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Faculty of engineering

Department of Textile Engineering

Thesis Report on

Production Line Balancing for Productivity Improvement in Apparel Manufacturing

Course code: TEX – 441 **Course Title:** Project (Thesis)

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This report presented in partial fulfillment of the Requirement for the Degree of Bachelor of Science in Textile Engineering.

Advance in Apparel Manufacturing Engineering

Duration: From 2022

Declaration

We here by announce that this project has been done by us under the observation of **Ashan Habib , Department of Textile Engineering Sonargaon University.** We also announce that neither this project nor any part of this project has been submitted elsewhere for the award of any degree.

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Letter of Approval

This project report on "**Production Line Balancing for Productivity Improvement in Apparel Manufacturing"** is prepared by **MD:Dulal Rahman T**EX-1703012142, Jomor Aktar TEX-1701010014**, Palash chandra Das** TEX-1802014037, is accepted and fulfills the Requirement for the Degree of Bachelor of science in Textile Engineering. The said students have completed their project work under my supervision. During the research period, I found them sincere, hardworking and passionate.

… …….....

ASHAN HABIB

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Acknowledgment

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Abstract

The project is on production line balancing for productivity improvement in apparel manufacturing through work sharing method. The objective is the increase the production by allocating work equally by removing bottleneck process. The standard minute value is calculated for every work station of a production line. Then the bottleneck process is marked and eliminated by work sharing method. No further machine allocation or new layout is needed in this method only the mobile worker or helper is used to transfer the material to the balancing work station. The table of efficiency is given before and after the balancing process to show the increase in productivity. The actual capacity and balanced capacity is shown comparing with the benchmark capacity. In this project work the productivity is improved after balancing and the efficiency and productivity is shown in the result section.

TABLE OF CONTENT

CHAPTER – 1

01.01 INTRODUCTION:

At present Industrial Engineering (IE) is one of the important department for each garments or textile factory. Today‘s maximum factory is run by industrial engineers, where they have to follow a process flow chart. By which they can easily control the whole garments production processes**.** Such kinds of process flow chart has discussed in this article.

01.02 PROCESS FLOW CHART OF INDUSTRIAL ENGINEERING (IE):

Negotiation with **garments merchandiser**
↓
Garments analysis
↓
Make **P.P meeting** if all the required fabrics, **trimmings and accessories** are in housed
↓
Production target
↓
Set machine layout
↓
Line setting
↓
Line balancing
↓
Continuous production meeting
↓
Collecting production data
↓
Preparing production report
↓
Production report analysis
↓
Report submit to factory manager

All the above processes are discussed in the below table:

SL No.	Process	Procedure
01	Negotiation with garments merchandiser	It is the very first work of an industrial engineer. Here, he should vastly discussed with garments merchandiser about the in-coming garments product.
02	Garments analysis	Confirmed garments product is clearly analyzed here by industrial engineer. It helps to complete rest of the processes very easily.
03	Make P.P meeting	Here, P.P meeting should be organized if all the required fabrics, trimmings and accessories are in housed and take all the pre-cautions for the up-coming garments production.
04	Production target	Production target should set here according to factory capacity. It helps to respect the shipment date.
05	Set machine layout	Machine layout is set here according to total processes needed to complete a garment item.
06	Line setting	In this process, actual line setting should be done to utilize the garment workers properly. If it takes more time in line

		setting then garments production will be decreased.
07	Line balancing	To minimize the number of work stations, cycle time, line balancing is done here. Its a very important process to achieve desired production target.
08	Continuous production meeting	Production meeting should be done here at regular interval. If any problem will arise during garments production, should take necessary actions to solve that.
09	Collecting production data	Production data should be collected here for preparing production report.
10	Preparing production report	Here, total garments production report has prepared to analysis about the whole production.
11	Production report analysis	Garments production report is analyzed here from different points of view.
12	Report submit to factory manager	Finally garments production report have to submit into the factory manager.

01.03 LINE BALANCING IN APPAREL PRODUCTION:

Line Balancing Line Balancing is leveling the workload across all processes in a cell or value stream to remove bottlenecks and excess capacity. A constraint slows the process down and results if waiting for downstream operations and excess capacity results in waiting and absorption of fixed costs.

It is the allocation of sewing machine, according to style and design of the garments. It depends on what types of garments we have to produce. It is done to increasing productivity. When you consider mass production, garments are produced in lines or set of machines instead of single machine. A line may be assembly line, modular line or section, a line set with online finishing and packing. A line includes multiple work stations with varied work contents. Production per hour is varied depending on work content (standard minutes of particular task/operation), allocation of total manpower to a particular operation, operator skill level and machine capacity. Operation with lowest production per hour is called as bottleneck operation for that line.

01.04 OBJECTIVES OF LINE BALANCING:

Match the production rate after all wastes have been removed to the talk time at each process of the value stream.

1. Regular material flow.
2. Maximum uses of man power and machine capacity.
3. Minimum process time.
4. Minimizing slack time.
5. Minimizing workstation.
6. Maximum output at the desired time.
7. Quality maintenance of the garment.
8. Reduce production cost.

01.05: IMPORTANCE OF LINE BALANCING:

1. Line balancing helps to know about new machine required for new style.

2. It becomes easier to distribute particular job to each operator.

3. It becomes possible to deliver goods at right time at the agreed quality for list cost.

4. Good line balancing increase the rate of production.

5. Line balancing helps to compare the required machinery with the existing one and compare balance.

6. It also helps in the determination of labor requirement.

7. Good balancing reduces production time.

8. Profit of a factory can be ensured by proper line balancing.

9. Proper line balancing ensured optimum production at the agreed quality.

10. It reduces faults in the finished product.

01.06 EXAMPLE OF LINE BALANCING:

Machine layout with actual production

Process#1. Production 40 pieces by 1 machine end production 40 pieces.

Process#2. Production 45 pieces by 1 machine end production 40 pieces.

Process#3. Production 75 pieces by 1 machine end production 40 pieces.

Process#4. Production 80 pieces by 1 machine end production 40 pieces.

Process#5. Production 50 pieces by 1 machine end production 40 pieces.

Output: 40pices/hour. **Analysis:** Insufficient production due to lack of supply.

01.07 LIMITATIONS OF LINE BALANCING:

1. Production lines were designed so that conveyor belts paced the speed of the employees‟ work. This arrangement wasn't appreciated by the employees.

2. Inevitable changes lead to production lines being out of balance.

3. Rebalancing causes disruptions to production .

01.08 ROLE OF INDUSTRIAL ENGINEER IN GARMENT INDUSTRY:

Each executive/supervisor has eight areas of responsibility that need to be managed.

1. Safety

2. Line balancing

3. Quality – operation control

4. Training – how to train new employees

5. Operator output – maintains high output and improves abilities of those with low output.

6. Loss control – minimize off-standard loss

7. Waste control – in materials, supplies and machinery

8. Standard conditions – in the workplace, in sewing method, in the machines

Executive as a leader A good way of showing leadership is to be a good example for others. Every executive/supervisor represents the company and any of his/her actions are an extension of the Maintenance

- ❖ Quality work
- ❖ Productivity

Authority is usually earned but from the beginning, executives will be assigned to do the following tasks that require authority:

1. Employee transfers between the operations
2. Assigning of off-standard tasks
3. Overtime planning
4. Rejecting defective product
5. Disciplinary actions
6. Recommendations for dismissal

Employee respect will depend on how an executive/supervisor acts as a leader and uses his/her authority to benefit all employees in his/her department.

