PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING & LAYOUT IN AN APPAREL INDUSTRY TO BUILD UP A REFERENCE MODEL

MOHAMMAD SAIDUR RAHMAN

DEPARTMENT OF INDUSTRIAL & PRODUCTION ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING &
TECHNOLOGY
DHAKA, BANGLADESH

April 2016

PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING & LAYOUT IN AN APPAREL INDUSTRY TO BUILD UP A REFERENCE MODEL

By

MOHAMMAD SAIDUR RAHMAN

Thesis Submitted

To

Department of Industrial & Production Engineering

In Partial Fulfillment of the Requirement for the award of the Degree of

MASTER IN ADVANCE ENGINEERING MANAGEMENT

DEPARTMENT OF INDUSTRIAL & PRODUCTION ENGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

DHAKA, BANGLADESH

April 2016

The thesis titled **Productivity improvement through line balancing & layout in an apparel industry to build up a reference model** submitted by **Mohammad Saidur Rahman**, Student No. 0412082124, Session- April 2012, has been accepted as satisfactory in partial fulfillment of the requirement for the award of the degree of Master In Advance Engineering Management on April 26, 2016.

BOARD OF EXAMINERS

____

1. Dr. Shuva Ghosh — Chairman (Supervisor)

Assistant Professor

Department of Industrial & Production Engineering

BUET, Dhaka

____

2. Dr. Nikhil Ranjan Dhar — Member

Professor

Department of Industrial & Production Engineering

BUET, Dhaka

____

3. Dr. Ferdous Sarwar — Member

Assistant Professor

Department of Industrial & Production Engineering

BUET, Dhaka

This work is dedicated
to my loving parents
Mohammad Abul Hossain
&
Shahida Begum

ACKNOWLEDGEMENTS

First of all, I have to readily acknowledge and thank to Allah, The Omnipotent and Omniscient who created everything and in giving me the ability to start and complete this project. I also wish to express my sincere appreciation to my supervisor, Dr. Shuva Ghosh, for his guidance, advices, motivation, and critics. Without his help and support, this thesis would not have been the same as presented here.

I want to thank to my family, and all of my big family, for their affection, prayer, and support throughout my study. Without them, this work of mine will never be a success.

Last but not least, I would also like to thank to the people of the garment industry who helped me from collecting data to all information. This study would not be complete without the support that was obtained from that company. Thank you for all the help and advice given.

ABSTRACT

RMG industry sustains on customer satisfaction directly or indirectly. Customer satisfaction comes from value added activities which mainly focus on low cost, quality & on time delivery. For confirming the value added activities, an industry must give concern to decrease the waiting time, process bottleneck and above all, increasing the productivity. Line balancing is an effective technique to improve the productivity. This technique is already applied in different industry and proved its effectiveness to improve the productivity.

In this work, line balancing is considered in an RMG industry at a sewing line as a sample project. At the begging of the project, existing data is collected through time study and then, analyze the data & find out the opportunity. Using the line balancing technique, production line refers to balance through the balance distribution of work among the workstations. In reference production line, productivity may possible to increase almost 38 %. Existing problems are identified and refer to solve considering the sequence of operation.

This research report provides guideline for the garments manufacturer to improve their industrial productivity and capacity by implementing the productivity improvement techniques like line balancing technique.

LIST OF ABBREVIATIONS

RMG	: Ready Made Garments
GDP	: Gross Domestic Product
IUH	: Incremental Utilization Heuristic
KAIZEN	: Continuous Improvement
PDM	: Precedence Diagram Method
WIP	: Work In Process

LIST OF FIGURES

FIGURE	TITLE	PAGE
3.1	Methodology flow chart	07
4.1	Product picture	11
4.2	Process flow chart	12
4.3	Process capacity chart (Before)	15
4.4	Existing layout	16
4.5	Precedence Diagram	17
4.6	Proposed layout	22

LIST OF TABLES

TABLE	TITLE	PAGE
4.1	Calculation before line balancing	14
4.2	Task precedence table	19
4.3	Task allocation table	21

CONTENTS

CHAPTER	TITLE			PAGE
1	**INTRODUCTION**			**1**
	1.1	Introduction		1
	1.2	Project background		1
	1.3	Problem statement		2
	1.4	Objective with specific aim & possible outcome		2
2	**LITERATURE REVIEW**			**3**
	2.1	Introduction		3
	2.2	Literature review		3
		2.2.1	Productivity	4
		2.2.2	Line balancing	5
		2.2.3	Layout	6
3	**METHODOLOGY**			**7**
	3.1	Introduction		7
	3.2	Methodology flow chart		7
		3.2.1	Company & product choosing	8
		3.2.2	Data collection	8
		3.2.3	Measuring method	8
		3.2.4	Calculation	9
		3.3.5	Create the reference model	10
4	**DATA ANALYSIS & RESULT**			**11**
	4.1	Introduction		**11**
	4.2	Data analysis & calculation		11
		4.2.1	Before balancing the line	13
			4.2.1.1 Existing layout	16
		4.2.2	After balancing the line	17
			4.2.2.1 Proposed layout	22
5	**LIMITATION & CONCLUSION**			**23**
	5.1	Limitation		23
	5.2	Conclusion		23
	REFERENCE			**24**

Chapter-1
INTRODUCTION

1.1 Introduction

Every service or manufacturing based industry has a common goal to minimization of the input and maximization of the output. The relation between of those two factors is called productivity. One of the major causes of an industry's decline is low productivity. Failure to meet targeted productivity can result to high costs per unit which making goods, services not competitive enough on the market. As a result, industry faces low quality, high cost and on time delivery problem. To remain competitive in the market, many industries try to implement strategies to make improvements in productivity levels. Actually productivity varies due to cross county and cross-regional differences, culture & knowledge. Getting the optimum productivity, a management gives concern on scientific management technique to measure man, machine or value utilization. Increment in productivity level reduces manufacturing cost. Industry can make more profit through productivity improvement. Productivity of Bangladesh industry worker is comparable low compare to others country due to the lack of using scientific tools & technique & proper management. This paper intends to improve the productivity of an apparel industry in Bangladesh by the use of line balancing.

1.2 Project Background

The RMG (Ready Made Garment) sector contributes around 76 percent to the total export earnings and contributes around 13 percent to the GDP, which was only around 3 percent in 1991. Of the estimated 4.2 million people employed in this sector, about 50 percent of them are women from rural areas. In 2000, the industry consisting of some 3000 factories employed directly more than 1.5 million workers of whom almost 80% were female. [1] McKinsey forecasts export-value growth of 7 to 9 percent annually within the next ten years, so the market will double by 2015 and nearly triple by 2020. [2]

To obtain the forecasts growth, each RMG industry must manage the production line very well & follow the cost effective strategy. Cost effective strategy mainly includes two key points: Cost reduction strategy & labor productivity improvement. Cost reduction strategy should begin with assigning the highest priority for establishing backward linkage. The establishment of backward linkages will reduce dependence on foreign sources which will reduce the total & average production cost of garments. This strategy will make products more competitive in the world's RMG market. At the same time, labor productivity must be improved to keep place in the world largest competitive market.

