3. Performance Timing

Performance rating is the assessment of the worker's rate of working relative to the observer's concept of the rate corresponding to the standard pace. In reality, the rate of work hardly remains constant during the working time due to the intrinsic differences among employees. Performance rating can be measured by the following equation [3].

$$\text{Performance rating}=\frac{\text{Normal Rating}}{Standardrating} * 100\ \%$$

Here, the standard rating is the average rate at which qualified workers will naturally work at a job when using the correct method and the employees are motivated to apply themselves to their work [3]. And the normal rating is the average rate at which a qualified worker will naturally work even if he has no specific motivation to apply himself to his work [3]. Therefore, a score of 100 % denotes the standard. A score less than 100% represent an operator with a lower effective speed. But a score above 100% represents an operator with an effective rate that is higher than the standard performance. At the end of a successful work study on a selected product, a standard method and standard task time will be achieved.

Henry Ford and his engineers initially used the phrase 'Assembly Line'. Assembly line balancing is a method of allocating all tasks to various workstations in order to limit the amount of unassigned (i.e., idle) time and maximize the amount of work that can be done in each workstation within its cycle time [5]. Assembly line balancing in sewing lines assigns tasks to the workstations so that the machines of the workstation can perform the assigned tasks with a balanced loading. Two main goals of balancing an assembly line are to minimize the number of workstations for a given cycle time and the cycle time for a given number of workstations. Some basic definitions and terminologies about line balancing techniques are enhanced here.

1. *Work Element:* Any process is divided into its component tasks so that the work may be spread along the line. And these tasks are called work elements. For instance, shoulder joining is a work element of the t-shirt manufacturing process.

2. *Standard Minute Value (SMV):* Standard minute value is the time required for a qualified worker working at standard performance to perform a given task. The SMV includes additional allowances for rest and relaxation, machine delay and anticipated contingencies [6].

   SMV = Normal Time+(Normal Time*Allowance) [7].

3. *Process Cycle Time:* Process cycle time is the interval between two subsequent assemblies leaving the production line. It is calculated as the maximum time allowed at any workstation [8].

   $$\text{Cycle time in minutes} = \frac{\text{working hour per day}*60}{Daily\ target\ output}$$

4. *Normal Time:* It is work element cycle time that takes into account performance rating factors.

   Normal Time = Average work element cycle time * performance rating [7].

5. *Work Stations:* It is a location on the line where a combination of few work elements is performed.

   $$\text{Theoretical Minimum no. of workstation} = \frac{\text{Total SMV}}{\text{Process Cycle Time}}$$

6. *Precedence Diagram:* It is a graphical diagram that shows all work elements as predecessors and successors with the help of some arrows and nodes [8].

7. *Line Efficiency:* It is the ratio between total SMV and the multiplication of process cycle time and number of work stations.

   $$\text{Total SMV Line Efficiency} = \frac{\text{Total SMV}}{\text{Process cycle time}*\text{No of workstation}} * 100\%$$

8. *Idle Time:* Idle time defined as the difference from a line's process cycle time and the overall amount of time spent at a workstation [8].

   Workstation Idle Time = Process cycle Time - Total SMV in workstation

9. *Balance Delay:* This is used to quantify a line-inefficiency which is targeted to minimize by efficient balancing.

Balance Delay = (100-Line Efficiency) %

Several methods of line balancing technique are used. Some of them are,

a. Ranked Positional Weight Rule

This is a method for line development was introduced by Helgeson and Birnie in 1961. In this technique, computes the sum of work element SMV and following all work elements SMV. To perform the procedure at first the ranked positional weight for each element with the TE values are counted. It is followed by listing the elements in order to their ranked positional weight. Largest RPW will stay at the top. And finally assign elements to WS according to their RPW without precedence constraint and time cycle violations.