01.09 OBLIGATIONS OF AN EXECUTIVE:

To manage effectively, an executive/supervisor should identify and divide his/ her obligations to primary and secondary. He/she must first take care of primary obligations adequately. In some cases this means that secondary obligations will have to be delegated to someone under the supervisor‘s authority.

Primary obligations

1. Provide safety
2. Plan and balance production lines
3. Control quality
4. Develop employees
5. Follow up on low output employees
6. Material utilization
7. Discipline

Secondary obligations

1. Bundle handling and movement
2. Adjustments to machines
3. Distributes supplies
4. Handle parts that needs reprocessing
5. Samples
6. Maintenance
7. House keeping
8. Miscellaneous

01.10 DAILY ACTIVITIES OF AN EXECUTIVE:

- First thing in the morning Arrive early
- Greet arriving employees
- Encourage them to start work early
- Check attendance •
- Make adjustments to balance the line according to absence.
- Attend production meeting and discuss yesterday‘s results and today‘s targets and plans.
- Plan

.....How to increase efficiency? .....How to improve outgoing quality? .....How to prepare for routine problems or problems that might arise?

01.11 DURING THE DAY:

- ❖ Measure the target vs. actual output every hour
- ❖ Check quality level
- ❖ Check inline and end line quality reports
- ❖ Discuss with quality inspectors Perform quality drill
- ❖ Work with low output operators
- ❖ Check proper method
- ❖ Motivate and empower operator
- ❖ Follow up on new operators in training
- ❖ Follow up on operator in re-training
- ❖ Identify the bottle neck operations and balance accordingly
- ❖ Provide immediate and continuous follow-up to repairs
- ❖ Monitor and follow up on bundle tracking and outgoing bundles
- ❖ Authorize any off-standard ―clock-out‖
- ❖ Order supplies and material for production

At the end of the day

1. Make sure the operators have turned off their machines, cleaned their work area, kept a piece of fabric under the pressure foot, and covered their machine.
2. Check and authorize the production work sheet
3. Organize production sheets and check the last hour production with the sheet.
4. Review the hourly production report and WIP report .
5. Analyze the next day‘s needs and take notes for implementation .
6. Calculate the next day‘s initial inventory according to production information

Weekly

1. Review the capacity studies of low output operators
2. Plan operator cross training to solve balancing problems

As and when required

- ❖ Resolve any operator efficiency problems
- ❖ Follow up and motivate new employees
- ❖ Work out quality problems with quality inspectors
- ❖ Work out problems with operators; review the proper method with them when necessary

01.12: CONCEPT OF IE:

The garment manufacturing and exporting industry is facing heavy challenges due to various factors including global competition, production costs increase, less productivity/efficiency, labor attrition, etc. the basic fact that our country has immense strength in human resources itself is the motivating aspect to feel for such an analysis. For overcoming those challenges our need industrial engineering knowledge. Industrial engineers (IEs) are responsible for designing integrated systems of people, machines, material, energy, and information. Industrial engineers figure out how to do things better. They engineer processes and systems that improve quality and productivity. They work to eliminate waste of time, money, materials, energy, and other resources. This is why more and more companies are hiring industrial engineers and then promoting them into management positions. .

We can see at a glance of IE,

Industrial Engineering (IE) = Production ↑ **Cost** ↓ Proper use of all elements ↑ Efficiency ↑ Profit ↑ I‘m giving some formula for Industrial engineering students or professionals. If those help them then I will be thankful.

CHAPTER – 2

02.01 OVERVIEW OF LINE BALANCING

From ancient times to the modern day, the concept of assembly has naturally been changed alot. The most important milestone in assembly is the invention of assembly lines. In 1913,Henry Ford completely changed the general concept of assembly by introducing assembly lines in automobile manufacturing for the first time. He was the first to introduce a moving belt in a factory, where the workers were able to build the famous model-T cars, one piece ate time instead of one car at a time. Since then, the assembly lines concept revolutionized the way products were made while reducing the cost of production. Over the years, the design of efficient assembly lines received considerable attention from both companies and academicians. It had been found from that a well-known assembly design problem is assembly line balancing, which deals with the allocation of the tasks among workstations so that a given objective function is optimized". Assembly line balancing has been a focus of interest to academics in operation management for the last four decades. Mass production has saved huge costs for manufacturers in various industries for some time. (2005) stated that mixed -model assembly lines are increasing in many industrial environments which deals with mixed-model assembly line balancing for n models, and uses classical genetic algorithm approach to minimize the number of workstations". Scholl et al.(2006) found that assembly line balancing problems arise whenever an assembly line is

Configured, redesigned or adjusted" .An assembly line balancing problems consists of distributing the total workload for manufacturing any unit of the products to be assembled among the work stations along the line. The sequence-dependent assembly line balancing problem is an extension of the standard simple assembly line balancing problem which has significant relevance in real-

world assembly line settings. Kara et al. (2006) suggested that „a successful implementation

of a mixed-model U-line requires solutions for balancing and sequencing problems. The study proposes an approach for simultaneously solving the balancing and sequencing problems of mixed-model U-

lines". The primary goal of the proposed approach is to

minimize the number of workstations required on the line To meet this aim, the proposed approach uses such a methodology that enables the minimization of the absolute deviation of workloads among workstations as well. In terms of minimizing the number of workstations required on the mixed-model U-line, as well as minimizing the absolute deviation of workloads among workstations, the proposed approaches the first method in the literature dealing with the balancing and sequencing problems of mixed-model U-lines. The newly developed neighborhood generation method employed in the simulated annealing method is another significant feature of the proposed approach.

Scholl et al. (2009) stated as „sequence

-dependent assembly line balancing problem consist of distributing the total workload for manufacturing any unit of the products to be assembled among the work stations along a manufacturing line as used in the automotive or the

electronics industries". Usually, it is assumed that the production process is fixed, i.e. has been determined in preceding planning step. However, this sequential planning approach is often suboptimal because the efficiency of the production process cannot be evaluated definitely without

knowing the distribution of work. Oscan and Toklu (2008) proposed „a new hybrid

improvement heuristic approach to simple straight and U-type sequence-dependent assembly line balancing problem which is based on the idea of adaptive learning approach and sequence-

dependent assembly". The proposed approach uses a weight parameter to perturb

task priorities of a solution to obtain improved solutions. The weight parameters are then modified using a learning strategy. The maximization of line efficiency i.e. the minimization of the number of stations and the equalization of workload among stations i.e. the minimization of the smoothness index or the minimization of the variation of workloads are considered as the performance criteria.

Kilincci and Bayhan (2006) found that „simple assembly line balancing problem of type aims to minimize the number of workstations for a given cycle time". In the relevant

literature, several heuristics based on a branch-and bound procedure, Tabu search and genetic algorithms were proposed to solve simple assembly line balancing problem. In this paper, analgorithm based on the reachability analysis of Petri nets is developed for simple assembly line balancing problem .

