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Case Study

Productivity improvement of a sewing line of a garment factory by line balancing

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Abstract

Since the apparel industries should be associated with high productivity, production lines should be balanced in a less time and efficient manner. Line balancing technique rearranged production line having an optimal or sufficient balancing way by assigning tasks to workstations in sequence. The goal of this paper is set to improve productivity in a selected sewing line by analyzing existing data, conducting time studies, and applying methods to balance the line. Line balancing methods like-Ranked Positional Weight Method, Largest Candidate Rule and Continuous Improvement Method, were applied to obtain significant improvements like reduction in workstations as well as idle time and improvement in labor productivity and thus the efficiency. Having current efficiency of 43.96%, by RPW and LCR method, the efficiency was increased to 67.64%. Moreover, the best result was assumed by Continuous Improvement method, inferred increase in line efficiency to 69.06%. The number of workstations is also reduced from 20 to 13. Although having improved resultants, the limitations of lack of method study is considered and so the existing method is considered standard. Another one is the omission of performance rating. Workstations are assigned considering multi-skilled workers.

Keywords: Productivity, Line Balancing, Time Study, Workstation, Process Chart, Bottleneck.

Introduction

Ready-Made Garment (RMG) sector plays a crucial role within the total economy of Bangladesh which has been improving our gross domestic product (GDP) that makes us a potential among new rising countries on the world since late 20th century[1]. The recent growth of the business and economy in Bangladesh was registered 0.2% growth, 8.7% growth and 11.49% growth for 2016-17, 2017-18, and 2018-2019 severally by this monopoly[2]. In terms of employment, the Center for Policy Dialogue (CPD) reported employment data of about 3.5 million individuals, of which, about 60.8% are female candidates. Compatibly, the country exports usually trade with different nations like the U.S.A, UK, Germany, France, and alternative E.U countries that build a more robust international relationship among the nations[1].

With the vision of upholding the reputation of the biggest market, no further achievement is forgone by improvement of productivity. Productivity is commonly outlined as a relation between the output volumes and also the volume of inputs[1]. Time study is a structured technique of directly observation and mensuration of each task operation to work out the time required for completion of the work by knowledgeable worker. Line Balancing is also a method of leveling the work across all processes throughout a workstation to minimize any bottlenecks and excess capability. Thus, overall productivity is increased by reduction of workstations.

Garment industry contains spinning, knitting, dyeing, cutting, sewing, finishing. This thesis work has been carried out in a selected sewing line of a readymade garment industry, to measure the performance in terms of productivity. The analysis conducted to extract showing weak points which hinder the overall productivity as well as the strength of that production line. The paper focuses on the productivity improvement of a specific line by line balancing in an RMG Industry (Fashion Asia).

The objectives of this study are: i. Analyze current status of the existing sewing line. ii. Conducting time study. iii. Applying different methods of line balancing.

Literature review: Productivity can be computed and expressed as the ratio of average acceptable output per period by the total costs incurred through various resources (Labor, input material, consumables, power utilized, capital, energy, material, personnel) consumed in that period. Peter F Drucker, an Austrian-American consultant said *"Productivity means a balance between all factors of production that will give the maximum output with the smallest effort"*[3]. The best way to start is by defining areas of any workflow that are lacking optimization because of various factors; such as, expensive manufacturing equipment.

The concept of lean manufacturing stemmed from Toyota Production System, adopted by many manufacturing techniques from Henry Ford's assembly-line concept. Utilization of latest tech trends is undoubtedly inefficient without trained employee; so the requirement of investment in continuous education and training has been a major concern of productivity improvement in manufacturing industries. To make sure the highest possible workshop efficiency, it is necessary to take liabilities at the floor layout plan. Organizing equipment, tools, and materials properly will not only reduce manufacturing drawbacks but will also aid to keep a sustainable working environment for employee[2].

Time Study: Time study is a computational rate of time at which a particular task completes in a recursive occasion. Stop watch time study, historical times, predetermined data and work sampling are commonly used methods for setting a standard time in any production problem[4]. Activity work sampling is preferred for estimating machine allowance. Stop watch time study is used for sewing operations because of its flexibility.

Standard time calculation is crucial for task assignment and distributing employment to machine operators as well as for balancing the lines in order to get targeted production rate and cycle time[5]. Though the time and training required for an analyst to become skilled in conducting time studies and the fact that operators have to be experienced in the operation before time studies can be done[6]. Another disadvantage is the subjectivity of performance rating that must be done by the time analyst.

Time Study Tools: A stopwatch.

Performance rating: Performance rating denotes a workforce assessment of any operation given to a particular worker respective to performance.

Standard rating: It simply incorporates the average rate of a skillful worker's inherent performance that completes an operation without hindrance. To establish standard rating, following three preconditions must be ensured. i. skillful workers, ii. Optimized method, iii. quality assurance of the operation/product.

Normal rating: It complies the rate of a worker's natural work without optimized method and motivation. Each worker has different ratings ranging from zero to over hundred percentile.

Rating factors: i. 100%rating represents standard performance. ii. Operators with below 100% rating is apparently considered less effective and not optimized. iii. If the rate of working is above standard for any worker, the operator gets a rating above hundred[7].

Performance rating will follow this relation:

Observed time × performance rating = constant[8].

When the standard method and standard task time was achieved after a successful work study on a selected item, the engineer should focus on assembly line[9].