b. Largest Candidate Rule

This rule stands for allocating the work elements in order to largest operating time. If the work elements are to be assigned in a work station, then the work elements of large SMV is assigned first. For perfuming the procedure firstly all elements in descending order of work element time value (TE) are collected. So, the largest TE will be placed at the top. Then at the first workstation, start the top of list and work down, select the first element for placement. This feasible element satisfies the precedence requirements. Carrying the process of work element to the station until no elements can be added without exceeding TE. And Repeat these steps for the other stations in the line until all the elements have been added.

c. Continuous Improvement Technique

Continuous improvement technique can give an improvement in efficiency, production rate, productivity, and reduction of idle time, production cost, production time, etc. It has three following steps which are very simple and easy to execute. It is advisable to create a process control chart prior to the beginning of any improvement initiatives. To generate a process chart following equation of harmonic average is used:

Harmonic average, $1/R = 1/R1 + 1/R2 + \ldots\ldots\ldots\ldots\ldots\ldots$

Where R= Harmonic average and
R1, R2......= Observed time

After the development of the process chart, we need to conduct the following steps.

Step 1: Need to identify the work element done by the same machine category so that the respective workstation can do other elements also.

Step 2: Need to identify the work element done by the helper, to share the other helping element done by the helper.

Step 3: In this step, the helping process will be shared by the operator.

III. RESEARCH METHODOLOGY

To conduct the research work, some previous research paper was studied, and visited the selected T-shirt-producing factory which guided us to conduct the research work. Based on the understanding, research objectives were established, and a detailed questionnaire of the research was prepared. However, for some unavoidable constraints, it was not possible for us to conduct a method study in the assembly process of the T-shirt.

Consequently, it is assumed that the current production process is standard and only the work measurement (by using time study) is conducted by using a stopwatch as part of the study. For data collection, fly back cumulative method is used as recommended by experts. The existing status of the studied assembly line of T-shirts was evaluated. And finally, the existing line is improved using different line-balancing techniques as described in the literature review.

IV. DATA COLLECTION AND ANALYSIS

A. Breaking the Job into Element

According to the operation sequence, the T-shirt was broken into 19-elementtasks for operating in a line. And for the existing line, a time study was conducted. Result is summarized in Table I.

B. Line Balancing Analysis

Process cycle time can be calculated from the demand or output. So, the demand data for t-shirts for the selected line of six months of the recent year is collected from the factory. Table II shows the demand of t-shirts for last six months.

Each month has 4 weeks, and each week has 6 working days with 10 working hours per day.

So daily demand = 97780/ (6*4*6) = 680 pieces per day

$$\text{Process cycle time} = \frac{60*10}{680} = 0.8823 \text{ minute per piece}$$

$$\text{Line Efficiency} = \frac{7.216}{0.8823*19} * 100\% \quad = 43.04\%$$

TABLE I TIME STUDY OF THE EXISTING LINE

Work Element No.	**Work Element Name**	**Machine type**	**Observed Time (sec)**											**Harmonic Average**	**No. of Employee**	**Allowance**	**Standard Time (min)**	**SMV**
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**					
1	Back & front part match	H	21	20	19	21	18	18	18	20	21	19	20		1	14	22.23	0.37
2	Shoulder joint with scissoring	O/L	20	18	18	20	18	19	20	18	19	19	19		1	20	22.68	0.38
3	Neck piping & cut	O/L	12	10	10	12	11	12	13	11	11	10	11		1	20	13.44	0.22
4	Extra stitch open & cut	H	18	16	18	17	18	17	18	18	19	18	18		1	14	20.18	0.34
5	Neck rib tack	SNLS	10	12	12	14	12	13	12	13	10	12	12		1	20	14.4	0.24
6	Neck servicing	O/L	17	16	18	18	17	15	18	15	17	15	17		1	20	19.92	0.33
7	Back neck piping & scissoring	SNLS	16	17	15	16	18	17	18	18	18	17	17		1	20	20.4	0.34
8	Piping corner tack & scissoring	SNLS	17	19	17	19	16	17	19	17	18	17	18		1	20	21.12	0.35
9	Front neck top stitch	F/L	18	18	17	21	18	18	20	18	19	17	18		1	20	22.08	0.37
10	Label top stitch	SNLS	19	19	17	19	18	18	19	18	18	22	19		1	20	22.44	0.37
11	Sleeve hem	F/L	13	14	14	12	12	12	14	14	13	12	13		1	20	15.6	0.26
12	Thread cut & sleeve pair	H	6	7	7	6	5	6	6	5	6	5	6		1	14	6.73	0.11
13	Sleeve & body match	H	19	18	19	21	21	20	19	19	19	19	19		1	14	22.12	0.37
14	Sleeve join	O/L	38	42	45	46	48	43	42	47	43	44	44	39	2	20	47.01	0.78
			38	36	37	34	33	35	35	37	35	36	36			20		
15	Care labels attach with position mark	SNLS	32	33	31	32	32	33	31	32	31	33	32	34	1	20	40.49	0.67
			33	37	40	34	37	36	35	36	35	35	36			20		
16	Side seam	O/L	24	25	24	23	25	24	24	23	26	25	24		2	20	29.16	0.47
17	Body fold & sticker remove	H	17	14	18	17	18	17	18	17	17	17	17		1	14	19.38	0.32
18	Sleeve close & security tack	SNLS	25	26	25	25	26	26	26	26	27	27	26		1	20	31.08	0.52
19	Bottom hem & thread remove	F/L	18	20	18	18	19	17	19	18	19	22	19		1	20	22.56	0.38