The proposed algorithm searches enabled transitions or assignable tasks in the Petri net model of precedence relations between tasks, and then the task minimizing the idle time is assigned to the station under consideration. The algorithm is coded in MATLAB a fourth

generation programming language, and its efficiency is tested on Talbot‟s and Hoffmann‟s benchmark datasets according to some performance measures and classifications

02.02 LINE BALANCING

A line is defined as a group of operators under the control of one production supervisor. Balancing is the technique of maintaining the same level of inventory at each and every operation at any point of time to meet the production target and to produce garments of acceptable quality. It is a function of the work study office to provide management with information to help the efficient and productive running of the factory, and part of this information is the process known as line balancing. Line balancing is a vital key in the efficient running of a line .The objective of the process is to balance the workload of each operation to make sure that the flow of work is smooth, that no bottlenecks are created, and that the operators are able to work at peak performance throughout the day. This process is intended to reduce waiting time to a minimum, or in fact with the use of some work in progress to eliminate waiting time completely. The process to balance the line is given below.

In operation breakdown we try to equalize the standard time.

But still there will be the difference in the standard time which leads to work in progress.

So, we try to set the flow through each operation to be similar as possible.

Checking from time to time to see how things are going and then making adjustments to even out the flow again. This process is called balancing.

02.02.01 NEEDS FOR LINE BALANCING

Line balancing is a basic need for any garments industry. It is done on purpose it is not any unnecessary operation to perform. The need [7] of balancing are given below

- Keeping inventory cost low.
- Enabling better production planning.
- Enabling the supervisor to attend other problems.
- Enabling the operator to work at the optimal pace.
- Balancing line results in on-time shipments, low cost, and ensures reorders.

02.02.02 GOALS FOR BALANCING

There are many goals of line balancing they are given below

- Meeting production schedule.
- Avoiding the waiting time.
- Minimizing over time.
- Protecting operator earnings.

02.03 RULES FOR BALANCING

Some small rules are to be followed for balancing the production line; the rules are givenbelow in short

- Having between 3 and 5 bundles of work in process at each operation.
- Solving the problem before they become larger.
- Meeting production goals by keeping every operator working at maximum capacityand make sure he has constant feeding to ensure his capacity is high

02.04 PROCESS TO BALANCE THE TIME

The balancing of the time is necessary to balance the line, so the process [7] of balancing thetime is to be followed as given in the points here

- Knowing work available at the start of the day.
- Planning transfer needed to compensate for any known absenteeism.
- Checking attendance at the start of the day.
- Making additional assignments to compensate unexpected absentees.
- Making periodic checks during the day to check production.

02.05 POINTS TO BE NOTED WHEN MAKING BALANCING

Some points are to be considered for balancing they are listed below

- Meeting production target by usage ofa. Regular operators,b. Utility operators,c. Shuttle operators.
- Work flow should be constant throughout all operations.
- Avoiding over time.
- Determining human resource.
- Checking absence daily.
- Assigning utility shuttle operators based on need.
- Updating daily production every two hours.

02.06 BALANCED PRODUCTION SYSTEM

It is a production line where the line targets are achieved in all the operations with sameamount of normal work in process at all workstations, at any point of time in the day [7].

02.07 METHOD TO KEEP ALL OPERATIONS PRODUCING AT THE SAME RATE

Methods are proposed or followed to keep the same rate of production, the basic of themethod [7] is given here and they are needed to be improvised

- This is very difficult to achieve as the operator's skill vary.
- We should balance using utility operators to cover the gaps in production.
- We should keep operators at the expected level of production, or higher if possible.

02.08 PROCESS TO START BALANCING THE PRODUCTION LINE

The two processes to start the balancing is given before to perfectly establish balanced lines

- Allocating operators based on the planned efficiency.
- Determining the amount of work in process required to ensuring smooth flow.

02.09 REASONS TO BALANCE THE LINE

Nothing is done in a factory without a reason, so line balancing has its own reason to performin the assembly line; the reasons are given below

- To keep inventory cost low results in higher income.
- To keep the normal inventory levels let the operator work consistently.
- To free the supervisors to concentrate on other areas.
- To keep the production cost low will increase the profits, which in turn will make thefacility more competitive

02.10 STEPS TO BALANCE THE LINE

The method of line balancing can vary from factory to factory and depends on the garments manufactured; but at any instance, line balancing concerns itself with two distinct

applications: “Opening the line” and “Operating the line”

02.10.01 Opening the Line

Opening the line means the operations that are done to obtain a basic of the line or the collection or establishment of a semi balanced line before final balancing. The processes [7]of opening the line are given here

- Calculation of labor requirements.
- Operation breakdown.
- Opening the line Theoretical operation balance.
- Initial balance.
- Balance control.

02.10.02 Operating The Line

Operating the line means the successful running of the line to always keep the balance in progress of the production .

Operating the line. Opening the line and operating the line is significant steps to balance the line for any further production in a single or multiple production lines. Though it varies from different production system the application signifies to balance properly.

02.11 CALCULATION OF LABOR REQUIREMENT

Before a new style comes onto a line, it is necessary to establish the operation sequence, the time, the type of equipment and the attachments required to manufacture the order .Management must have this information

before the commencement of the order, so that the line can be balanced and laid out in such a way as to maximize productivity .

02.12 There are two methods which can be used to set up a line

Two methods are followed to set up a balanced line; the methods are shortly given below before further advancement.

Method 1 calculating how many operators will be necessary to achieve a given production rate per hour.

Method 2 Calculating how many garments can be produced by a given number of operators. One should know the total: work content of garment, standard time, estimated production per day, efficiency of operator.

Pieces per machine = 480 min/SAM. Labor required = Estimated production per day / pieces per machine

02.13 Operation breakdown

Using either technique, there is certain information required before commencing the calculations

- The number of operators in the line.
- Sequential list of operations by method study.
- The standard minute values for each operation.

Output required form a given group of operators

02.14 Addition information required for calculation

Some other information is required for the proper calculation of minute value or the efficiency of the line they are given below

The size of the group, an operation sequence, the standard time for each operation ,the total standard time for the garment

- Type of machine.
- Machine attachments

- Process name/code
- Work aids

02.15 Initial balance

From the skill inventory chart, choosing the right operator whose efficiency matches the target output mentioned in the man/machine chart of theoretical operation balance sheet [8].Floaters used to balance the time due to absenteeism and imbalance. The method [8] of calculating the line balance is as follows:

- Adding up the operation time for the whole of the style.
- Establishing what percentage each operation is of the total time.
- Working out what the theoretical balance is by using each operation's percentage of
- the total number of operators on the line.
- Rounding the theoretical balance to the nearest half an operators on the line.
- Listing the type of equipment required for each operation at the side of our rounded figure.
- Where we have "half" operators, combine similar equipment to get "full" operators.
- If we have an odd "half" operator, this obviously will be rounded we can now
- calculate the number of garments that would be produced per hour on each operation by multiplying the number of operators through each operation.
- Using knowledge of the skill levels of each operator to establish which operators will give us the best possible by 60 minutes and dividing by the total minutes for the style. This will give us the theoretical number of garments that will be produced output per operation

02.16 LINE IMBALANCE

The line imbalance is need to be carefully noticed to efficiently solve the balancing problem information [8] is given about line imbalance

When operating a line, supervisor will be concerned with eliminating any problem switch arise throughout the day; as even with the most carefully planned style and best organized production floor, it is impossible to balance the production from operator too operator.