Basic Definitions and Terminologies: i. Work Element: It is a single component task, a sequential part of any total process content in a manufacturing line. A work element of T-shirt manufacturing is sleeve outer tuck. ii. Operation Breakdown Process: Consists of work elements that produce a product. T-shirt manufacturing is a process which consists of several work elements. iii. Standard Minute Value (SMV): the time value required for a qualified worker working at standard performance rate to complete a given task with additional allowances for relaxation, contingency and machine time anticipated. iv. Average Work Element Cycle Time: It is measured average time to complete the work of a work element. It does not include rating factor and allowances. v. Process Cycle Time: the time between start of a process till the initiation of the next successive process[9]. vi. Normal Time: It is the cycle time of a single process that depends on performance rating factor. vii. Work Stations: It is a small section on a line where a group of works are performed. viii. Cycle time: It is the time between starting a particular manufacturing operation and finishing of it. ix. Delay or Idle Time at Station: This is the difference between the process cycle time of the line and total time in a work station. x. Precedence Diagram: It diagrammatically presents the work elements as per their sequence relations. Any job is considered incomplete unless its predecessor has the successor work element. xi. Balance Delay or Balancing Loss: This is a measurement of line-inefficiency; when a task is not fully optimized due to imperfect allocation of work along various stations, there is idle time which increases balance delay[9]. xii. Line Efficiency: It is expressed as the ratio of the total SMV to the process cycle time, divided by the number of work stations.

Necessary Equations of Line Balancing

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

2. Line Efficiency= $\frac{\text{Total SMV}}{\text{process cycle time} * \text{no of workstation}}$ *100%

3. Balance Delay = (100-Line Efficiency) %[9].

4. No. of workstation = $\frac{\text{Total SMV}}{\text{Process Cycle Time}}$

5. Normal Time = Average work element Cycle Time * Performance Rating[10].

6. Standard Minute Value, SMV = Normal Time + (Normal Time x Allowance)[11].

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

Developing Process Chart: Before starting the improvement activities, a process control chart should be developed. For generation of process chart the following equations should be use: Pitch time = $\frac{\text{SMV}}{\text{no. of operation}}$

$$\text{Efficiency}=\frac{\text{Total process time}}{\text{No.of workstation} \times \text{cycle time}}\%$$

$$\text{Harmonic average, } \frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \ldots\ldots\ldots\ldots\ldots\ldots$$

Where: R= Harmonic average. And, R1, R2......= Observed time After constructing the process chart, following steps should be executed.

Assembly Line Balancing: The term 'Assembly line balancing' is a technique of assigning all task to a series of work station so that each work station has no more than can be done in the workstation cycle time and so that the unassigned time across all workstations is minimized[12].

Methods applied for line balancing technique: i. Ranked Positional Weight rule. ii. Largest Candidate rule. iii. Continuous Improvement Technique.

Largest Candidate Rules: This method starts with assigning the task of large SMV first. After sequentially assigning, the first element is selected to place at the first workstation. Then the following the process of work element assigned to the same station as the following steps until no elements can be added that exceeds cycle time. Repeating steps for the other stations in the line until no element left.

Ranked Positional Weight Rule: This method used for line development was introduced by Helgeson and Birnie[12]. This technique initiates by calculating the ranked positional weight value of each workstation. The existing precedence diagram of process is figured out to calculate rank positional weight value for each element. Then listing up the elements in order to their ranked positional weight. Largest RPW is placed at the top. Furthermore, assigning tasks to workstations according to their RPW without precedence constraint and time cycle violations.

Continuous Improvement Technique: The three steps of Continuous improvement technique is outlined below. i. Merging the tasks done by same machine. ii. Merging the tasks done by assistant operator. iii. Distributing the work sharing process among operators.

Bottleneck Observation: When a process loses its flow by having longer cycle time in order to move on the next process within the assembly line, bottleneck occurs. This is the main reason for reducing the efficiency of any assembly line. At present, traditional production system possesses to urge replaced with assembly lines for greater product variability and shorter cycle time[13]. The aim of this study is to unravel the bottleneck problem of sewing line during a garment manufacturing operation and modifying the layout using identification and proper allocation of task elements, thus line balancing by optimizing time and examination technique.

Methodology

By a case study and questionnaires, the experiment was done in Fashion Asia ltd, Gopalpur, district of Gazipur, Bangladesh. The steps involved in research are shown below in Figure-1.

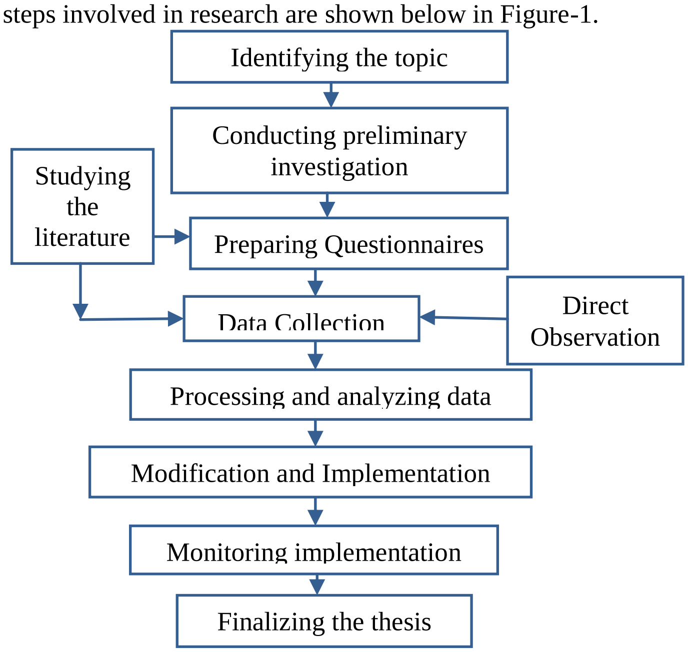

Figure-1: Overview of the research study.