TABLE II DEMAND OF SIX MONTHS

Month	**Demand**
Month 1	14072
Month 2	12072
Month 3	16572
Month 4	19072
Month 5	13572
Month 6	22420
Total	97780

Balance delay=100-line efficiency = 56.96%

Theoretical minimum number of workstations =

$$\frac{7.216}{0.8823}=8.256=9$$

However, the existing workstation has a big amount of idle time which is undesired from the theoretical perspective. The data for the existing workstation are summarized in Table III.

No. of workstation = 19

From Table III,
Labor productivity = $\frac{680}{21}$ = 32 units per worker

Total productive time = 7.216 minutes per cycle
Total idle time = 9.401 min per cycle.

TABLE III EXISTING ALLOCATION OF WORKSTATION

Workstation No.	Assigned Work Element	No. of Worker	SMV (min)	Idle Time (min)
A	1	1	0.37	0.5123
B	2	1	0.378	0.5043
C	3	1	0.224	0.6583
D	4	1	0.336	0.5463
E	5	1	0.24	0.6423
F	6	1	0.332	0.5503
G	7	1	0.34	0.5423
H	8	1	0.352	0.5303
I	9	1	0.368	0.5143
J	10	1	0.374	0.5083
K	11	1	0.26	0.6223
L	12	1	0.112	0.7703
M	13	1	0.368	0.5143
N	14	2	0.783	0.0993
O	15	2	0.674	0.2083
P	16	1	0.468	0.4143
Q	17	1	0.323	0.5593
R	18	1	0.518	0.3643
S	19	1	0.376	0.5063
Total		21	7.216	9.401

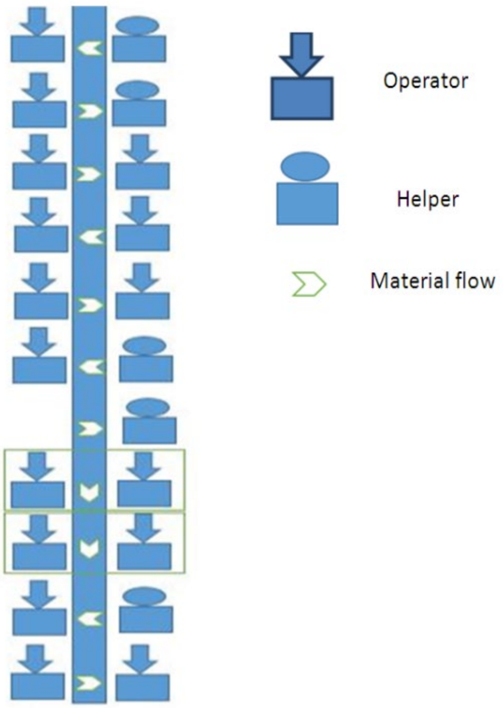

Fig. 1 Current layout

The layout of the existing workstation is depicted with the material flow in Fig. 1. Again, the precedence diagram of work elements with SMV is depicted in Fig 2.