Due to factors such as machine breakdown, absenteeism, different performance levelsbetween operators, the supervisor have to constantly to re-assess the balance between

operations and this is one of the supervisor's most important functions.

The experienced supervisor will know there is a problem on the line, by the variances in the work in progress levels; but there are certain factors which the supervisor can look for to help the balancing of the line.

02.17 BALANCE CONTROL

The way and technique to balance and to hold the balanced system is an important issue. The discussion [7] about the balance control is briefly given below

- There should be a reasonable level of work in progress. A recommended level is between 30 minutes to 1 hour between operations. Anything below 30 minutes will not give the supervisor sufficient time to react to a breakdown. Anything above 1
- hour"s supply is unnecessary.
- Work in progress should always be kept in good order and full view.
- Have a number of additional machinists trained on many operations so that they can be used, wherever necessary, to cover for absenteeism. Therefore if absenteeism is5%, a squad of skilled operator would be required to cover this amount.
- Space should be made available within the line for spare machines in case of breakdown.
- Ensure that the mechanics keep the machines regularly serviced.
- If a bottle-neck keeps occurring at a particular place in the line, improve the method to eliminate the bottle neck
- Supervisors must know the capabilities and skills of the operators under their control.

- Supervisors must learn that the amount of work waiting for each operation will increase or decrease over a period of time, and must plan when to take appropriate action.
- The supervisor should have in mind a minimum and maximum number of bundles that should be at each operation, and what action to take if the level drops or rises.
- Supervision could carry out „balancing duty" regularly at 2
- -hour intervals, checking every operation on the line to ensure that the work in- progress level is within the correct limits.
- Balancing duties should be carried out on time irrespective of what else the supervisor is doing.
- The supervisor should be able to make up his/her mind about what to do if the levels are not correct, and not have to wait for the manager to make the decision for him/her.

02.18 USE OF THE DAILY PRODUCTION SHEET IN LINE BALANCING

- The daily production report plays an important role in balancing the production line, with the report the efficiency and SMV can be calculated as a result the balancing can be done simply with a little observation .

- The using of a daily production sheet will also assist the supervisor in the balancing of the line, as it shows where problems exist due to the difference in production levels between operations.
- The output of each operation and each operator is recorded hourly, thus giving hourly production figures throughout the day. If the production rate drops below the target, the supervisor can identify the problem and help to redress the balance.
- The advantages of using the production sheet are that the supervisor can address any problems hourly as they occur. This, done in conjunction with the balancing form, will stop the situation getting out of hand.

02.19 EFFICIENCY

Efficiency is another way of expressing productivity, although efficiency figures are more useful and meaningful. Efficiency figures tell us how we perform against a target which has been set by scientific means. As the target is expressed as a time per garment or a required level of production, the efficiency is quite easy to calculate. Targets are normally set at performance level of 100%, and therefore if an operator reaches his/her target production, then his/her efficiency would be 100% Likewise, should an operator only produce 75% of his/her target, and then his/her efficiency would be 75% .The formulae for calculating efficiencies are as follows Efficiency% = (Time allowed) (Time taken) X 100%Where time allowed = (Quantity produced) X (time per unit)Time taken = (Attended minutes)

(Lost time)Efficiency% = (Achieved production) / (Target production) X 100%Productivity and efficiency improvement are keys to job security, better wages and lower price.

02.20 CYCLE CHECKS

A cycle check is a brief time study with the purpose of setting a target quickly, or checking whether an operator is capable of achieving a standard time .The cycle time is the time taken by the operator to perform one cycle of the operation, i.e., time between pick-up and dispose. Conducting a cycle check according to the following steps :

- Selecting the operation/s to be studied and enter the details on an appropriate form.
- Watching five cycles of each operation, noting the time for each complete cycle.
- Calculating the average cycle time for each operation.
- Comparing cycle time to the issued basic time

02.21 LOST TIME

Lost time is the time an operator loses which is outside of his/her control. This time will affect the efficiency of an operator unless it is taken into consideration. Categories [7] of lost time are below

- Waiting for work,
- Machine trouble,
- Doing other
- people's repairs,
- Doing samples,
- Power failures,
- Meetings. Since the above points cannot be controlled by the operator, the time spent is subtracted from the attended minutes of the operator.

02.22 BALANCING TOOLS

There are four line balancing tools [7] to be studied for application the suitable one to thebalancing process in lines they are below1.

Balancing matrix.2.

Operation-wise hourly production monitoring report.3.

Bi-hourly production board.4.

Daily line inventory report.

02.22.1 Balancing matrix

The chart shown gives the clear idea to make a balancing decision based on the work in progress and capacity. Our balancing will be done on the basis of this balancing matrix method [7].

02.22.2 Operation-wise hourly production monitoring report

From the hourly production report for each and every process so that the monitoring and balancing has been done with these data. The report gives the entry level WIP and closing WIP to plan for the day and the next day too .

02.22.3 Bi-hourly production board

The bi-hourly production report where the production details of each and every section note dfor every 2 hours. This is vital information to conduct bi-hourly meeting with all the department staffs to ensure the line in balance. This report has the loading details and WIP details to make the balancing decision [7].

02.22.4 Daily line inventory report

The daily line inventory report gives the overall performance of the line for the day. The feeding and production details give the remaining inventory in the line for each and every section and also the efficiency of the sections recorded. These details are used for the next day planning and balancing

02.23.1 Advantages

- There are advantages of bundle system they are given below for better understanding the line of production
- Laborers of all levels, i.e., unskilled, skilled, semi-skilled laborers, are involved in this system where the operations are broken into small simple operation. Hence the cost of labor is very cheap.
- Here the quantity of each component is checked during the individual operation it self, so the quality is good.
- The components are moved in bundles from one operation to next operation, so there is less chance for confusion like, lot mix-up, shade variation, size variation, etc.
- Specialization and rhythm of operation increases productivity.
- As the WIP is high in this system, it is a stable system. Because of the buffer, the breakdown, absenteeism, balancing of line, change of style can be easily managed.
- An effective production control system and quality control system can be implemented.(a) Time study, method study techniques;(b) Operator training program;(c) Use of material handling equipment, such as Centre table, chute, conveyor, trolley, bins, etc.
- Bundle tracking is possible, so identifying and solving the problems becomes easy.

02.23.2 Disadvantages

The disadvantages [9] of the progressive bundle system should also be kept in mind before line balancing so they are given below in the simplest way

- Balancing the line is difficult and this problem is solved by effective supervisor.
- Proper maintenance of equipment and machinery is needed.
- Proper planning is required for each batch and for each style, which takes lot of time.
- Improper planning causes labor turnover, poor quality, less production, etc.
- Increase in WIP in each section increases the inventory cost.
- Planned and proper layout should be made to make the system effective, i.e. smooth flow of material.
- Variety of styles, less quantity is not effective in this system. 8. Shuttle operators and utility operators are needed in every batch to balance the line effectively Our balancing carried on this type of production system.