Data collection and analysis

Implementation of Time Study: To estimate the production time of Callie top, six steps of time study are followed. First, the production process of Callie top is selected. According to the operation breakdown, the job was divided into 20 element tasks. The task times were recorded by using fly back and cumulative method and is shown on the table-1 with sequential list of element tasks. By observation it is found that employee performance level is low. If we want to set standard task time then method study should be conducted to improve the level of performance which was not possible to conduct due to limitations. So, employee performance rate is omitted and we have decided to find simple standard time. After processing the task times, the average observed time is found as shown in the Table-1. But for the omission of performance rating the normal time is same as average observed time.

Allowance: 15% allowance for machine operation and 20% allowance for manual operation is used in the analysis of this research, provided by the organization (Fashion Asia).

Measure the standard time: Standard time = Normal time × (1 + Allowance). Now at the end of the work measurement, we will discuss the precedence diagram for all the element task of Callie-top production.

Table-1: Time Study for existing line.

Work no.	Process Name	M/C	Observed Time (Second)						No. of employee	Harmonic Avg.	Allowance	Standard time (second)	SMV
			1	2	3	4	5	Avg.					
1	Label Make	SN	12	11	13	12	12	12	1	-	15%	13.8	0.23
2	Neck Piping	O/L	14	15	14	13	14	14	1		15%	16.1	0.27
3	Neck Piping Cut	HP	12	12	13	13	12	12	1		20%	14.4	0.24
4	Neck Thread Cut	HP	35	36	35	36	35	35	1		20%	42	0.70
5	Bk Tape Piping	SN	17	16	18	17	18	17	1		15%	19.55	0.33
6	Shoulder Join	O/L	28	30	31	28	29	29	2	30.1339	15%	34.654	0.58
		O/L	30	31	32	32	31	31			15%		
7	Neck Servicing	O/L	18	17	18	16	15	17	1	-	15%	19.55	0.33
8	Bk Tape Top St	SN	19	21	21	20	22	21	1		15%	24.15	0.40
9	Sleeve Join	O/L	40	38	36	39	40	39	2	34.0928	15%	39.2067	0.65
		O/L	31	32	30	29	31	31			15%		
10	Thread Cut	HP	23	24	24	25	22	24	1	-	20%	28.8	0.48
11	Neck Inner Tuck	SN	12	13	12	11	12	12	1		15%	13.8	0.23
12	Neck Tuck	SN	12	14	14	13	12	13	1		15%	14.95	0.25
13	V Join	SN	31	33	32	31	32	32	2	32.275	15%	37.1163	0.62
		SN	33	34	33	32	32	33			15%		
14	Thread Cut	HP	22	23	24	24	23	23	1	-	20%	27.6	0.46
15	Btm Hem	F/L	19	18	18	17	19	18	1		15%	20.7	0.35
16	Slv Round Hem	F/L	21	21	20	19	20	20	1		15%	23	0.38
17	Side Seam Join	O/L	45	46	45	47	46	46	2	46.0719	15%	52.9827	0.88
		O/L	46	47	47	48	44	46			15%		
18	Hanger Loop Attach	SN	24	23	23	24	24	24	2	24.4426	15%	28.1089	0.47
		SN	25	26	24	27	25	25			15%		
19	Sticker Remove & Body Turn	HP	16	17	15	16	15	16	1	-	20%	19.2	0.32
20	Thread Cut & Body Turn	HP	17	18	18	19	18	18	1		20%	21.6	0.36
Total													8.53

According to the precedence relationship of the element tasks, the precedence diagram is shown in the Figure-2.

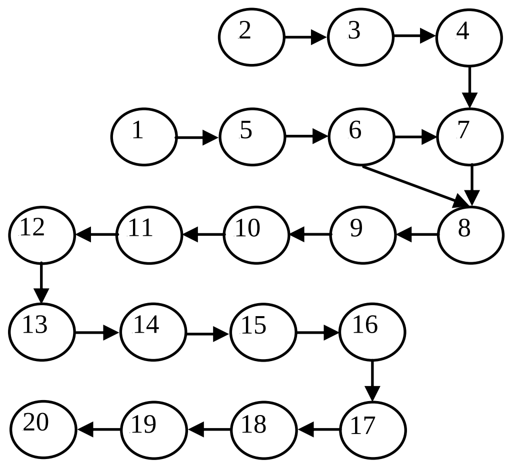

Figure-2: Precedence Diagram of work elements.