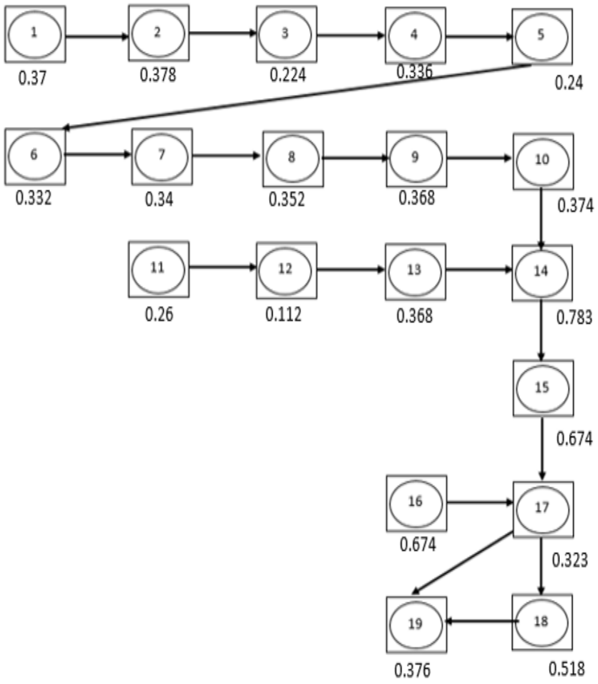

Fig. 2 Precedence diagram of work elements with SMV

V. IMPROVEMENT

This study tried to improve the existing assembly line by line balancing. According to expert opinion ranked positional weight method, largest candidate rules, and continuous improvement technique are most effective in the scenario. So current line was improved using these methods below.

A. Ranked Positional Weight Method

The entire amount of time spent on the largest route from the network's start to finish is called the ranked positional weight. So, to initiate the line balancing analysis using the ranked weighed method of reallocation, the ranked positional weight value of each element is computed by summing elements' SMV together with the SMV value for all elements that follow it in the arrow chain of the precedence diagram as shown in Fig. 2.

For work element no 1, the SMV is 0.37 min and the work elements that follow the work element in the sequence are work element no 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 17, 18, 19. So the sum of SMV of work element no 1 and other work elements is 5.988. So, the ranked positional weight of work element 1 is 5.988.

By the same procedure, all the work elements' ranked positional weights are calculated. Then all work elements are arranged in order of their Ranked positional weight value. The next step is to assign all the work elements according to RPW value to different workstations without breaking their precedence relationship and exceeding cycle time. Table IV shows the workstation containing work elements with their RPW value.

Line Efficiency$=\frac{7.216}{0.8823*11} * 100\%$ =74.35%

Balance delay=100-line efficiency = (100 – 74.35) % = 25.65 %

TABLE IV ASSIGNMENT OF WORK ELEMENTS INTO DIFFERENT WORKSTATIONS USING THE RPW METHOD

Workstation	Work Element	RPW	SMV (min)	Sum of SMV	Idle Time Per Workstation
A	1	5.988	0.371	0.749	0.1333
	2	5.618	0.378		
B	3	5.24	0.224	0.8	0.0823
	4	5.016	0.336		
	5	4.68	0.24		
C	6	4.44	0.332	0.672	0.2103
	7	4.108	0.34		
D	8	3.768	0.352	0.72	0.1623
	9	3.416	0.368		
E	11	3.414	0.26	0.746	0.1363
	12	3.154	0.112		
	10	3.048	0.374		
F	13	3.042	0.369	0.369	0.5133
G	14	2.674	0.783	0.783	0.0993
H	15	1.891	0.674	0.674	0.2083
I	16	1.685	0.468	0.791	0.0913
	17	1.217	0.323		
J	18	0.894	0.518	0.518	0.3643
K	19	0.376	0.376	0.376	0.5063
Total				7.216	2.5073

Labor productivity = $\frac{680}{11}$ = 62 units per worker

Total productive time = 7.216 minutes per cycle

Total idle time = 2.5073 min per cycle.