02.24 STANDARD ALLOWED MINUTE (SAM)

Standard time is the total time in which a job should be completed at the standard performance. The unit that measures the amount of work to be done by an operator in an operation by the number of minutes it should be completed. The time required by a worker with standard experience to complete a given task when working at a pace sustainable for an entire workday under normal working conditions and work methods thus comprises the following components .

02.25 WAYS TO DETERMINE THE STANDARD TIME

The standard time can be determined by various methods. The most common method used in sewing factories is the stopwatch method, which is described below .

02.26 STOP-WATCH MEASUREMENTS

02.26.1 Cautions on measurements by stopwatch

When using a stopwatch some points are to be noted on mind to exactly make the best use of the equipment and perfectly measure the time or SMV.

Carefully explaining the purpose of the time measurements so that the operators understand the purpose of being timed.

The position of the person taking the measurements should make it easy for the observer to watch the operator but should not be distracting to the operator.

A position diagonally behind or in front of the operator is usually best.

Before measuring the time, record the component tasks in the task column of the time measurement sheet after observing the job to be measured.

The points when recordings are taken must be consistently defined and followed for greater accuracy and to prevent confusion during the timing process. The component tasks should be recorded as the smallest measurable task unit

02.26.2 Other time measurement considerations

There are some other considerations [8] in time measurement they are given below

For time measurements, keeping our eyes, the stopwatch, and the operator in line so that we will keep an eye on the clock and hand movements. When there will be a succession of short component tasks, sound can also be used effectively. Starting the stopwatch at the start of the time measurement, and leaving it running until the number of required measurements has been completed.

Recording the stopwatch reading at the designated reading point on the time measurement sheet. For short repetitive operations requiring 23s each, such as chained stitching and stacked thread trimming, record the time required to complete a known number (between 10 and 20) of operations. Unexpected actions or changes in

the work procedure may occur even during repetitive tasks if the work procedure is not sufficiently standardized.

02.26.3 Number of measurements

The number of measurements taken will vary with the purpose for which the results will be used. If for defining the standard time or improving work methods, measurements should, in principle, be taken ten times (five or more times for repetitive tasks performed at a steady rhythm) .

02.26.4 Record working conditions

Work movements and work time are obtained as the results of various work conditions, and can therefore be used as reference for similar jobs and component tasks. It is important in this case to record the time measurements so that other people can understand the conditions under which the readings were obtained .

02.26.5 Calculating and organizing time measurements

The calculation and organize of the calculated data is very essential in line balancing so this need to be precisely described and understood for proper line balancing and to hold the condition of the balance. The need of measurement [8] given below

When time measurements are completed, writing the time for each component task in red pencil on the bottom row of the measurements. The time is used to calculate the difference between measurements.

Circle times (indicated with a V) that are clearly abnormal, and we will not include the devalues when calculating the average time.

In the averages column of the time measurement sheet, recording the average times tone decimal point.

Totaling the times in the component task averages column, and recording to the totals column. When there are two pieces per garment, e.g. pockets, and the time measurement was for only one pocket, multiply the measurement by two to obtain the actual time per garment for both pieces.

For short repetitive operations requiring 23 s each, such as chained stitching and stacked thread trimming operations, divide the measured time by the number of operations per garment to obtain the time per garment, and record this figure in the actual time column. Determining and recording an allowance factor.

Calculation of the standard time as: Standard time = actual time (Basic time) + allowance time

Standard time is not constant and unchanging. It is necessary to periodically reassess the standard time to accurately reflect the current work conditions as workplace improvements and the introduction of new equipment rationalize work procedures.

02.27 ALLOWANCES

Before it is possible to complete and issue that standard time for a job, it is necessary to add to the basic time certain allowances. The reason for adding these allowances is that the work study engineer has only been considering the productive work of the operator and has not taken into account the periods of rest that are required by the operator to enable the operator to recover from the energy expended, nor the time that he/she needs to allow attention to personal needs. There are certain special allowances for cleaning or re-threading machines which must be taken into account or the work study officer will not be issuing accurate times

02.27.1 Reason to add allowances to the basic time

Allowances are basic need of whether it is a machine or a worker operating. So the need [11]for adding allowances are given below in the list

When a worker works for a long duration, there is no consistency in her pace. Also she requires some attention to personal needs, time is required for fixing needle in case of needle breakage, rethreading the needle in case of thread breakage, time lapsed due to machine breakdown, etc.

The standard time is arrived at by adding up some allowances to the basic time. This will be a correct measure to set daily targets which are more practical or reliable.

To get the standard time, a proper allowance must be added consisting the working conditions. While deciding the quantum (generally in terms of percentage) of allowance to be added to the normal time, following types of allowance are considered.

The allowances are given below:

- Machine allowances
- Relaxation allowance
- Interference allowance
- Process allowance
- Contingency allowance
- Special allowance

02.27.1.1 Machine allowances:

One of the important allowances is machine allowance this covers the following

- Thread cone or tube change
- Thread and needle breakage
- Adjusting tension
- Small problems in machineType of machine Allowance Type of machine Allowance
- Single needle lock stitch 12.5%
- Multi-needle chain stitch 16%
- Double needle lock stitch 14%
- Safety stitch (5TOL/FL) 18%
- Single needle chain stitch 13%
- Bar tack stitch 12%Overclock stitch 12%

02.27.1.2 Relaxation allowance:

People are not machines and they need to go the toilet, scratch, blow their nose, etc. Relaxation and fatigue allowances are provided to give the operator worker the opportunity to recover from the effort of doing his/her work, and to allow for attention to personal needs. The relaxation and fatigue allowance is given to every operation .Recommended allowances for personal and fatigue allowances in the sewing trade are set at11% for sitting jobs and 13% for standing. Relaxation allowance is an addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and tallow attention to personal needs. The amount of this allowance depends upon the nature of the job and includes the following two categories.

02.27.1.3: Personal need allowance:

It provides for the necessity to go away from the work place to attend the personal needs such as washing, going to lavatory, getting a drink, etc. It is commonly taken as 5% for male and 7% for female worker .

02.27.1.4: Fatigue allowance :

Fatigue allowance is provided to recover a worker, from the physical efforts of carrying outwork. It consists of A constant portion (the minimum or basic fatigue allowance) which must be adequate for a worker who carries out the job while seating, engaged on light work in an ideal working conditions. This is generally considered as 4% for both men and women.

A variable portion is added when the working conditions are severe. It is based on factors which vary with the working conditions. These factors are as follows.

- Standing or other abnormal position (2%)

- Use of force (1020%)Light Atmospheric condition (1020%)
- Visual strain (48%)
- Manual strain
- Mental strain
- Loud noise
- Vibration

02.27.1.5: Interference allowance:

When one worker is attending more than one machine, then interference is the time for which one or more machine units remain idle while the operator is occupied with the work on other machine units. The allowance provided to compensate this idleness due to interference is known as interference allowance [12].2.27.1.6 Process allowance This is an allowance provided to compensate for enforced idleness during a process. This includes [12] loss of time due to

- No work
- Power failure
- Faulty material
- Faulty tools or equipment

2.27.1.7: Contingency allowance

A contingency allowance should not be greater than 5% and should only be given in caseswhere the work study officer is absolutely satisfied that they are justified. The contingencyallowances should be expressed as a percentage of the basic time. This is an allowance oftime to meet legitimate, irregular and infrequent items of works or delays which cannoteconomically be measured correctly. It is usually taken as less than 5% .