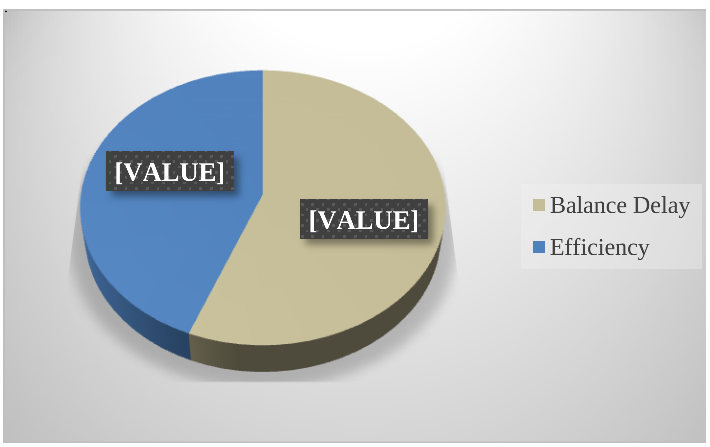

Figure-3: Balanced delay vs efficiency in existing method.

In the precedence diagram, the number inside the circle indicate the serial number according to the table and direction of arrow indicated the direction of flow.

Productivity of existing line: 4 weeks for 1 month, and each week has 6 working days and each day has 10 working hours.

Then our daily demand = $\frac{88910}{6*6*4}$ = 617.43 = 618 pieces/day.

Process cycle time = $\frac{60\times10}{618}$ = 0.97 minute/piece.

Line efficiency = $\frac{8.53}{0.97\times20}$ × 100% = 43.96%

Balance Delay = 100 – line efficiency = (100 – 43.96) = 56.04%

Theoretical minimum no. of workstation = $\frac{8.53}{0.97}$ = 8.79 ≈ 9.

Current Flow: The figures constructed to portray the existing line scenario.

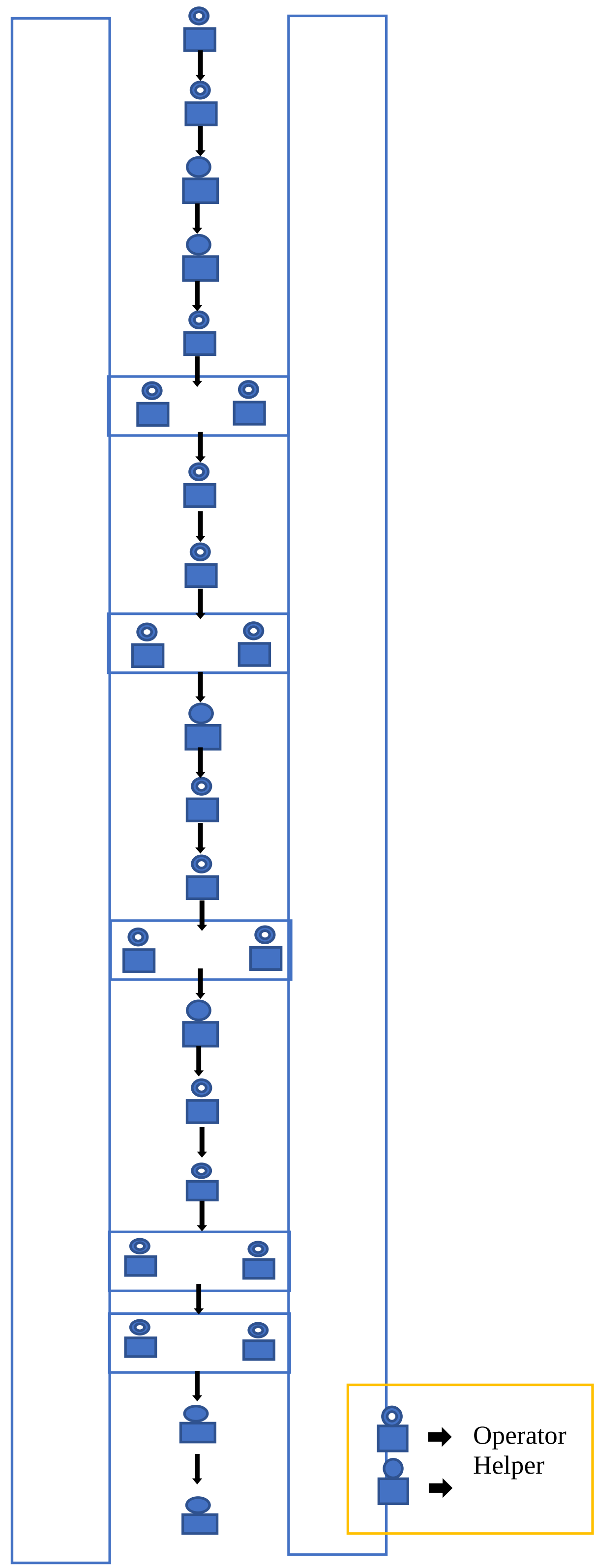

Figure-4: Current layout.

Table-2.1:

No of operators	19
No. of helpers	6
No. of workstations	20

Table-2.2:

Month	Demand
Nov-20	1520
Dec-20	16340
Jan-21	14000
Feb-21	14700
Mar-21	14550
Apr-21	14120
Total	88910

Improvement strategy: This chapter contains the improvement of existing assembly line through 3 different methods and the elimination of bottleneck by adjustment of operators by their capacity.

Ranked positional weight method: Following steps of balancing analysis using ranked positional weight method of reallocation are described below –

For work element 1, the SMV of the work element 5 is 0.33 min and the work breakdown that followed work no. 1 in that chain are work elements 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20. So the sum of SMV is 7.32. All ranked positional weight are calculated by same method and are arranged in order of their weight value.