Total number of workstations = 11

By applying the RPW method, the total number of workstations is reduced from 19 to 11. So, idle time for each workstation has been reduced. As a result, line efficiency, daily output, and labor productivity have been increased.

B. Largest Candidate Rules

To apply this method at first all the elements are listed in descending order of SMV as in Table V.

TABLE V ARRANGEMENT OF WORK ELEMENTS IN DESCENDING ORDER OF SMV

Assigned Work Element	SMV (min)	Immediate Predecessors
14	0.783	13
15	0.674	14
18	0.518	17
16	0.468	-
2	0.378	1
19	0.376	17
10	0.374	8
1	0.37	-
9	0.368	6
13	0.368	12
8	0.352	7
7	0.34	6
4	0.336	3
6	0.332	5
17	0.323	16
11	0.26	-
5	0.24	4
3	0.224	2
12	0.112	11

The first feasible element that satisfies the precedence requirements and does not cause the sum of the SMV at the station to exceed the cycle time is selected to assign to the first workstation.

TABLE VI REALLOCATION OF WORK ELEMENT INTO WORKSTATIONS BY LARGEST CANDIDATE RULE (LCR)

Workstation	Assigned Work Element	SMV (min)	Sum of SMV	Idle time (min)
A	1	0.37	0.748	0.1343
	2	0.37		
B	3	0.224	0.8	0.0823
	4	0.336		
	5	0.24		
C	6	0.332	0.672	0.2103
	7	0.34		
D	8	0.352	0.72	0.1623
	9	0.368		
E	10	0.374	0.746	0.1363
	11	0.26		
	12	0.112		
F	13	0.368	0.368	0.5143
G	14	0.783	0.783	0.0993
H	15	0.674	0.674	0.2083
I	17	0.323	0.841	0.0413
	18	0.518		
J	16	0.486	0.862	0.02
	19	0.376		
Total			7.216	1.6087

The process of assigning work elements to the station is being continued until no further elements can be added without exceeding cycle time. Table VI shows the workstation containing element and SMV after reallocation.

Line Efficiency= $\frac{7.216}{0.8823*10} * 100\%$ = 81.78%

Balance delay=100-line efficiency = (100 – 81.78) % = 18.72%

Labor productivity = $\frac{680}{10}$ = 68 units per worker

Total productive time = 7.216 minutes per cycle

Total idle time = 1.6087 min per cycle.

Total number of workstations = 10

C. Continuous Improvement Technique

In this technique, the elements done by the same machine or helper are merged and the elements done by helpers are distributed among the operators. So as Elements 2 & 3 are done by OL4 machine where the sum of their SMV = 0.602 and Elements 7 & 8 are done by SNLS machine where the sum of their SMV = 0.692 and the sum of both SMV are less than process cycle time (0.8823), both pair of the element can be selected under separate workstation, B & E respectively. Again, Elements 12 & 13 are done by helper where the sum of their SMV = 0.48, which is less than the process cycle time. So, these two elements can be selected under a workstation, H. Besides, Element 4 is done by helper & element 5 is done by SNLS machine where the sum of these two elements is 0.576, which is less than the process cycle time. So, these two elements can be selected under a workstation, C. And Element 17 is done by helper & element 18 is done by FLCS machine where the sum of these two elements is 0.699, which is less than the process cycle time. So, these two elements can be selected under a workstation, L. Table VII shows the workstation containing element and SMV after reallocation.