In this case, a systematic technique or approach should be introduced. One of the techniques is line balancing technique. The used of line balancing technique was proved able to increase the productivity for the small medium enterprise. By using the line balancing technique, the production will increase because the arrangement of the line is corrected and the maximum productivity will be archive.

1.3 Problem Statement

In line production system, the product moves one workstation to another after completing individual process. Once it's get stuck due to accumulation in certain workstation, it exceeds the cycle time in that station. Faster station is limited by slowest station. Thus, decreasing the rate of productivity & unbalance workloads due to starving, the workers need to wait the products to come.

1.4 Objectives with specific aims and possible outcome:

The objectives are expected in the end of the project:

- To minimize the idle time of men and machines.
- To group the tasks and worker in an efficient pattern in order to obtain an optimum line balance efficiency and productivity.

Chapter-2

LITERATURE REVIEW

2.1 Introduction

This chapter is to explore and gathered all information's in order to understand clearly about line balancing. The information's is come from reference books, journals and thesis. These sections are mainly concern about related knowledge about Line Balancing what are the efficiency & productivity after balance the line. Ready Made Garments (RMG) industries becoming the selected area then the scope is narrow down from manually assembly line through down until last part is productivity. In the first part of the Literature Reviews, study and analysis of previous work and other part is regarding the explanation of line balancing, productivity & layout. This particular area is discussed to give better understanding on what is purpose of this research.

2.2 Literature Review

Rezaul et al. studied an apparel industry and referenced an effective layout model where to hit upon the bottleneck process through benchmark capacity and led them to use balancing process using two separate concept of manufacturing processes- modular line and Traditional system both together. The research shows that this balanced layout model has increased the efficiency by 21%, and labor productivity by 22% [3]. Daniel et al. developed a simulation model that visualize the existing production process of basic polo-shirt in manual-operations oriented system so as to identify the bottlenecks and enhance system performance and developed different alternatives (scenarios) so as to improve existing labor utilization rate. Therefore, by adding three effective work centers the productivity of the line is increased from 349 to 692 pieces of finished polo-shirts. This means productivity is increased by two folds i.e. the productivity per operator is increased from 12 pieces to 19 pieces per operator per shift.[4] Robert W McClure studied at one Pulse Engineering's transformer manufacturing facilities in Mexico, the factory was straining to meet its delivery schedule because of large backlog. After line balancing, he achieved a 47 increase with fewer workers.

Nakajima et al. have proposed a simple calculating method to determine the number of workstations and cycle time. This calculating method is simple and intelligible but has not been attended to the said feature of apparel assembly line, i.e. machine type. This also has some disadvantage such as excess time required for moving operator between machines, necessity of multi-skilled operators, requiring more number of machine and thereupon further space. However, beside these disadvantage, developing a new method which could consider the machinery feature in balancing apparel assembly line is strongly required.[6] Latter, F Khosravi et al. have proposed a improve model based on Nakajima model for apparel assembly line balancing to take into consideration the machine type assigned to each workstation. By this improvement, proposed model was need less workers and less workstation [7]

V. P.Jaganathan worked to solve the assembly line balancing with different labour skill levels to reduce in-process inventory and workload smoothing in the workstations of sewing. After applying the rule of largest candidate heuristic, the Production time of the garment has been reduced from 5.18 to 3.90 minutes. Operators have been reduced to 8 from 16. Assembly line efficiency has been increased from 59.5% to 85.5 %. Productivity per hour has been increased by 25 % through assembly line balancing. [8] In another work, U.C Ubani studied and developed the precedence diagram and determined the balance efficiency, balance lost and other performance measures associated with line balancing in the design of product layout for automobile assembling. The study employed the method of Incremental Utilization Heuristic (IUH) in balancing the assembly line and determining other performance measures. He shows that line balance efficiency can possible to reach up to 96.88 % through the Incremental Utilization Heuristic. [9]

2.2.1 Productivity

Productivity can be defined as "OUTPUT" compared to "INPUT". It is quantitative relationship between what we produce and what we have spent to produce. Productivity is nothing but reduction in wastage of resources like men, material, machine, time, space, capital etc. It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be maximum distribution of benefits among maximum number of people. According to Marsh, Brush (2002) in his article Journal of industrial technology, productivity is a measure of the efficiency and effectiveness to which organizational resources (inputs) are utilized for the creation of products and/or services (outputs). [10] In case of garment manufacturing factory, "output" can be measured the number of products manufactured, whilst "input" is the people, machinery and factory resources required to create those products within a given time frame. The key to cost effective improvements in output – in "productivity" – is to ensure that the relationship between input and output is properly balanced. The proper utilization of line balancing technique can be created a dramatic effect for improving the productivity. For example, there is little to be gained from an increase in output if it comes only as a result of a major increase in input. Indeed, in an ideal situation, "input" should be controlled and minimized whilst "output" is maximized. There have different ways of measuring the productivity but mostly used are labour productivity, Machine Productivity and Value productivity.

2.2.2 Line Balancing

In RMG industry, the most critical section is sewing section where a set of workstations are assigned for a specific task to process according to a specific sequence. Usually, one or more tasks are assigned to a workstations and several consecutive workstations form as sewing line. Therefore, the aim of line balancing in sewing line is to assign tasks to workstations can perform the assigned tasks with a balance loading. [7] Balance loading means to balance the number & sequence of operations and manpower. Line Balancing means balancing the production line, or any assembly line. The main objective of line balancing is to distribute the task evenly over the work station so that idle time of man of machine can be minimized. Lime balancing aims at grouping the facilities or workers in an efficient pattern in order to obtain an optimum or most efficient balance of the capacities and flows of the production or assembly processes. Line balancing is the technique of assigning the operations to workstations in such a way that the assignment be optimal in some sense. Ever since Henry Ford's introduction of assembly lines, LB has been an optimization problem of significant industrial importance: the efficiency difference between an optimal and a sub-optimal assignment can yield economies (or waste) [11]

Time Study: The processing time exists simply because the process requires tasks and motion. To put it in a different way, the working method and the number of work components are closely related to the net processing time. The time study begins by measuring the number of seconds required to lift, operation and place. It then proceeds to make improvements based on the time values and ends by defining the differences in the time values caused by the individual differences of the workers. The Industrial Engineering Terminology Standard defines time study as "a work measurement technique consisting of careful time measurement of the task with a time measuring instrument, adjusted for any observed variance from normal effort or pace and to allow adequate time for such items as foreign elements, unavoidable or machine delays, rest to overcome fatigue, and personal needs. [12]

Precedence Diagram: PDM is a visual representation technique that depicts the activities involved in a project. Precedence Diagrams are also known as Project Network Diagrams. In this article, both terms are used interchangeably. [13]

PDM using for following help

- ✓ The visual representation makes it easier to communicate the flow of project execution or the project activity flow
- ✓ There is a greater chance for team to identify missing activities.
- ✓ Each activity is dependent on some other activity. When a dependency is not identified, the project will be delayed until such a time that identification occurs

Certain activities have a greater impact on project schedule than others. By using PDMs, can possible to determine the activities critical to the project schedule

Takt Time: Takt time is the average time between the start of production of one unit and the start of production of the next unit, when these production starts are set to match the rate of customer demand. [14] Assuming a product is made one unit at a time at a constant rate during the net available work time, the takt time is the amount of time that must elapse between two consecutive unit completions in order to meet the demand.