Line efficiency = $\frac{8.53}{0.97\times 13}\times 100\ \% = 67.64\ \%$

Balance delay = 100-line efficiency
= (100-67.64) %
= 33.36 %

Figure-5 shows the ratio between efficiency vs balanced delay in RPW method reallocation: Figure-6 shows the reallocation of work elements to workstation.

Table-3: List of work element in order to the RPW value.

Work elements	RPW	SMV	Immediate Predecessors
2	7.39	0.27	-
1	7.32	0.23	-
3	7.12	0.24	2
5	7.09	0.33	1
4	6.88	0.70	3
6	6.76	0.58	5
7	6.18	0.33	4,6
8	5.85	0.40	6,7
9	5.45	0.65	8
10	4.80	0.48	9
11	4.32	0.23	10
12	4.09	0.25	11
13	3.84	0.62	12
14	3.22	0.46	13
15	2.76	0.35	14
16	2.41	0.38	15
17	2.03	0.88	16
18	1.15	0.47	17
19	0.68	0.32	18
20	0.36	0.36	19

Table-4: Assignment of tasks into different workstations using RPW method.

Work Station	Work element	SMV (min)	Sum of SMV	Idle time/ work-station
A	2	0.27	0.74	0.231
	1	0.23		
	3	0.24		
B	5	0.33	0.33	0.64
C	4	0.70	0.70	0.27
D	6	0.58	0.91	0.06
	7	0.33		
E	8	0.40	0.40	0.57
F	9	0.65	0.65	0.32
G	10	0.48	0.96	0.01
	11	0.23		
	12	0.25		
H	13	0.62	0.62	0.35
I	14	0.46	0.81	0.16
	15	0.35		
J	16	0.38	0.38	0.59
K	17	0.88	0.88	0.09
L	18	0.47	0.79	0.18
	19	0.32		
M	20	0.36	0.36	0.61
Total=13			∑ 8.53	∑ 4.08

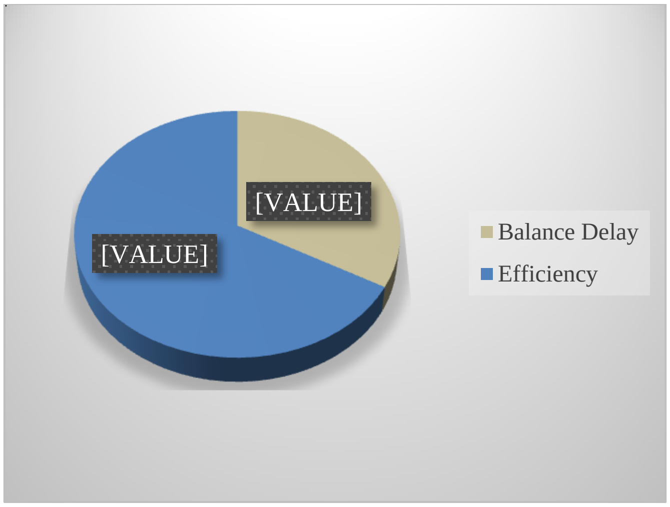

Figure-5: Balanced delay vs efficiency in RPW method.

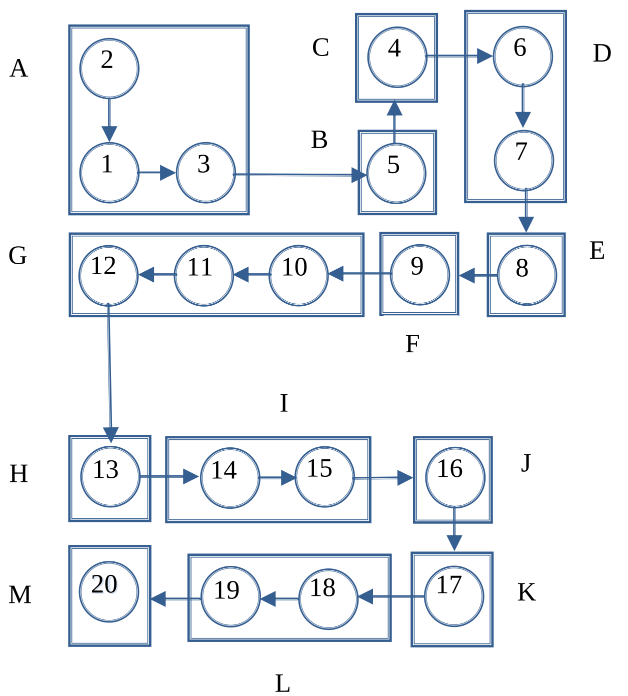

Figure-6: Assignment of different work elements into different work stations.

Largest candidate rule: This method assigns all elements in descending order of SMV, where largest is the top of the list.

The first feasible element for placement at the station are selected to assign into first workstation. A feasible element is one that satisfies the precedence requirements and does not cause the sum of the SMV at the station to exceed the cycle time. The process of assigning tasks to the station repeats until no further elements left to the limit of cycle time. The Table-6 shows the workstation containing element and SMV.

Table-5: Work element arrangement according to SMV.

Work elements	SMV	Immediate Predecessors
17	0.88	16
4	0.70	3
9	0.65	8
13	0.62	12
6	0.58	5
10	0.48	9
18	0.47	17
14	0.46	13
8	0.40	6,7
16	0.38	15
20	0.36	19
15	0.35	14
5	0.33	1
7	0.33	4,6
19	0.32	18
2	0.27	-
12	0.25	11
3	0.24	2
1	0.23	-
11	0.23	10

Line efficiency = $\frac{8.53}{0.97\times13}$ × 100 % = 67.64 %

Balance delay = 100-line efficiency
= (100-67.64) %
= 33.36 %

Figure-7 shows the ratio between efficiency vs balanced delay in LCR method reallocation:

From the table-6 assignment of work elements by LCR method is illustrated in Figure-8.