TABLE VII REALLOCATION OF WORK ELEMENTS INTO WORKSTATIONS BY CONTINUOUS IMPROVEMENT TECHNIQUE

Workstation	**Assigned Work Element**	**Element Performed By**	**SMV (min)**	**Sum of SMV (min)**	**Idle time (min)**
A	1	HP	0.37	0.37	0.4871
B	2	OL4	0.378	0.602	0.2551
	3	OL4	0.224		
C	4	HP	0.336	0.576	0.2811
	5	SNLS	0.24		
D	6	OL4	0.332	0.8	0.0571
	16	SNLS	0.468		
E	7	SNLS	0.34	0.692	0.1651
	8	SNLS	0.352		
F	9	FLCS	0.368	0.628	0.2291
	11	SNLS	0.26		
G	10	FLCS	0.374	0.374	0.4831
H	12	HP	0.112	0.48	0.3771
	13	HP	0.368		
I	14	OL4	0.783	0.783	0.0741
J	15	OL4	0.674	0.674	0.1831
K	18	SNLS	0.518	0.518	0.3391
L	17	HP	0.323	0.699	0.1833
	19	FLCS	0.376		
Total				7.216	3.1144

Line Efficiency=$\frac{7.216}{0.8823*12} * 100\%$ = 68.16 %

Balance delay=100-line efficiency = (100 – 68.16) % = 31.84%

Labor productivity = $\frac{680}{12}$ = 57 units per worker

Total productive time = 7.216 minutes per cycle

Total idle time = 3.114 min per cycle.

Total number of workstations = 12

VI. COMPARISON OF ASSEMBLY LINE BEFORE AND AFTER THE IMPROVEMENT

In this study, an existing assembly line was tried to balance by some specific improvement techniques suggested by experts. However, the end results for these techniques are not the same. So, a comparative picture of the assembly line before and after deploying the improvement techniques is summarized in Table VIII.

TABLE VIII THE COMPARATIVE PICTURE OF THE ASSEMBLY LINE BEFORE AND AFTER THE IMPROVEMENT

Topic	**Before Improvement**	**After Improvement**		
		RPW	**LCR**	**CIT**
Line Efficiency (%)	43.04	74.35	81.78	68.16
Balance delay (%)	56.96	25.65	18.72	31.84
Total productive time (minutes per cycle)	7.216	7.216	7.216	7.216
Total idle time (minutes per cycle)	9.401	2.507	1.608	3.114
Number of workstation	19	11	10	12
Labor productivity (units per worker)	32	62	68	57

And from Table VIII it can be seen that Largest Candidate Rules (LCR) is the best techniques for improvement as it produces the optimal solution after improvement.

VII. CONCLUSION

The actual line efficiency and balance delay of the studied line were 43.04% and 56.96% respectively. After improving with existing resources, the efficiency and balance delay became 80.78 % and 18.72% respectively. So, from these improvement results, it is proved that Largest Candidate Rules is an effective improvement tool in this situation. However, the employee of the analysed line's performance rating was not sufficient, thus it was deleted from the study. So, in future investigations, a standard working method should be developed for better improvement. And in this factory, enough multi-skilled workers should develop to get a more balanced line and revise the machine allowance according to the thread needle configuration of the respective type of machine.

REFERENCES

[1] Mohammed Ziaul Haider, "Competitiveness of the Bangladesh readymade garment industry in major international market," Vol. 3, No. 1, June 2017.

[2] R. W. Griffin, Management principles, 8th edition. New Delhi: *Tata Mcgraw-Hill Publishing Co Ltd.*

[3] International labour organization, Introduction to work study, 4th edition, Geneva: *International labour office,* 1992.

[4] Shyam Bhatawdekar. Work Study: Method Study and Work Measurement, [Online]. Available: https://workstudy-measurement.blogspot.com/search?q=work+measurement, 2010, Aug. 15

[5] R. D. Reid and N. R. Sanders, *Operations Management: an Integrated Approach,* 7th edition, John Wiley & Sons, Inc., 2020.

[6] P. Sarkar. [Online]. Available: http://www.onlineclothingstudy.com, 2021.

[7] M. P. Groover, *Work Systems and the Methods, Measurement, and Management of work,* Pearson, 2013.

[8] O. E. G. D. A. Offiong, "Productivity Improvement in Breweries through Line Balancing Using Heuristic Method," *International Journal of Engineering Science and technology (IJEST)*, 2013.