2.2.3 Layout

Sewing work is carried out manually, greatly depending on manpower. This means that a difference in motoin levels of operators will directly affect the time value.Work result vary depending of presence/absence of waste time, work speed and degree of consistency. Layout can be improved through maintaing this bellow issues:

- The distance by which the goods (Products) move shall be minimized
- The distance by which the goods worker move shall be minimized
- The distance by which the information is distributed shall be minimized.
- Machine shall be laid out so that the progress of work can be visually checked at a glance
- The layout of machines shall be flexible to accept a slight change in specifications.

CHAPTER-3

METHODOLOGY

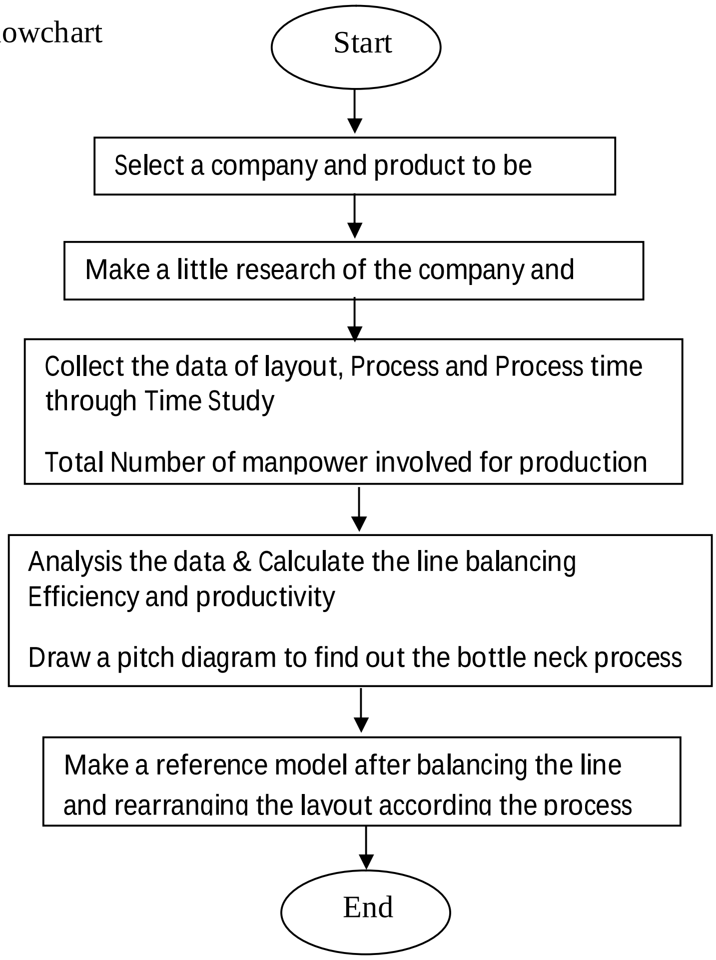
3.1 Introduction

In order to achieve the objectives and goal of the project, the methodology flow chart has been planned and designed. The main objective to do the methodology flow chart is to be a guideline and direction to make sure the project run smoothly and successfully. In this project many of method will be used such as calculate the Standard processing time, Line Balance efficiency and productivity also. Latter, will use a PDM diagram or Precedence Diagram Method for showing the precedence of tasks.

3.2 Methodology Flowchart

To make sure the project will run smoothly, the methodology flowchart was created. The following step is the method that will be used in this project. The step was:

Figure 3.1 Methodology Flowchart



3.2.1 Company & product choosing

Make a little research of the product of the company and the process that involve to make a product because in the company that has many assembly line so that this research is to make sure that the choosing of the assembly line is correct place and correct time to apply the line balancing technique.

3.2.2 Data collection

To understand the production capacity, line balance efficiency, total process time, productivity and for design the optimum production system, process time is required. The processing time exists simply because the process requires tasks and motion. To put in a different way, the number of work components is closely related to the net processing time. The time study begins by measuring the number of seconds required to lift, sew and place.

Number of workers also must being identified to know where the place or machine that needed the worker. Total time and time collecting also will be observed and recorded. Total time is the amount of time that the assembly line finishes all task work in all workstation to make one product. Time collecting is the amount of time used to complete the task by one workstation.

3.2.3 Measuring Method

Continuous time Observation: Continue making observations without stopping the hand on the stop watch. Then, read and record the value pointed to by the hand when the work is stopped. Upon completion of all the work components, subtract the value recorded at the start of each work component from the value recorded at the end of each work component so as to obtain the time required for each work component. Measuring procedure can be describe with bellow steps:

i. Calculate the individual time

ii. Don’t calculate the individual time for a work component in which an irregular movement was observed.

iii. Calculate the average individual time value.

iv. Now collect the values of all the process and calculate the total net processing time.

3.2.4 Calculation

Related relation among different factor for doing the calculation of line balancing & productivity are given bellow: Standard processing time is the difference between the standard time and basic time is whether or not the allowance rate is included. The relation is expressed with the following formula,

Standard Processes Time = Basic Processes Time (1+ Allowance Rate)

There are some more formula required to calculate the line balancing & as follow:

Takt time or Cycle time can be first determined with the formula:

$$C = Ta / D$$

Where
C = Takt time or Cycle Time, e.g. [work time between two consecutive units]
T_a = Net time available to work, e.g. [work time per period]
D = Demand (customer demand), e.g. [units required per period]

Theoretical Min. Number of Workstations,

$$N_t = \frac{\text{Sum of task times (T)}}{\text{Cycle time (C)}}$$

$$\text{Efficiency} = \frac{\text{Sum of task times (T)}}{\text{Actual number of workstations (Na) x Cycle time (C)}}$$

Productivity earlier defined as “Output” by “Input”. The expression is:

Productivity = $\frac{\boldsymbol{Outpur}}{\boldsymbol{Input}} * 100\%$

3.2.5 **Create the reference model**

For building the reference model, Line balancing and layout improvement is very essential to make the production flow almost smoother compare to previous layout and work allotment. There are several rules for allocation of tasks among workstations as bellows:

- Largest number of following tasks rule
- Longest task time heuristic rule
- Incremental utilization heuristic

Our primary rule is to prioritize task based on the length number of following tasks. If there is a tie, our secondary rules is to prioritize tasks in the order of the longest task time.