Table-6: Reallocation of work element into workstation by Largest Candidate Rule.

Work Station	Work element	SMV (min)	Sum of SMV	Idle time/ workstation
A	2	0.27	0.83	0.14
	1	0.23		
	5	0.33		
B	6	0.58	0.58	0.39
C	8	0.40	0.40	0.57
D	9	0.65	0.65	0.32
E	10	0.48	0.72	0.25
	3	0.24		
F	4	0.70	0.70	0.27
G	7	0.33	0.81	0.16
	11	0.23		
	12	0.25		
H	13	0.62	0.62	0.35
I	14	0.46	0.81	0.16
	15	0.35		
J	16	0.38	0.38	0.59
K	17	0.88	0.88	0.09
L	18	0.47	0.79	0.18
	19	0.32		
M	20	0.36	0.36	0.61
Total=13			∑ 8.53	∑ 4.08

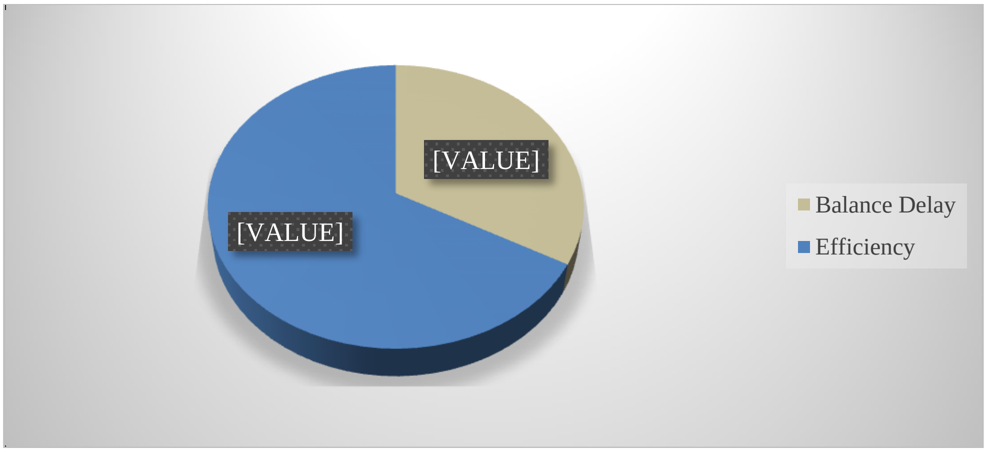

Figure-7: Balanced delay vs efficiency in LCR method.

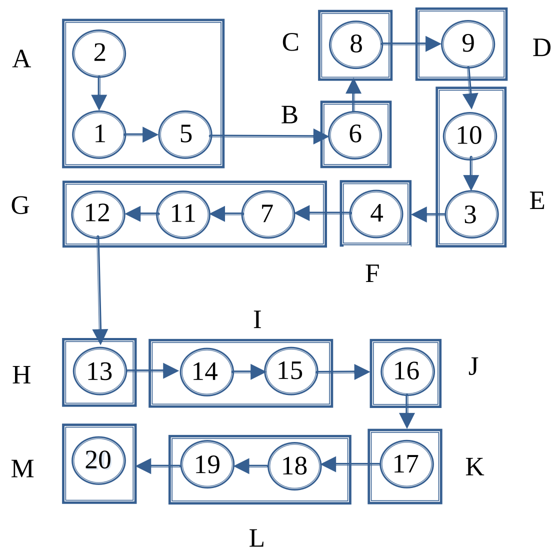

Figure-8: Assignment of different work elements into different work stations.

Continuous Improvement Technique: In this technique, we tried to merge the elements done by same machine or helper as well as tried to distribute the elements done by helpers among operators.

According to the current production status of line, it is 630 pieces per day. (Questionnaire)

New cycle time(C) = $\frac{60\ minutes \times 1Hr}{630\ pieces}$

= 0.95 min per cycle

As a part of this technique, below steps has been followed.

Merging the work element has been done by same machine: Elements 1 & 5 are done by SN machine and their cumulative SMV = 0.56, Elements 2 & 6 are done by O/L machine and their cumulative SMV = 0.85, Elements 12 & 13 are done by SN machine where sum of their SMV = 0.87.

As the sum of these SMV are not much than process cycle time (0.95), so both tasks can be selected inside separate workstation, A, B & H respectively.

Merging the work elements done by helper: Elements 3 & 4 are done by helper where sum of their SMV = 0.94.

Elements 19 & 20 are done by helper and their cumulative SMV = 0.68, Here, the sum of both SMV are less than process cycle time so they can be selected inside the separate workstations C & M respectively.

Distributing the helping process among operators: Element 10 is done by helper and element 11 is done by SN machine where sum of SMV of these two elements is 0.71, which is less than process cycle time. So, they can be selected under workstation G. All of these selections are done by keeping in mind the precedence of the elements.

Table-7: Reallocation of tasks into workstation by Continuous Improvement Technique.