2.27.1.8 Special allowance:

These allowances are decided as a policy matter of management. These are allowed foractivities which are normally not a part of the operation cycle bur are essential forsatisfactory performance of work. These include [12] for the following items

- Start up
- Cleaning
- Shut down
- Set up
- Dismantling allowance
- Change over
- Reject allowance
- Excess work allowance
- Learning allowance
- Training allowance
- Implementation allowance
- Small batch allowance
- Tool changing and regrinding
- Bundle handling allowanceBundle handling can, if required, be expressed as a percentage and added as an allowance

CHAPTER 3

METHODOLOGY

One production line is selected from the garments sewing floor. One garments order is chosen which started in that line, knowing total amount of order, style description, and fabric type and color. Two important attributes is considered, one is possible standard method for each process and another is considerable time in between the input has been fed to the time study took to record the actual individual capacity of each worker. The time is recorded to make each process for each and every worker to find out the number of operator and helper, type of machines, basic and standard pitch time and individual capacity for the experiment. To find out the standard allowable minute value, process wise capacity is calculated in addition to that we calculated the target, benchmark capacity, theoretical manpower, labor productivity and line efficiency. Line is balanced considering the bottleneck and balancing process where the balancing process shared the excess time after the benchmark production in the bottleneck process. The labor productivity and line efficiency is compared before and after the balancing of line. The bar chart is given to show the decrease in bottleneck processes and the balancing processes quantity reduction for work sharing. A line diagram is given in the result section to show the benchmark and actual capacity along with the revised capacity to visualize the improvement in the productivity of line .Finally, a proposed production work sharing plan is given comparing with benchmark and balanced capacity.

03.01 Equations to balance the production line

These equations are needed to calculate the data required for the balancing of production line for further improvement

Standard minute value (SMV) = (average cycle time X allowance) in minute

Takt time = $\frac{Total\ SMV}{Number\ of\ operators}$

Target = $\frac{Toal\ manpower\ per\ line\ X\ total\ working\ minute\ per\ day}{SMV}\ X\ 100\%$

Theoretical manpower = $\frac{Benchmark\ terget\ per\ hour}{process\ capacity\ per\ hour}$

Labor productivity = $\frac{Total\ number\ of\ output\ per\ day\ line}{Number\ of\ workers\ worked}$

Line efficiency = $\frac{Total\ output\ per\ day\ per\ lines\ X\ SMV}{Total\ manpower\ per\ line\ \ X\ total\ workinbg\ minutes\ per\ day}$ X 100%

03.02 Balancing the line

The first step of line balancing is to breakdown the operation into sequential logical order. The breakdown is done to better understand and implement the sequential order of product processing steps. Taking cycle time for each operation is done manually and SMV is calculated from the average time with suitable allowance. Adding total SMV we can obtain target/hour. In this case 90% efficiency is the desired output level per hour. The number of operator remains same to keep the SMV same before and after the line balancing

Process name with sequence, machine type, SMV and actual capacity

SL NO	Process	M/C type	No of operator	SMV	Total capacity
1	Back and Front matching	ASO	1	.29	207
2	Shoulder join	O/L	1	.25	240
3	Thread cut & fold	ASO	1		
4	Neck rib make & cut	P/M	1	.28	214
5	Neck rib join with body	O/L;	1	.28	214
6	Main label attach with body	P/M	2	.26	220
7	Back tape join and cut	F/L	1	.28	214
8	Front cut mark label top seam	F/L	1	.25	240

9	Trim and mark label top seam	ASO	1		
10	Back tape close with label	P/M	2	.50	240
11	Sleeve hem	F/L	1	.25	240
12	Trim and pair	ASO	1	.25	240
13	Sleeve match with body	ASO	1	.29	207
14	Sleeve join with body	O/L	2	.50	240
15	Trimming tread	ASO	1		
16	Side seam with care label	O/L	3	.95	189
17	Thread cut & sticker remove	ASO	1		
18	Sleeve open and press tuck	P/M	2	.58	212
19	Thread cut & body fold	ASO	1		
20	Body bottom hem	F/L	1	.29	207
21	Thread cut	ASO	1		

Bench mark Target, Labor productivity and Line Efficiency before balancing line

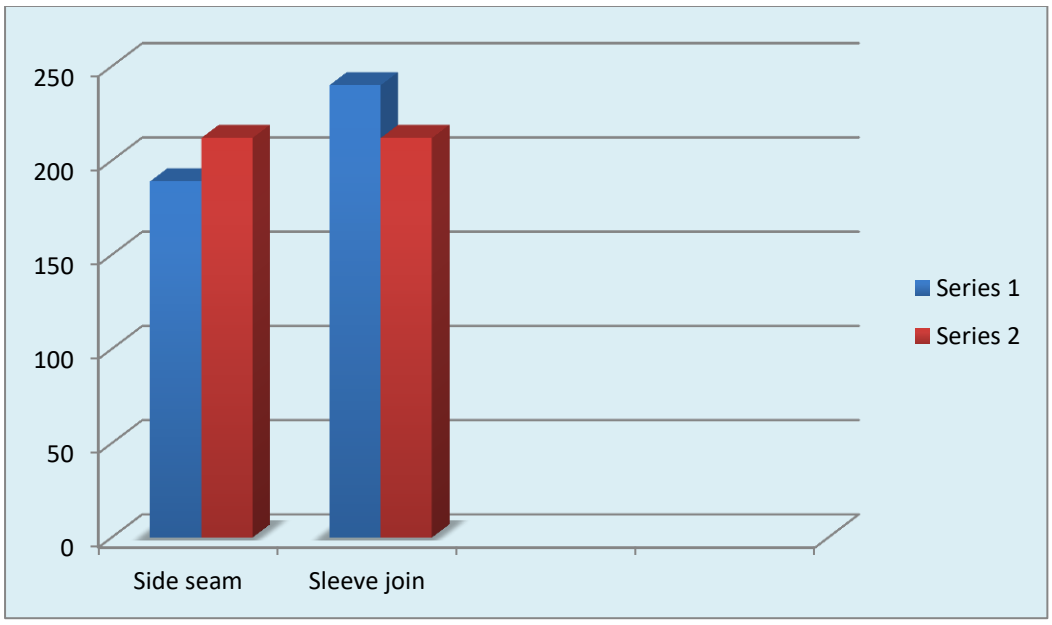
Total output per day	1320
Total man power	27
Working time	480
SMV	5.50
Takt time (min)	.204
Target /hour	236(efficiency 100%)
Target/ hour	212 (efficiency 100%)
Target/ hour	188 (efficiency 80%)
Target / hour (actual)	165 (efficiency 70%)
Labor productivity	48
Line efficiency	56%

Process wise capacity of each work station has been shown in table 4.1 where Standard minute value has been calculated by taking average cycle time for each process and considering allowances. Table 4.2 shows the target per hour for the line calculating total 27 manpower worked on that line for 480 minutes with a SMV value of 5.50.We have standardized the Bench mark target of 212 pieces of garment at 90% efficiency. Observation before balancing the line has been reflected as labor productivity is 48, line efficiency is 56%.