CHAPTER-4

DATA ANLAYSIS & RESULT

4.1 Introduction:

The analysis of data and information gathered led to significant improvement carried out in line balancing. Comparison result before and after technique implementation was extensively reviewed. This data analysis chapter is constructed with coordination of some steps as data collection through time study, analysis the data through graphical representation; show the existing layout and their shortcoming. Finally this chapter will show the existing line balance efficiency and productivity and later the increase efficiency & productivity of reference model after balancing the line.

4.2 Data analysis & Calculation

In this project, to analyze the structure of garment assembly processes, kids pant sewing line was considered. The first step performed in this study was to understand kids pant sewing processes' components and sewing line problems. The objective was to have a clear idea on how a kid pant production-sewing process line flows and then, how the line can be balanced as well as the performance of production line can be increased. In the production of kids pant, there is sequence of phases namely:

1. Bow making
2. Front Part
3. Back Part
4. Waist band panel
5. Waist band
6. Assembly

Fig. 4.1 : Product picture

Process Flow

Business dictionary define the process analysis as a step by step breakdown of the phases of a process, used to convey the inputs, outputs and operations that take place during each phase. A process analysis can be used to improve understanding of how the process operates and to determine potential targets for the process improvement through removing waste

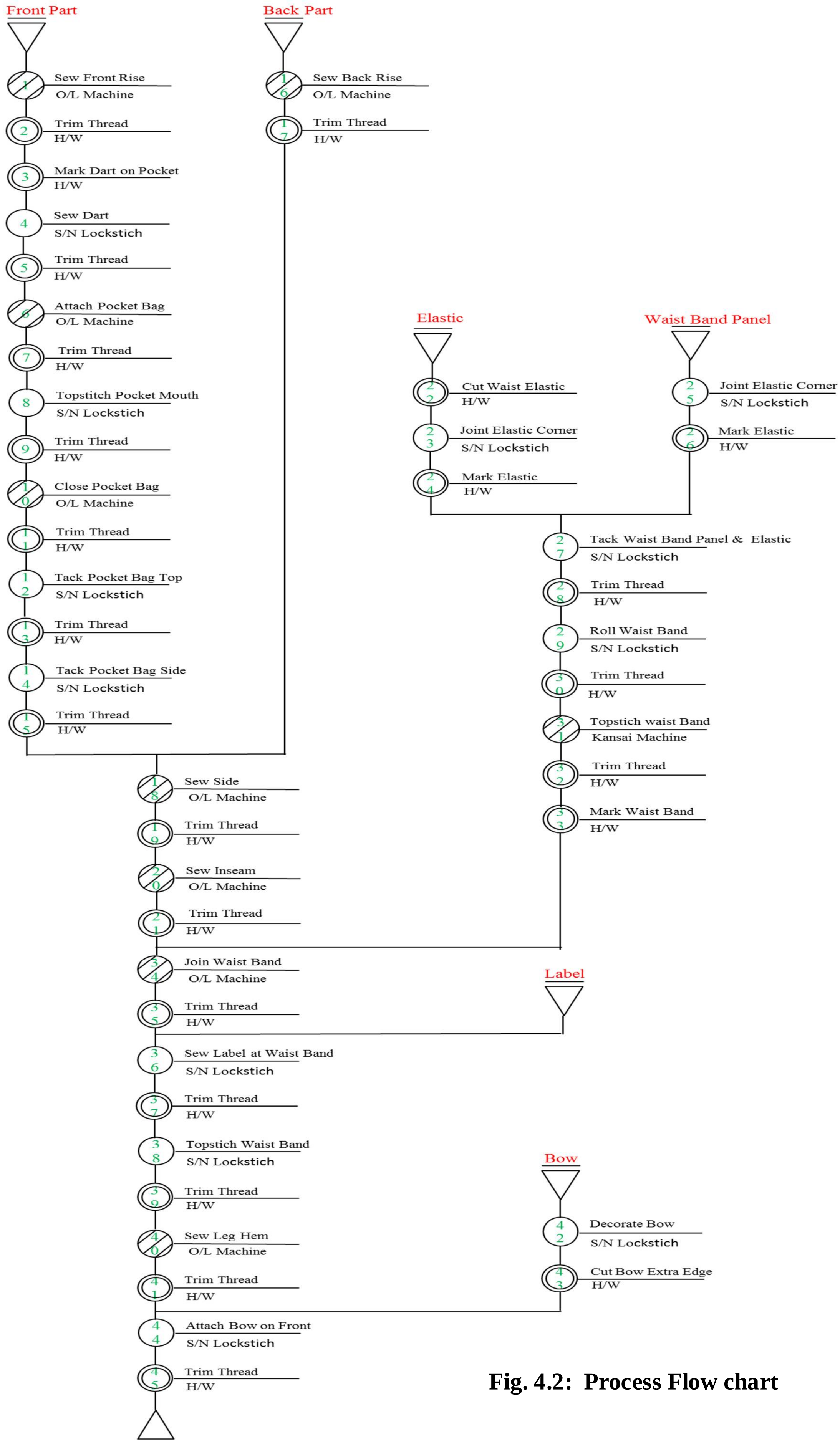


Fig. 4.2: Process Flow chart

4.2.1 Before balancing the line:

Therefore to calculate the approximate real process time of a task, 5 measurements were taken for each task and operator working on the line. Time study was performed along the line by chronometer. Each operation was measured in seconds and recorded.

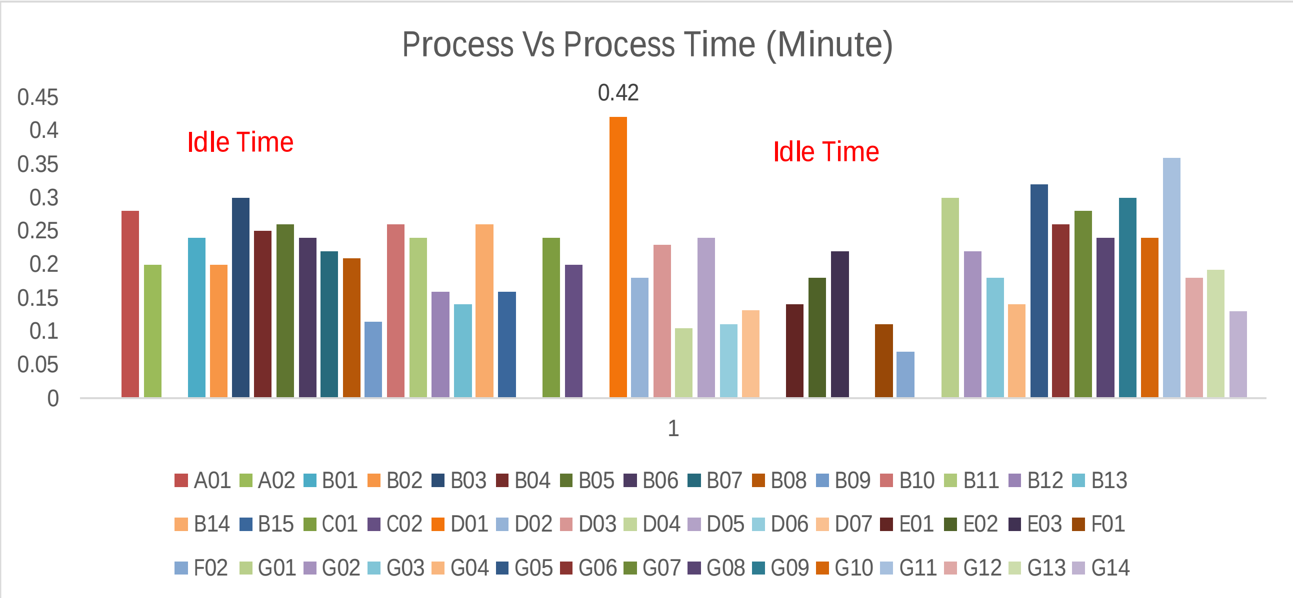
Time study sheet is showing the different types of processes and machine used, number of operators and helpers, basic and standard pitch time and capacity per hour