Work-Station	Work element	M/C	SMV (min)	Sum of SMV	Idle time/ work-station
A	1	SN	0.23	0.56	0.39
	5	SN	0.33		
B	2	O/L	0.27	0.85	0.10
	6	O/L	0.58		
C	3	HP	0.24	0.94	0.01
	4	HP	0.70		
D	7	O/L	0.33	0.33	0.62
E	8	SN	0.40	0.40	0.55
F	9	O/L	0.65	0.65	0.30
G	10	HP	0.48	0.71	0.24
	11	SN	0.23		
H	12	SN	0.25	0.87	0.08
	13	SN	0.62		
I	14	HP	0.46	0.81	0.14
	15	F/L	0.35		
J	16	F/L	0.38	0.38	0.57
K	17	O/L	0.88	0.88	0.07
L	18	SN	0.47	0.47	0.48
M	19	HP	0.32	0.68	0.27
	20	HP	0.36		
Total=13				∑ 8.53	∑ 3.82

Line efficiency = $\frac{8.53}{0.95\times13}\times 100$ %

= 69.06 %

Balance delay = 100-line efficiency
= (100-69.06) %
= 30.94 %

Figure-9 shows the ratio between efficiency vs balanced delay in CIT method reallocation:

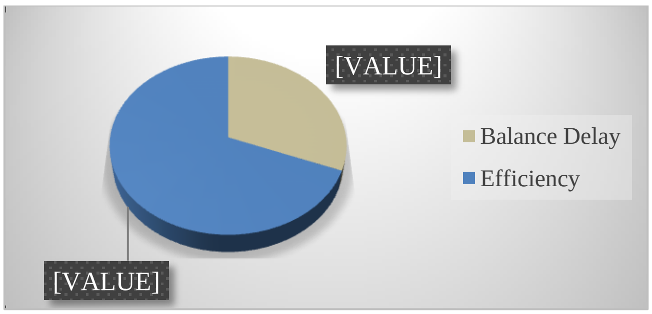

Figure-9: Balanced Delay vs Efficiency for Continuous Improvement Technique.

From Table-7, assignment of work elements by Continuous Improvement Technique is illustrated in Figure-10.

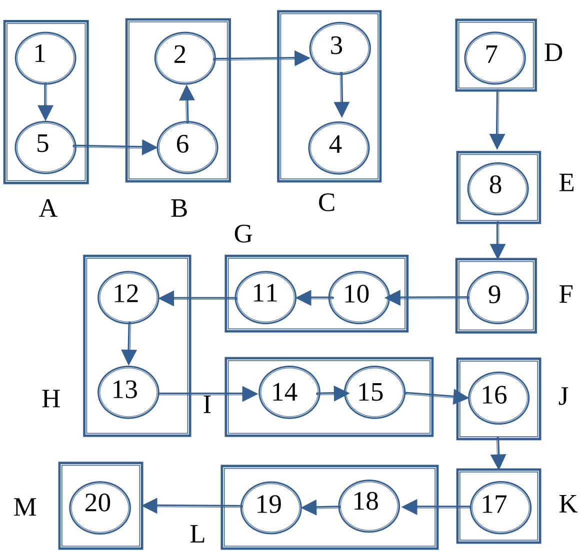

Figure-10: The assignment of different work elements into different work stations.

Bottleneck Identification: By the data collected from the industry and the data provided from the industry we got the capacity of the workers and the target. From these we can compare and find the bottleneck of the existing line. Table-8 shows the capacity of the workers and hourly target.

Proposed strategies for eliminating bottleneck: i. Split the task and share the task. ii. Use parallel workstation. iii. Use/hire more skilled worker. iv. Use inventory buffer system but it is difficult to implement. v. Introduce flexible line layout.

Repositioning of Workers in Bottleneck Points: Operators operating the same machine type can be exchanged or the operator with high capacity can help the operator in bottleneck points. Similarly, helpers with high capacity can help the helper with low capacity. This way the bottleneck points can be minimized easily and the quality is maintained as well. These are all done keeping the precedence of work in mind. The Figure-11 shows the relocation of the worker.

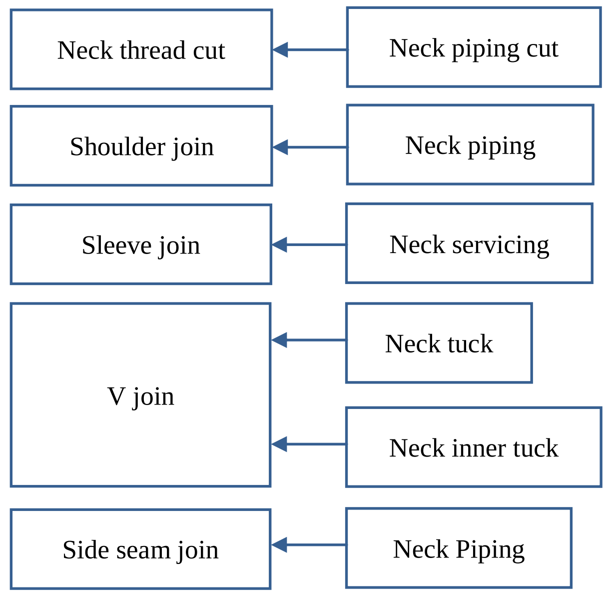

Figure-11: Relocation of workers in bottleneck points.