Balancing Process to equalize the bottleneck process:

SL NO	Bottleneck process				Balancing process			
1	Process name	process	Capacity/ hour	Balanced capacity	Process Name	Process No	Capacity / hour	Balanced capacity
	Side seam	16	189	212	Sleeve join with body	14	240	212

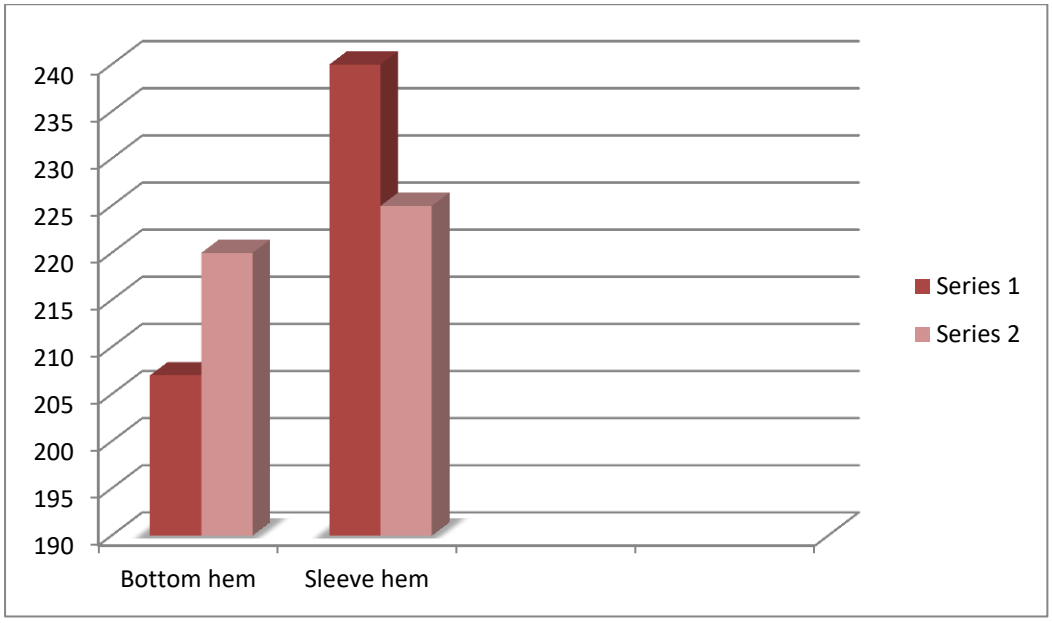
Remarks Process # 14 can work for 52 min. and share work with process # 16 for at least 8min.That increases the production from 189 pieces to 212 pieces noticeably increasing the efficiency and eliminating the bottleneck process.



Change of productivity in process no. 16 and no. 14

SL NO	Bottleneck process				Balancing process			
2	Process name	process	Capacity/ hour	Balanced capacity	Process Name	Process No	Capacity / hour	Balanced capacity
	Bottom seam	20	207	220	Sleeve hem	11	240	225

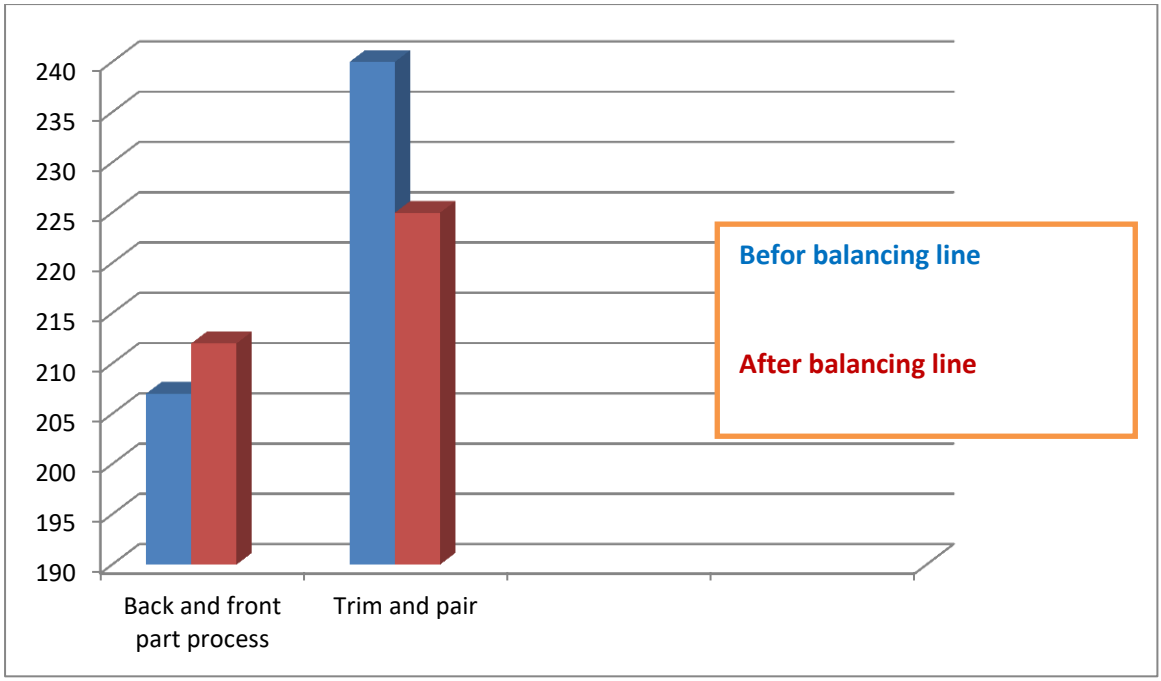
Remarks Process # 11 can work for 55 min. and share work with process # 20 for at least 5min.That increases the production from 207 pieces to 220 pieces noticeably increasing theefficiency and eliminating the bottleneck process.



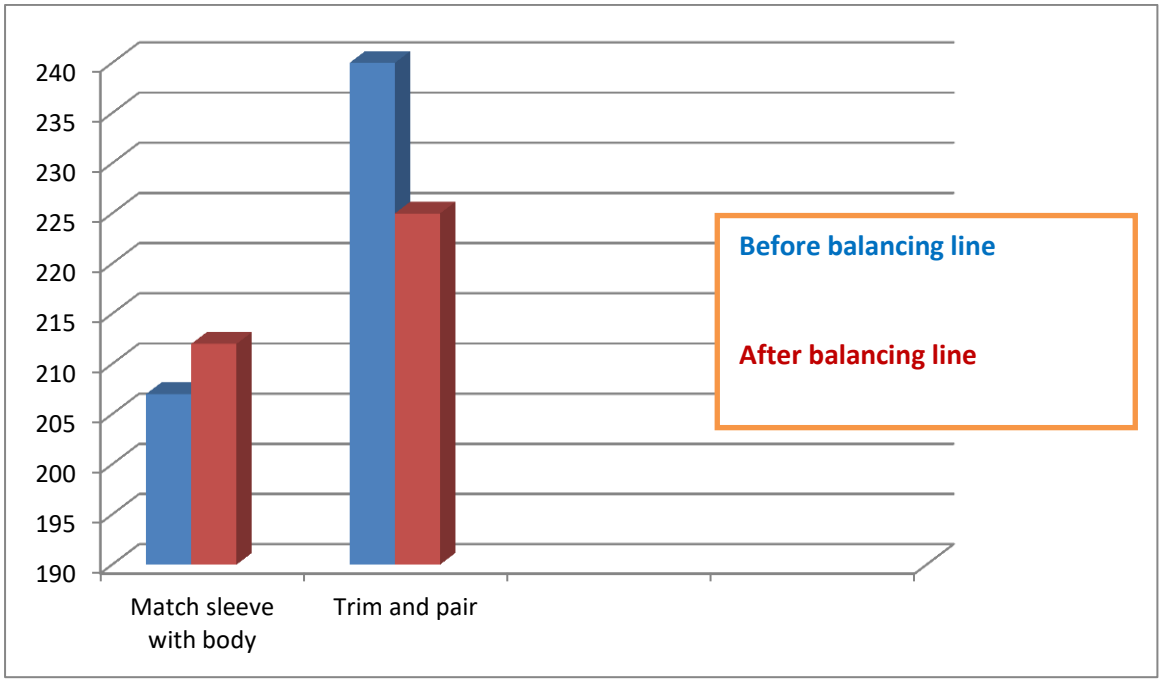
Change of productivity in process no. 20 and no. 11