S/N	Operation Name	TYPE OF MACHINE	AVG. OPEARATION TIME (sec.)	OPERATION TIME (SAM) Include 20 % Allowance	CAPACITY/OP/HR	Allocated Operator	Allocated time for Each Operator (SAM)
A	**Bow**						
A01	Decorate Bow	S/N	14	0.28	214.3	1	0.28
A02	Cut Bow extra Edge	H/W	10	0.2	300	1	0.2
B	**Front part**						
B01	Sew Front Rise	O/L	12	0.24	250	1	0.24
B02	Trim Thread	H/W	10	0.2	300	1	0.2
B03	Mark Dart on Pocket	H/W	15	0.3	200	1	0.3
B04	Sew Dart	S/N	25	0.5	120	2	0.25
B05	Trim Thread	H/W	26	0.52	115.4	2	0.26
B06	Attach Pocket Bag with Pocket	O/L	12	0.24	250	1	0.24
B07	Trim Thread	H/W	11	0.22	272.8	1	0.22
B08	Topstitch pocket Mouth	S/N	20.9	0.418333	143.5	2	0.209166667
B09	Trim Thread	H/W	11.5	0.23	260.9	2	0.115
B10	Close Pocket Bag	O/L	13	0.26	230.8	1	0.26
B11	Trim Thread	H/W	12	0.24	250	1	0.24
B12	Tack pocket Bag top with Body	S/N	8	0.16	375	1	0.16
B13	Trim Thread	H/W	7	0.14	428.6	1	0.14
B14	Tack Pocket Bag side with Body	S/N	13	0.26	230.8	1	0.26
B15	Trim Thread	H/W	8	0.16	375	1	0.16
C	**Back Part**						
C01	Sew Back Rise	O/L	12	0.24	250	1	0.24
C02	Trim Thread	H/W	10	0.2	300	1	0.2
D	**Waist Band**						
D01	Tack waist band Panel & Elastic	S/N	21	0.42	142.9	1	0.42
D02	Trim Thread	H/W	9	0.18	333.4	1	0.18
D03	Roll Waist Band	S/N	23	0.46	130.5	2	0.23
D04	Trim Thread	H/W	10.5	0.21	285.8	2	0.105
D05	Topstitch Waist Band	KANSAI	12	0.24	250	1	0.24
D06	Trim Thread	H/W	11	0.22	272.8	2	0.11
D07	Mark Waist Band	H/W	13.1	0.263333	227.9	2	0.131666667
E	**Elastic**						
E01	Cut Waist Elastic	H/W	7	0.14	428.6	1	0.14
E02	Joint Elastic Corner	S/N	9	0.18	333.4	1	0.18
E03	Mark Elastic	H/W	11	0.22	272.8	1	0.22
F	**Waistband panel**						
F01	Tack Waist Band Panel Corner	S/N	11	0.22	272.8	2	0.11
F02	Trim Thread	H/W	6.9	0.138333	433.8	2	0.069166667
G	**Assembly**						
G01	Sew Side	O/L	15	0.3	200	1	0.3
G02	Trim Thread	H/W	11	0.22	272.8	1	0.22
G03	Sew Inseam	O/L	9	0.18	333.4	1	0.18
G04	Trim Thread	H/W	7	0.14	428.6	1	0.14
G05	Join Waist Band	O/L	16	0.32	187.5	1	0.32
G06	Trim Thread	H/W	13	0.26	230.8	1	0.26
G07	Sew label at Waist Band	S/N	14	0.28	214.3	1	0.28
G08	Trim Thread	H/W	12	0.24	250	1	0.24
G09	Topstitch Waist Band	S/N	15	0.3	200	1	0.3
G10	Trim Thread	H/W	12	0.24	250	1	0.24
G11	Sew Leg Hem	F/L	18	0.36	166.7	1	0.36
G12	Trim Thread	H/W	9	0.18	333.4	1	0.18
G13	Attach Bow on Front	S/N	19.2	0.385	155.9	2	0.1925
G14	Trim Thread	H/W	13	0.26	230.8	2	0.13

Table 4.1: Calculation before line balancing

Process wise time & capacity of each work station has been shown in Table where total process time is 9.64 Min and Standard Total Process Time is 11.565 Min and total number of operators are 57. Graph: The graphical representation of process time respect with Workstations & process code.

Fig. 4.3 Process capacity chart



Plotting process wise capacity in a line graph shows the variation of each process according to workstations as the upper capacity is 490 pieces per hour where the lower capacity is only 142 pieces per hour where upper capacity is 433 pieces per hour. This shows the imbalance situation in the line and bottleneck condition throughout the process of the whole garment making as lots of WIP stations in the line.

Total Process Time = 11.565 Min

Total Allocated No of Operator = 57

Bottleneck Process time = 0.42 Min

Maximum output = (Working Hr/Bottleneck process time)

= (60/0.42) = 142.8 Pcs

Line Balance Efficiency = (Standard total Process Time * Output) /(No of Op. * Workhour)

= (1651.5 / 3420) * 100 %

= 48.2 %

Waiting Time = (57 Op * 60 Min) - (142.5 Pcs * 11.565 Min)