Results and discussion

After selecting a production line, this thesis was carried out by breaking down the operation of a ladies garment (Callie top) into different element along with types of machines and helpers. Each work element has been meticulously experimented with the help of officials in charge of that area. Due to pandemic and lockdown, method study was kept closed. Time has been observed carefully for each element and several observations were taken into account. After calculating the average time of each element, allowances have been added according to the type of element (machining or helping). A precedence diagram has been developed. After collecting the demand data, process cycle time has been calculated. The assembly line balancing methods that were used were Ranked Positional Weight Method, Largest Candidate Rule Method and Continuous Improvement Method. We observed the line for around 7 days and collected the data. For studying a single line a week's observation gave enough data to implement in the methods we used.

This thesis study was to reduce the number of workstations to lessen the balanced delay. Initially, the no. of workstations was 20 and after improvement it was turned to 13.

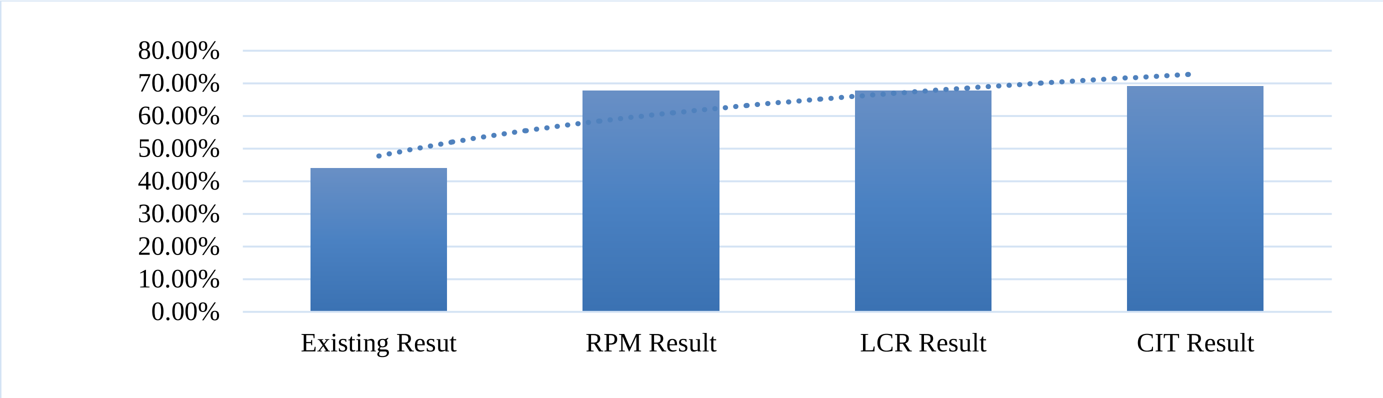

Figure-12: Summary of Efficiency.

Table-8: Capacity vs Target.

Work element no.	Operation name	M/C	Capacity of Process	Target
1	Label Make	SN	274	125
2	Neck Piping	O/L	238	125
3	Neck Piping Cut	HP	266	125
4	Neck Thread Cut	HP	98	125
5	Bk Tape Piping	SN	196	125
6	Shoulder Join	O/L	230	250
7	Neck Servicing	O/L	201	125
8	Bk Tape Top St	SN	166	125
9	Sleeve Join	O/L	204	250
10	Thread Cut	HP	145	125
11	Neck Inner Tuck	SN	274	125
12	Neck Tuck	SN	254	125
13	V Join	SN	215	250
14	Thread Cut	HP	148	125
15	Btm Hem	F/L	186	125
16	Slv Round Hem	F/L	169	125
17	Side Seam Join	O/L	152	250
18	Hanger Loop Attach	SN	281	250
19	Sticker Remove & Body turn	HP	212	125
20	Thread Cut & Body Turn	HP	188	125

Table-9: Summary of calculation of proposed line.

Items	Existing Result	RPM Result	LCR Result	CIT Result
Cycle time	0.97	0.97	0.97	0.95
Balance Delay	56.04%	32.36%	32.36%	30.94%
Efficiency	43.96%	67.64%	67.64%	69.06%
Labor productivity(per worker per day)	31/ worker/day	47.5/ worker/day	47.5/ worker/day	48.5/ worker/day
No. of workstation	20	13	13	13
Total process time	8.53	8.53 min	8.53 min	8.53 min
Idle time per cycle (min)	10.87	4.08 min	4.08 min	3.82 min
Time Allocate per cycle	19.40	12.61 min	12.61 min	12.35 min

Conclusion

Because of the enormous increasing competition in Apparel manufacturing industries, they are focusing on to maintain the demand and shipment deadline to cope with the dynamic market. By the successful application of the line balancing, the improvement of efficiency, production rate, reduction of idle time etc. can be achieved which are the ultimate goal of an organization. In this research, we tried to extract the actual scenario of a particular production line. After conducting time study, the work elements were arranged into different workstations by RPW, LCR and Continuous Improvement method. The main aim was to reduce the number of workstations with the theoretical value as much as possible so that idle time reduced and efficiency and labor productivity improved. RPW and LCR method gave the same results, but the best way was possible by Continuous Improvement Technique which increased labor productivity by 17.5 pieces/worker/day and efficiency by 25.1%.

Limitation: Although the objectives of this research are achieved but there were some limitations. The main limitation was the lack of method study. There were obstacles to directly evaluate the existing method due to pandemic situation. It was only assumption that the existing method is standard. Another limitation was the omission of the performance rating. The reason for omission was that it was not satisfactory due to absence of standard time.

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