SL NO	Bottleneck process				Balancing process			
3	Process name	process	Capacity/ hour	Balanced capacity	Process Name	Process No	Capacity / hour	Balanced capacity
	Back and front part match	1	207	212	Trim and pair	12	240	225
	Match sleeve with body	13	207	212	Trim and pair	12	240	225

Remarks Process #12 can work for 55 min. and share work with process # 1 and #13 for at least 5 min. That increases the production from 207 pieces to 212 pieces noticeably increasing the efficiency and eliminating the bottleneck process.



Change of productivity in process no. 1 and process no.12



Change of productivity in process no. 13 and process no.12

03.03 Bottleneck processes:

We have identified some variations in process capacity from the bench mark target and the lower capacity from the bench mark target is the bottleneck process as production flow would stuck on the bottleneck point. Comparing total capacity of each process to the 90%bench mark target, we have identified the bottleneck process named Side seam with care label attaching, Body hem. Total production has been blocked in these seven work stations and large work in process(WIP) has been stuck in that bottleneck process.

4.4 Balancing Processes

Balancing method is very essential to make the production flow almost smoother compare tithe previous layout. Considering working distance, type of machines and efficiency, workers who have extra time to work after completing their works, have been shared their work to complete the bottleneck processes. Previously identified bottleneck process has been plotted in the left side of the Table 4.3.Side seam and Sleeve join with body both have been made by over lock machine and these have been shared by two over lock machine processes. Operator who work in Process no. 14Sleeve join with body, have been worked for 52 minutes per hour in first process, capacity 240 pieces and then have been worked in the process no. 16 Side seam for last 8 minutes to make additional 23 pieces for overall capacity of 212 pieces on process no. 16.Again identified bottleneck process has been plotted in the left side of the Table 4.3. Bottom hem and Sleeve hem both have been made by flat lock machine and these have been shared by flat lock machine processes. Operator who work in Process no. 11 Sleeve hem, have been worked for 55 minutes per hour in first process, capacity 240 pieces and then have been worked in the process no. 20 bottom hem for last 5 minutes to make additional 13 pieces for overall capacity of 220 pieces on process no. 20.

Again identified bottleneck process has been plotted in the left side of the Table 4.3. Backend front match, Trim and pair and Match sleeve with body have been done by the assistant sewing operator. Operator who work in Process no. 12, have been worked for 55 minutes per hour in first process, capacity 240 pieces and then have been worked in the process no. 1 and13 for last 5 minutes to make additional 10 pieces for overall capacity of 212 pieces on process no. 1 and 13.

SL NO	Process	M/C type	No of operator	SMV	Total capacity	Total capacity revised	Target
1	Back and Front matching	ASO	1	.29	207	212	212
2	Shoulder join	O/L	1	.25	240	240	212
3	Thread cut & fold	ASO	1				
4	Neck rib make & cut	P/M	1	.28	214	214	212
5	Neck rib join with body	O/L;	1	.28	214	214	212
6	Main label attach with body	P/M	2	.26	220	220	212
7	Back tape join and cut	F/L	1	.28	214	214	212

8	Front cut mark label top seam	F/L	1	.25	240	240	212
9	Trim and mark label top seam	ASO	1				
10	Back tape close with label	P/M	2	.50	240	240	212
11	Sleeve hem	F/L	1	.25	240	225	212
12	Trim and pair	ASO	1	.25	240	225	212
13	Sleeve match with body	ASO	1	.29	207	212	212
14	Sleeve join with body	O/L	2	.50	240	212	212
15	Trimming tread	ASO	1				
16	Side seam with care label	O/L	3	.95	189	212	212
17	Thread cut & sticker remove	ASO	1				
18	Sleeve open and press tuck	P/M	2	.58	212	212	212
19	Thread cut & body fold	ASO	1				
20	Body bottom hem	F/L	1	.29	207	240	212
21	Thread cut	ASO	1				

CHAPTER 4

RESULT AND DISSCUSSION

Changing from traditional layout to balanced layout model with work sharing method, there are considerable improvements have moved toward us. Among the operators who were replaced to another line, have been used in the over lock and flat lock machines. Labor productivity has been increased from 48 to 62. In a day we have boost up the production up to 1696 and with manpower remaining same, line efficiency has been improved from 56% to72% which will be shown in Table 4.5. In an improved layout, target has been decreased at each efficiency level. At 90% efficiency, target is now 212 pieces per hour which has been considered as new bench mark target.

Total output per day	1696
Total man power	27
Working time	480
SMV	5.50
Takt time (min)	.204
Achived Target/hour	212 (efficiency 90%)
Labor productivity	62
Line efficiency	72%

49In figure 5.1 it can be seen that the line of actual capacity is mostly below the benchmark line and it is before the balancing. In figure 5.2 after balancing the line the revised capacity line is always over the benchmark capacity line or equal to the benchmark line. The output per day is increased from 1320 to 1696 that means an increase in quantity of 376 pieces of garments. If it is calculated in the mean of SMV it states that total 2068 working minute is saved and total of approximately 34 hours is in hand due to the work sharing line balancing method. A total increase of 28% in production is obtained by balancing the lines. It can be seen that all the target capacity for each operations are above or similar to the benchmark capacity/hour. So the effect of bottleneck operation has been minimized by this balancing method.

CHAPTER 5

CONCLUSION

Result would have been more effective if we would have taken some large quantity order and balancing the process is highly related to the type of machines as machine utilized in bottleneck and balancing process should be similar. Further improvements in the productivity can be achieved by considering large amount of order minimum. Proposed model has been followed the logic of modular system one worker works more than two processes and traditional system one worker works in one process and all the workers who may be skilled or not finish their work in bundle flow production both together where only modular production system can be applicable with a series of skilled workers to achieve more productivity. On this occasion, skilled workers are eligible for the production processes and proper training and supervision is essential to achieve the optimum improvements on productivity and efficiency. As shown in the table and in the figures the productivity is increased by work sharing production line balancing method in apparel manufacturing.

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