= 1772 Min/Hr

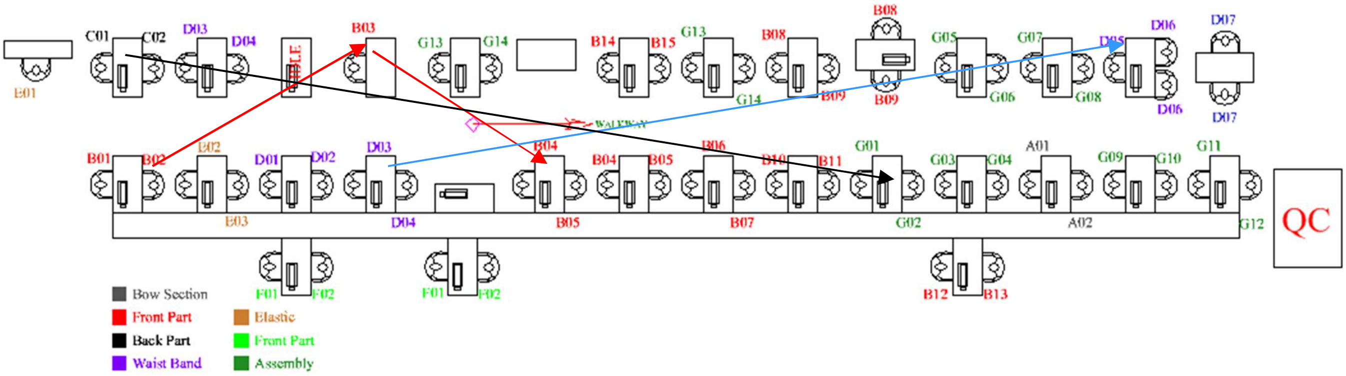
= 51.8 %

Productivity/Op = $\frac{Total\ Output}{Total\ Manpower} = \frac{142.5\ Pcs}{57\ Op}$ = 2.5 Pcs/Op

4.2.1.1 Existing Layout:

Layout means the arrangement of sequence of process. Existing layout is showing the garments flow condition where each section is marked with different collar. And it is clear that there have lot of jumping, back flow & long transportation. Waist band process is doing in the back side of the layout where as in assembly line also. This layout will affect badly the parts flow of garments for getting better productivity due to not following the process sequence.

Fig. 4.4: Existing Layout

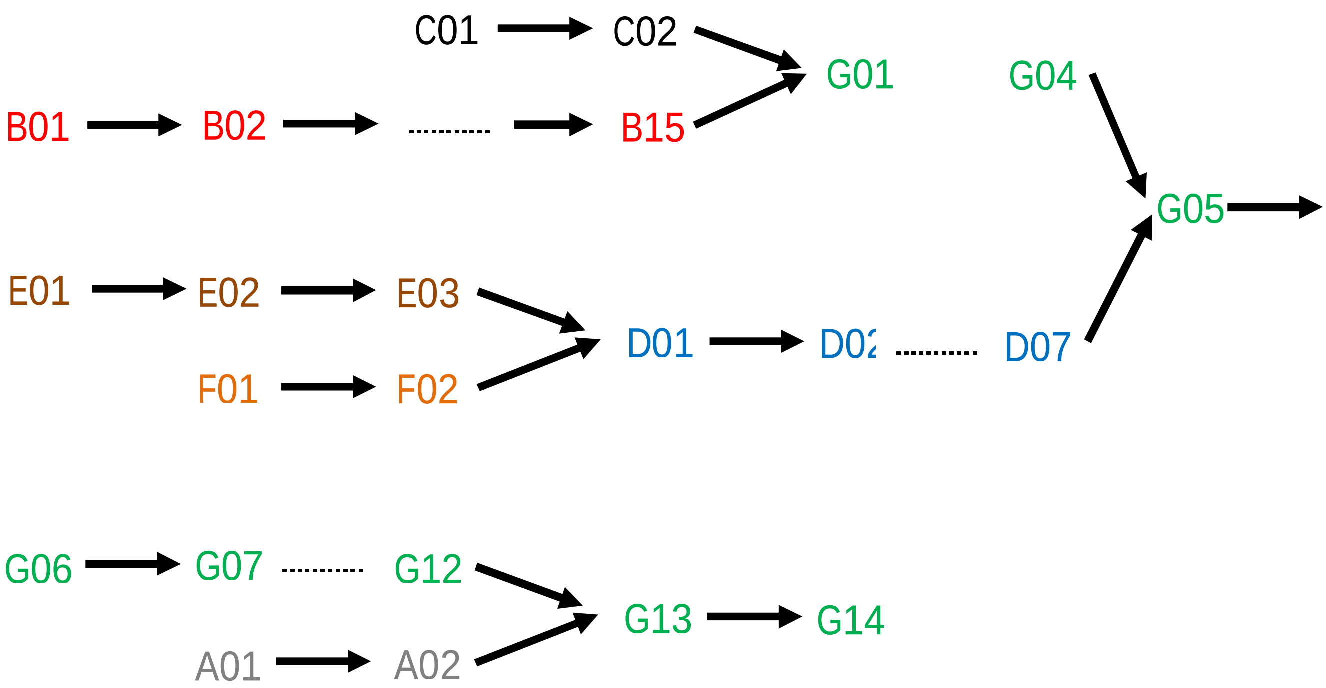


4.2.2 After balancing the line

To review the actual production status, pay attention particularly of the task and line balance efficiency. If the operator who is in charge of the process just after the bottleneck process carries out his job at a normal speed, he will wait for the delivery of the work piece from the bottleneck process. Like this way, operator will waste resources and finally affect the productivity. For balancing line & productivity, i am going to follow the Precedence diagram with largest number of following task rule:

- Draw the precedence diagram according the operations (Tasks) breakdown
- Represent the task name, time & the precedence with a table
- Calculate the Target/Maximum output, Takt time
- Calculate the required number of workstations theoretically & allocate the task among workstations
- Calculate line efficiency, Waiting time & Productivity/Op.

Fig 4.5: Precedence Diagram



The precedence diagram clearly shows that some task cannot proceed without completing the before or precedent work. There have 2 types of work where one is dependent work & others is independent work. Independent works can possible to start any time whereas dependent work need to wait for finishing the previous work. Hear, B01 is independent work & B02 is dependent work. B15 work can possible to start only when the tasks B14 will complete. Same as previous one, B14 will start when only B13 will complete. But G01 will start only when B15 & C02 both are finished. Due to G01 is dependent on previous two tasks B15 & C02. Same like as, we can draw the precedence table until final task G14

S/N	Operation Name	TYPE OF MACHINE	AVG. OPEARATION TIME (sec.)	OPERATION TIME (sec.) Include 20 % Allowance	OPERATION TIME (SAM) Include 20 % Allowance	Precedence Task
C	**Back Part**					
C01	Sew Back Rise	O/L	12	14.4	0.24	
C02	Trim Thread	H/W	10	12	0.2	C01
B	**Front part**					
B01	Sew Front Rise	O/L	12	14.4	0.24	
B02	Trim Thread	H/W	10	12	0.2	B01
B03	Mark Dart on Pocket	H/W	15	18	0.3	B02
B04	Sew Dart	S/N	25	30	0.5	B03
B05	Trim Thread	H/W	26	31.2	0.52	B04
B06	Attach Pocket Bag with Pocket	O/L	12	14.4	0.24	B05
B07	Trim Thread	H/W	11	13.2	0.22	B06
B08	Topstitch pocket Mouth	S/N	20.9	25.1	0.418333	B07
B09	Trim Thread	H/W	11.5	13.8	0.23	B08
B10	Close Pocket Bag	O/L	13	15.6	0.26	B09
B11	Trim Thread	H/W	12	14.4	0.24	B10
B12	Tack pocket Bag top with Body	S/N	8	9.6	0.16	B11
B13	Trim Thread	H/W	7	8.4	0.14	B12
B14	Tack Pocket Bag side with Body	S/N	13	15.6	0.26	B13
B15	Trim Thread	H/W	8	9.6	0.16	B14
E	**Elastic**					
E01	Cut Waist Elastic	H/W	7	8.4	0.14	
E02	Joint Elastic Corner	S/N	9	10.8	0.18	E01
E03	Mark Elastic	H/W	11	13.2	0.22	E02
F	**Waistband panel**					
F01	Tack Waist Band Panel Corner	S/N	11	13.2	0.22	
F02	Trim Thread	H/W	6.9	8.3	0.138333	F01
A	**Bow**					
A01	Decorate Bow	S/N	14	16.8	0.28	
A02	Cut Bow extra Edge	H/W	10	12	0.2	A01
D	**Waist Band**					
D01	Tack waist band Panel & Elastic	S/N	21	25.2	0.42	E03,F02
D02	Trim Thread	H/W	9	10.8	0.18	D01
D03	Roll Waist Band	S/N	23	27.6	0.46	D02
D04	Trim Thread	H/W	10.5	12.6	0.21	D03
D05	Topstitch Waist Band	KANSAI	12	14.4	0.24	D04
D06	Trim Thread	H/W	11	13.2	0.22	D05
D07	Mark Waist Band	H/W	13.1	15.8	0.263333	D06
G	**Assembly**					
G01	Sew Side	O/L	15	18	0.3	C02,B15
G02	Trim Thread	H/W	11	13.2	0.22	GO1
G03	Sew Inseam	O/L	9	10.8	0.18	G02
G04	Trim Thread	H/W	7	8.4	0.14	G03
G05	Join Waist Band	O/L	16	19.2	0.32	G04,D07
G06	Trim Thread	H/W	13	15.6	0.26	G05
G07	Sew label at Waist Band	S/N	14	16.8	0.28	G06
G08	Trim Thread	H/W	12	14.4	0.24	G07
G09	Topstitch Waist Band	S/N	15	18	0.3	G08
G10	Trim Thread	H/W	12	14.4	0.24	G09
G11	Sew Leg Hem	F/L	18	21.6	0.36	G10
G12	Trim Thread	H/W	9	10.8	0.18	G11
G13	Attach Bow on Front	S/N	19.2	23.1	0.385	G11,A02
G14	Trim Thread	H/W	13	15.6	0.26	G13

Table 4.2: Task precedence Table

Total Process Time = 11.565 Min

Maximum Process time = 0.52 Min

Maximum output = (Working Hr/Maximum process time)

= (60/0.52) = 115.3 Pcs

Takt time = (Available time/Demand)

= (60/115.3) Min

= 0.52 Min

Theoretically Number of work stations required = (Standard total process time / Takt time)

= (11.565 / 0.52)

= 22.24 Workstation

= 23 Workstations

Now, we start out to assign task for work station 1, the eligible task are C01 & C02. Due to after assigning these 2 tasks, remaining time (Takt time –Allocated time, 0.52- 0.44) 0.08 Min cannot possible to assign for any other task which follow the precedence. Now move to B01 task, allocate this task for workstation 2 & remaining 0.28 Min is still remain idle. So as precedent, allocate B02 work for also workstations 2. Finally remaining time, 0.08 Min cannot possible to any other works. Latter, allocate some process like03,B04 & B05 cannot possible to allocate more than one task due to other tasks has limitation for the precedence rule. In the case of, B15, E01 & E02 max 3 tasks allocate for one workstation but remaining 0.04 min is unable to allocate for any other works. So following the rule of largest number of following task, total number of workstations required 30 practically. The difference of number of workstations between theoretical & practical is due to the limitation of equipment use varying on operations. So have to consider the types of operation & the types of machine using for operation.

S/N	Operation Name	TYPE OF MACHINE	AVG. OPEARATION TIME (sec.)	OPERATION TIME (SAM) Include 20 % Allowance	Precedence Task	Allocated Time	Waitting Time	Workstations
C	**Back Part**							
C01	Sew Back Rise	O/L	12	0.24		0.44	0.08	1
C02	Trim Thread	H/W	10	0.2	C01			
B	**Front part**							
B01	Sew Front Rise	O/L	12	0.24		0.44	0.08	1
B02	Trim Thread	H/W	10	0.2	B01			
B03	Mark Dart on Pocket	H/W	15	0.3	B02	0.3	0.32	1
B04	Sew Dart	S/N	25	0.5	B03	0.5	0.02	1
B05	Trim Thread	H/W	26	0.52	B04	0.52	0	1
B06	Attach Pocket Bag with Pocket	O/L	12	0.24	B05	0.46	0.06	1
B07	Trim Thread	H/W	11	0.22	B06			
B08	Topstitch pocket Mouth	S/N	20.9	0.418333	B07	0.4183	0.1	1
B09	Trim Thread	H/W	11.5	0.23	B08	0.49	0.03	1
B10	Close Pocket Bag	O/L	13	0.26	B09			
B11	Trim Thread	H/W	12	0.24	B10	0.4	0.12	1
B12	Tack pocket Bag top with Body	S/N	8	0.16	B11			
B13	Trim Thread	H/W	7	0.14	B12	0.4	0.12	1
B14	Tack Pocket Bag side with Body	S/N	13	0.26	B13			
B15	Trim Thread	H/W	8	0.16	B14	0.48	0.04	1
E	**Elastic**							
E01	Cut Waist Elastic	H/W	7	0.14				
E02	Joint Elastic Corner	S/N	9	0.18	E01			
E03	Mark Elastic	H/W	11	0.22	E02	0.44	0.08	1
F	**Waistband panel**							
F01	Tack Waist Band Panel Corner	S/N	11	0.22				
F02	Trim Thread	H/W	6.9	0.138333	F01	0.138	0.382	1
A	**Bow**							
A01	Decorate Bow	S/N	14	0.28		0.48	0.04	1
A02	Cut Bow extra Edge	H/W	10	0.2	A01			
D	**Waist Band**							
D01	Tack waist band Panel & Elastic	S/N	21	0.42	E03,F02	0.42	0.1	1
D02	Trim Thread	H/W	9	0.18	D01	0.18	0.34	1
D03	Roll Waist Band	S/N	23	0.46	D02	0.46	0.06	1
D04	Trim Thread	H/W	10.5	0.21	D03	0.45	0.07	1
D05	Topstitch Waist Band	KANSAI	12	0.24	D04			
D06	Trim Thread	H/W	11	0.22	D05	0.483	0.037	1
D07	Mark Waist Band	H/W	13.1	0.263333	D06			
G	**Assembly**							
G01	Sew Side	O/L	15	0.3	C02,B15	0.52	0	1
G02	Trim Thread	H/W	11	0.22	GO1			
G03	Sew Inseam	O/L	9	0.18	G02	0.32	0.2	1
G04	Trim Thread	H/W	7	0.14	G03			
G05	Join Waist Band	O/L	16	0.32	G04,D07	0.32	0.2	1
G06	Trim Thread	H/W	13	0.26	G05	0.26	0.26	1
G07	Sew label at Waist Band	S/N	14	0.28	G06	0.52	0	1
G08	Trim Thread	H/W	12	0.24	G07			
G09	Topstitch Waist Band	S/N	15	0.3	G08	0.3	0.32	1
G10	Trim Thread	H/W	12	0.24	G09	0.24	0.28	1
G11	Sew Leg Hem	F/L	18	0.36	G10	0.36	0.16	1
G12	Trim Thread	H/W	9	0.18	G11	0.18	0.34	1
G13	Attach Bow on Front	S/N	19.2	0.385	G11,A02	0.385	0.135	1
G14	Trim Thread	H/W	13	0.26	G13	0.26	0.26	1

Table 4.3: Task allocation Table

Line Balance Efficiency = (Standard total Process Time * Output) /(No of Op. * Workhour)

= (1333.45 /1800) * 100 %

= 74.08 %

Waiting Time = (30 Op * 60 Min) - (115.3 Pcs * 11.565 Min)

= 466.55 Min/Hr

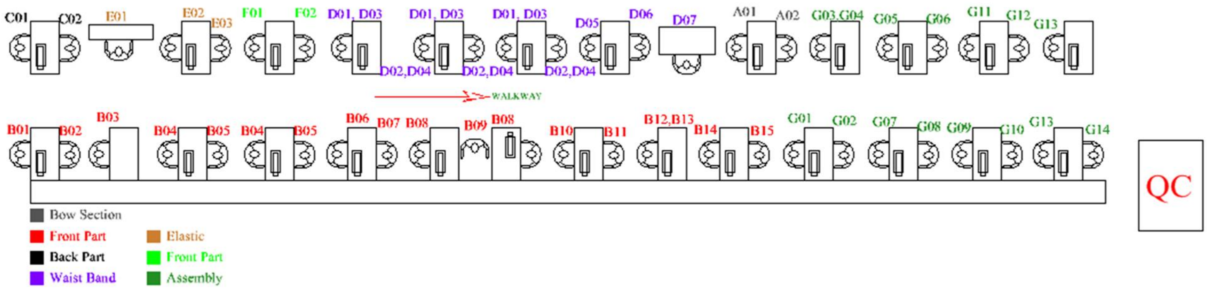
= 25.9 %

Productivity/Op = $\frac{Total\ Output}{Total\ Manpower}$ = $\frac{115.3\ Pcs}{30\ Op}$ = 3.84 Pcs/Op

4.2.2.1 Proposed Layout:

Earlier explained the condition to set a good layout like short transportation, short jumping, no back flow. In existing layout, there was long transportation like BO2 to BO3, DO4 to D05 and back flow like G12 to G13 & many more. To minimize the layout difficulties and improve the product flow, already make a process flow chart where all the process sequence is showing through T-Diagram. Taking aid form flow chart, the sequence of process and parts can be set in layout. All the parts section and assembly point is identified with collar for easy visualization.

Fig. 4.6: Proposed layout



4.3 Results based on reference model

Changing from existing line balance to reference model, there are considerable improvements have been observed. Existing condition, total was 57 operators where line balance efficiency & productivity were accordingly 48.2 % & 2.5 pc/Op. Latter, it can be referred a reference model through precedent diagram with largest number of follower rules. Allocated all the operations targeting takt time among the workstations for getting desired output. The line balancing efficiency & productivity will stand accordingly 74.08 % & 3.84pc/hr. So it can be calculate from existing & reference model that the productivity can be increased 53.6 % after taking steps of line balancing & layout technique.

5.1 Limitation:

The research is studied on only one sewing line but have scope other lines also. So the research can be extended to the other lines of the industries also. Beside of these, also have other limitation as like bellow:

- This thesis referred a reference model but still not check, is it practical or not?
- Sewing line is only a part of an industry where have also a vast area for study & productivity improvement.
- The line balancing is made as per manual calculation and assuming allowance rate is 20% but practically it can be varied.
- At the time of balancing, it is not check whether skill level of operator is same or not. If there is a high skill gap between operators of the same cell it is difficult to balance and will reduce the efficiency.

5.2 Conclusion:

The objective of the study is to improve the productivity after balancing the sewing line & build a reference model. This reference model is manually stood up but it would be better to work with simulation software. Beside of this line balancing technique, also have other productivity improvement techniques for improving the productivity. However, this evaluation has given an image that the lack of line balancing is responsible for resources wastage. The observations gained from this research indicate some limitation for future work. Although some meaningful conclusion can be made with respect to the reference model builds in the study.

Reference:

[1] http://en.wikipedia.org/wiki/Bangladeshi_RMG_Sector

[2]http://www.mckinsey.com/insights/consumer_and_retail/bangladesh_the_next_hot_spot_in_apparel_sourcing

[3]Shumon Md. R H, Arif-UZ-Zaman K & Rahman A, Productivity improvement through line balancing in apparel industries, paper presented at the International Conference on International Engineering and Operations Management, Dhaka, Bangladesh, 9-10 January 2010

[4] Daniel Kitaw, Amare Matebu and Solomon Tadesse(*Journal of EEA, Vol. 27, 2010)*

][5] Chen J C, Hsaio M H, Chen C C & Sun C J, A Grouping Genetic algorithm for the Assembly Line Balancing Problem of Sewing Lines in Garment Industry (Departement of Industrial and System Engineering, Chung Yuan Christian University, Chung Li, Taiwan), 2009

[6] Nakajima M, Uchiyama S & Miura Y, J Text Mach Soc Jpn, Transactions, 33 (4) (1980)22.

[7] F Khosravi, A H Sadeghi & F Jolai, An improvement in caldulation method for Apparel assembly line balancing, Indian Journal of Fibar & Textile Research, Vo. 38, September 2013, pp 259-264

[8] V. P.Jaganathan, LINE BALANCING USING LARGEST CANDIDATE RULEALGORITHM IN A GARMENT INDUSTRY: A CASE STUDY, International Journal of Lean thinking Volume 5 Issue 1 (December 1)

[9] E.C Ubani, Application of assembly line balancing heuristics to designing product layout in motor manufacturing operation, INTERDISCIPLINARY JOURNAL OF CONTEMPORARY RESEARCH IN BUSINESS, Vol 3, No 10 Feb 2012

[10] http://www.onlineclothingstudy.com/2011/02/what-is-productivity.html

[11] http://www.optimaldesign.com/Download/OptiLine/FalkenauerPLM05.pdf

[12] IIE, ANSI 1982

[13] http://www.brighthubpm.com/project-planning/49580-overview-of-the-precedence-diagram-method-pdm/

[14] https://en.wikipedia.org/wiki/Takt_time